Options for Delivering Ecosystem-based Marine Management

Milestones M6/M7/M8: Identification and management of the main human activities that compromise the operational objectives

WORK PACKAGE 4

October 2012

Options for Delivering Ecosystem-based Marine Management
Pressure Assessment - Species

ODEMM Work Package 4
Milestones M6/M7/M8.

Identification and management of the main human activities that compromise the operational objectives

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This document presents the results of three tasks of the ODEMM work package 4 “Management Strategies”.
The first task consisted of an Integrated Assessment (IA) aimed at identifying those human activities most likely to compromise the operational objectives.
In order to develop feasible management strategies to mitigate these activities we developed in the second task a framework that assists in the selection and development of these management strategies. The application of this framework together with the IA resulted in a suite of potential management strategies that can be evaluated in subsequent MSE work together with other work-packages (i.e. WP5 and WP6).
In addition we explored in the third task which indicators are available and can potentially be applied to measure the progress towards achieving the operational objectives. Some of these indicators may then be used in the following MSE work.
In this report we combined the three milestones covering these tasks in order to show how the combination of the different parts can be used to provide the ODEMM options for management which involve management measures and indicators required as part of the decision-making process that aims to achieve the policy objectives.

The IA was based on the methodology developed for the WP1 pressure assessment but was now applied across all ecosystem components in order to identify the impact chains (i.e. the chain linking driver-pressure-state that causes the impact) mainly responsible for failing to achieve the objectives, i.e. the high-threat chains.
The framework intended to provide the options for the selection of appropriate management measures is based on all the management measures that emerged from a literature review and a query among the regional partners and from which a method was developed that allows the construction of measures that can be potentially applied to reduce the impact of one or more of these impact chains including additional information that helps for further select what are the most appropriate measures to achieve specific objectives.
Based on the input form the regional partners a database was developed of the most appropriate specific regional indicators for each of the MSFD Descriptors including their operational status. This revealed that few operational indicators exist.

These high-threat chains were used as the basis for a synthesis where we actually applied the framework focussing on the high-threat chains only in order to identify which measures are most suitable for implementation to achieve the MSFD objectives.

Should you have any comments or suggestions, or if you require further detail, please feel free to contact Gerjan Piet (gerjan.piet@wur.nl)

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Glossary

WORD/PHRASE	ACRONYM	DEFINITION
[GES] Descriptor		Descriptors are used to describe or qualify the ecological characteristics and/or pressure and impacts (associated with human activities), used to define Good Environmental Status (GES) (e.g. Descriptor 1: Biodiversity and Descriptor 10: Marine Litter).
Degree of Impact	DoI	The generic severity of the interaction between a pressure and an ecological characteristic in terms of its effects on the characteristic [as used in the ODEMM pressure assessment].
Ecological Characteristic	EC	Ecologically coherent elements of an ecosystem, that group together more disparate taxonomic groups into the minimum number of elements, based on the view that the lower the number of elements, the easier it is to gain a coherent and integrated assessment across the ecosystem.
Ecosystem Goods and Services	ES	The capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly.
Frequency of Occurrence (of a pressure)		The frequency that a pressure associated with a particular sector occurs at, within a given year, where it overlaps with the ecological characteristic being assessed [as used in the ODEMM pressure assessment].
Good Environmental Status	GES	Environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations.
High Level Objectives	HLO	The overall objectives set by a particular policy or directive. For the Marine Strategy Framework Directive (MSFD) these are the eleven GES descriptors, whilst for the Habitat's Directive these are the criteria for Favourable Conservation Status.
Impact	I	The adverse consequence(s) of pressures on any part of the ecosystem where the change is beyond that expected under natural variation given prevailing conditions. According to DPSIR, impact is the changes in the physical, chemical or biological state of the environment which may have environmental or economic consequences affecting the functioning of ecosystems, their lifesupporting abilities, and ultimately human health as well as the economic and social performance of society.
Pressure	P	The mechanism through which an activity has an effect on any part of the ecosystem. Pressures can be physical (e.g. abrasion), chemical (e.g. introduction of synthetic components) or biological (e.g. introduction of microbial pathogens). The pressures are based on the MSFD Annex III
Resilience		The time required by an ecological characteristic to recover after cessation of any further activities causing the particular pressure.
Risk		A function of likelihood and consequence, where highest risk is assumed when a severe consequence is likely.

Spatial Extent		The extent and distribution of the pressure from a sector where it over-laps (in time and space) with a particular ecosystem component.
Sustainable Development		Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. To be successful, it requires environmental protection, economic growth and social development.
Indicator		An indicator is a standard measure (metric) that allows change to be measured. Indicators may be abiotic (e.g. a chemical concentration) or biotic (a species or taxon). A reference value is used to indicate the expected state of an indicator.
Business-as-Usual	BAU	Business-as-Usual is a description of the current management programmes in place (or in the process of being implemented but not yet operational) within a regional sea. BAU is used to describe the current operational environmental, societal or economic landscape.
BAU+	BAU +	A measure or suite of measures implemented in addition to Business-as-Usual that introduce a change or changes in the environmental, societal or economic landscape from its current state.
Reference value		A reference value (can also be referred to as a baseline) is the expected state of an indicator under predefined conditions.
Sector		A business that exploits the same or related product or service provided by the marine ecosystem (e.g. shipping; coastal infrastructure)
Management strategy		The strategy adopted by the management authority to reach the operational objectives. It consists of the full set of management measures applied and may include several sectors.
Management measure		Specific controls applied to contribute to achieving the objectives. Several mechanisms may be applied to apply these controls, including technical , social or economic.
Cumulative impact		The sum total of the impacts caused by separate activities.
Driver	D	According to DPSIR driver or 'driving force' is a need. Examples of primary driving forces for an individual are the need for shelter, food and water, while examples of secondary driving forces are the need for mobility, entertainment and culture. Here the driver is defined by the sector and activity.
State	S	According to DPSIR the 'state' of the environment is the quality of the various environmental compartments (air, water, soil, biota etc.) in relation to the functions that these compartments fulfill. The 'state of the environment' is thus the combination of the physical, chemical and biological characteristics (see MSFD Annex III)
Response	R	According to DPSIR a 'response' by society or policy makers is the result of an undesired impact and can affect any part of the impact chain
Impact chain		Chain linking driver-pressure-state that causes the specific impact

1 Introduction

The main aim of ODEMM WP4, “Management Strategies” is to:

1. Identify those human activities most likely to compromise the operational objectives
2. Develop a range of realistically feasible management strategies or options for these activities, using different types of measures and tools, to achieve regional Operational Objectives.
3. Apply a formal evaluation of these management strategies using a Management Strategy Evaluation (MSE) tool
4. Consider the resources required in terms of infrastructure and governance to enforce the management strategies evaluated.

In this document we aim to address the first two objectives of this work package and to that end the results of three separate tasks will be presented in this document. This document combines Milestones 6, 7 and 8. Milestone 6 is a summary report showing the human activities revealed to be most likely to compromise the achievement of operational objectives in each region. Milestone 7 is a report detailing the indicators and management measures selected for each of the major issues highlighted in each regional sea. Milestone 8 comprises a list of possible management strategies for each of the selected operational objectives in each region. These milestones are reported together in this document because the work in these milestones is complementary and the combined reporting allows an overall synthesis of the work done so far.

This document consists of three separate pieces of work reported in chapters 2, 3 and 4 followed by a synthesis in chapter 5.

Chapter 2 consist of an Integrated Assessment (IA) of which the final outcome will be the identification of those human activities most likely to compromise the achievement of operational objectives in each regional sea thereby fulfilling the first objective. This was done through the development of so-called impact chains representing the link through which a specific human activity through a specific pressure causes an impact on a specific ecosystem characteristic.
In our approach to fulfill the second objective we worked from the premise that a management strategy consists of one or more management measures possibly combined with monitoring activities and embedded in “good governance”. These management strategies will be evaluated in the next stage of the project.
Chapter 3 focusses on indicators. These can be used in the evaluation process but also to indicate where additional monitoring may be required as part of alternative management strategies. Therefore this chapter presents a database of potential regional indicators that match the components of the impact chain and can be linked to the operational objectives identified in earlier ODEMM work (WP3). This is based on the completed, or often still on-going, work in the member states covered by experts within the ODEMM project to establish operational indicators for the MSFD Descriptors, criteria and indicators as specified in the MSFD [1]. These indicators can be used to evaluate the management strategies in the subsequent steps of this work package aimed at addressing the third objective. These indicators should also drive the development of the monitoring programs that complement the management strategies developed in this work package.
Chapter 4 addresses the management measures and presents an inventory of measures that can be used to mitigate the human activities most likely to compromise the operational objectives. The measures match the list presented in Annex VI of the MSFD but in addition are stored in a database with additional information that allows linking them to any element in the impact chain including the pressures as well as the ecosystem characteristics (see Annex III of the MSFD).
Finally chapter 5 present a synthesis where the high-threat impact chains (Chapter 2) are linked to the appropriate indicators (Chapter 3) and management measures (Chapter 4) through the components that make up the chain (i.e. sectors, pressures, ecosystem characteristics). The linking of these components help us to make a first assessment of which measures are most appropriate to mitigate the effects of specific activities (driver-pressure combinations) and the human activities (i.e. drivers) that compromise a specific operational objective.

1.1 Background

1.1.1 MSFD (sub)regions

The MSFD identified the following marine regions, some consisting of several subregions (see Figure 1):

(a) the Baltic Sea;
(b) North-east Atlantic Ocean:
  (i) the Greater North Sea, including the Kattegat, and the English Channel;
  (ii) the Celtic Seas;
  (iii) the Bay of Biscay and the Iberian Coast;
  (iv) in the Atlantic Ocean, the Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands;
(c) Mediterranean Sea:
  (i) the Western Mediterranean Sea;
  (ii) the Adriatic Sea;
  (iii) the Ionian Sea and the Central Mediterranean Sea;
  (iv) the Aegean-Levantine Sea.
(d) the Black Sea.

These regions form the basis of any regional component in the work presented in this document.

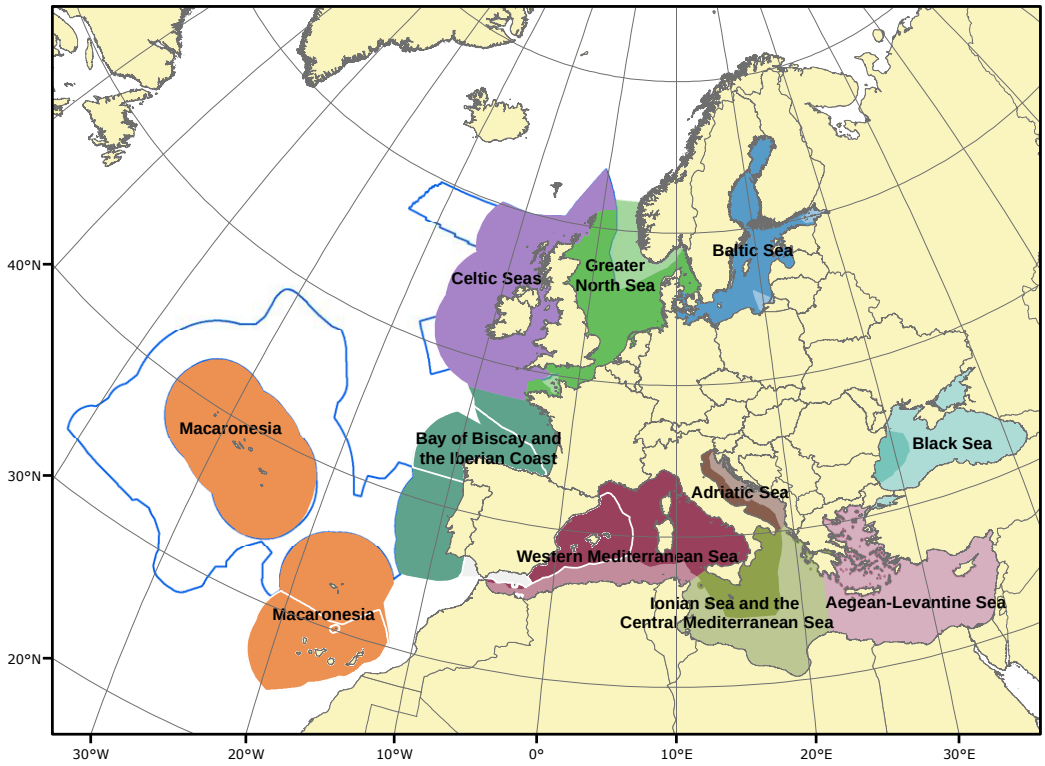

Figure 1. Draft map of MSFD regions and subregions (NOTE: this is a "live" map, subject to changes as MS provide input through MSFD-related processes).

1.1.2 DPSIR Framework

The components of the DPSIR framework are defined in the following. Classes of data on the past and present situations are listed after each definition.

Driver
A 'driving force' or driver is a need. Examples of primary driving forces for an individual are the need for shelter, food and water, while examples of secondary driving forces are the need for mobility, entertainment and culture. For an industrial sector a driving force could be the need to be profitable and to produce at low costs, while for a nation a driving force could be the need to keep unemployment levels low. In a macroeconomic context, production or consumption processes are structured according to economic sectors (e.g. agriculture, energy, industry, transport, households). - Population (number, age structure, education levels, political stability) - Transport (persons, goods; road, water, air, off-road) - Energy use (energy factors per type of activity, fuel types, technology) - Power plants (types of plants, age structure, fuel types) - Industry (types of plants, age structure, resource types) - Refineries/Mining (types of plant/minings, age structure) - Agriculture (number of animals, types of crops, stables, fertilisers) - Landfills (type, age) - Sewage systems (types) - Non-industrial sectors - Land use

Pressure
Driving forces lead to human activities such as transportation or food production, i.e. result in meeting a need. These human activities exert 'pressures' on the environment, as a result of production or consumption processes, which can be divided into three main types: (i) excessive use of environmental resources, (ii) changes in land use, and (iii) emissions (of chemicals, waste, radiation, noise) to air, water and soil. - Use of resources - Emissions (per driving force for numerous compounds) - direct emissions to air, water and soil - indirect emissions to air, water and soil - Production of waste - Production of noise - Radiation - Vibration - Hazards (risks)

State
As a result of pressures, the 'state' of the environment is affected; that is, the quality of the various environmental compartments (air, water, soil, etc.) in relation to the functions that these compartments fulfil. The 'state of the environment' is thus the combination of the physical, chemical and biological conditions. - Air quality (national, regional, local, urban, etc.) - Water quality (rivers, lakes, seas, coastal zones, groundwater) - Soil quality (national, local, natural areas, agricultural areas) - Ecosystems (biodiversity, vegetation, soil organisms, water organisms) - Humans (health) - Soil use

Impact
The changes in the physical, chemical or biological state of the environment determine the quality of ecosystems and the welfare of human beings. In other words changes in the state may have environmental or economic 'impacts' on the functioning of ecosystems, their lifesupporting abilities, and ultimately on human health and on the economic and social performance of society.

Response
A 'response' by society or policy makers is the result of an undesired impact and can affect any part of the chain between driving forces and impacts. An example of a response related to driving forces is a policy to change mode of transportation, e.g from private (cars) to public (trains), while an example of a response related to pressures is a regulation concerning permissible SO_2 levels in flue gases.

Figure 2 depicts the complete DPSIR framework. In addition to defining the components of DPSIR, it is useful to describe the various cause-effect relationships (because it is often difficult to attribute ecosystem changes unambiguously to human pressures). NERI[3] has proposed a methodology in which environmental problems are defined and structured in such a way that a clear relationship to pressures emerges. This often uses physical or chemical state indicators as the target variable, while the associated changes in biological state variables are treated as derived effects. A similar argument can be presented for the causal links between the driving forces (i.e. the basic socio-economic development of the different sectors of society) and the environmental pressures in terms of emissions, resource use and land use.

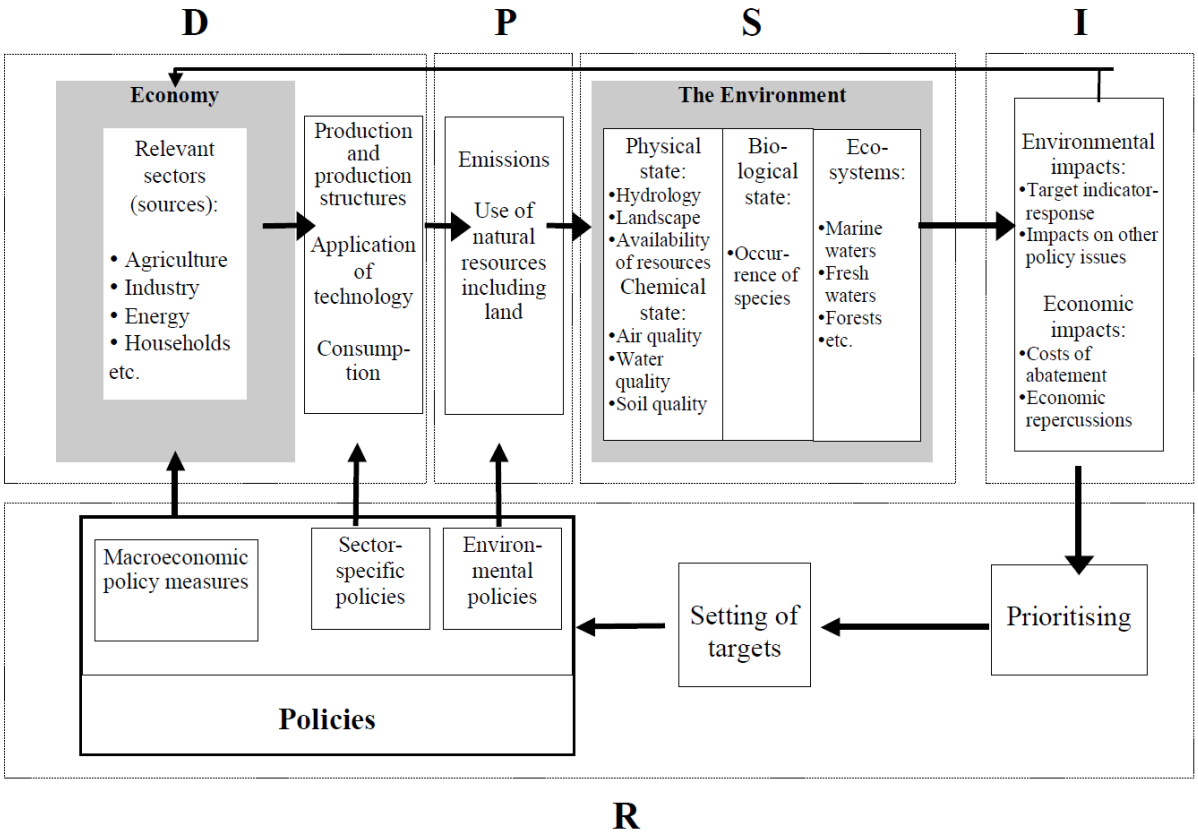

Figure 2. DPSIR framework

1.1.3 Marine Strategy Framework Directive

Selected MSFD Pressures, Sectors, Ecosystem characteristics were based on the MSFD annex III but sometimes slightly modified depending on the application. Pressures, sectors and ecosystem components were used to create impact chains. In the different databases (IA (Chapter 2), indicator database (Chapter 3) and management measures database (Chapter 4)) slightly different configurations of the lists were used (see Table 1 -

Table 3).
Table 1 shows the overview of the sectors that were used in the IA and the measures database. In order to merge the databases, sectors from the measures database were adopted as the basis.
The following differences occur:

- 'coastal infrastructure' was translated to 'coastal infrastructure (construction)' as 'coastal infrastructure' was only linked to habitats. We considered the habitat could only be disturbed in coastal infrastructure construction, not in coastal infrastructure operations.

- The same line of thought was followed for the translation of 'non-renewable energy (nuclear)' into 'non-renewable energy (nuclear) construction', translation of 'Non-renewable Energy (oil & gas)' into 'Non-renewable Energy (oil & gas construction)', Renewable Energy into Renewable Energy (wind) – construction, Telecom into Telecommunications construction and Fishing into Fishing - Benthic.

Table 1. Overview of sectors that are included in the different databases

Sectors (IA database)	**Sectors (measures database)**
(Hydro) Power Station Construction	(Hydro) Power Station Construction
(Hydro) Power Station Operations	(Hydro) Power Station Operations
Aggregates	Aggregates
Agriculture	Agriculture
Aquaculture	Aquaculture
Carbon sequestration	Carbon sequestration
Coastal Infrastructure	
Coastal Infrastructure (construction)	Coastal Infrastructure (construction)
Coastal Infrastructure (operations)	Coastal Infrastructure (operations)
	Coastal defence
Desalination	Desalination
Fishing	
Fishing - Benthic trawling	Fishing - Benthic trawling
Fishing - Fixed Nets incl. potting and creeling	Fishing - Fixed Nets incl. potting and creeling
Fishing - Pelagic trawling	Fishing - Pelagic trawling
Harvesting/Collecting	Harvesting/Collecting
Land-based Industry	Land-based Industry
Military	Military
Navigational Dredging	Navigational Dredging
Non-renewable Energy (Nuclear) Construction	Non-renewable Energy (Nuclear) Construction
Non-renewable Energy (Nuclear) Operations	Non-renewable Energy (Nuclear) Operations
Non-renewable Energy (nuclear)	
Non-renewable Energy (oil & gas construction)	Non-renewable Energy (oil & gas construction)
Non-renewable Energy (oil & gas operations)	Non-renewable Energy (oil & gas operations)
Non-renewable Energy (oil & gas)	
Renewable Energy	
Renewable Energy (wind) - construction	Renewable Energy (wind) - construction
Renewable Energy (wind) - operations	Renewable Energy (wind) - operations
Research	Research
Shipping	Shipping
Telecom	
Telecommunications construction	Telecommunications construction
Telecommunications operations	Telecommunications operations
Tourism/Recreation	Tourism/Recreation
Waste Water Treatment	Waste Water Treatment

Table 2. Overview of pressures that are included in the different databases

Pressures (both IA database as measures database)
Abrasion
Barrier to species movement
Change in wave exposure
Changes in siltation
Climate Change
Disturbance

Emergence regime change
Input of organic matter
Introduction of microbial pathogens
Introduction of NIS and translocations
Introduction of Non-synthetic compounds
Introduction of Synthetic compounds
Marine Litter
Nitrogen and Phosphorus enrichment
pH changes
Salinity regime changes
Selective Extraction of Non-living Resources
Selective extraction of species
Smothering
Substrate Loss
Thermal regime changes
Underwater noise
Water flow rate changes

Table 3. Overview of ecosystem components (i.e. ecologically coherent elements of an ecosystem that group together more disparate taxonomic groups into a minimum number of elements (Robinson & Knights, 2011[2]) that are included in the different databases

Ecological characteristics (IA database)	Ecosystem components (indicator database)	Ecosystem components (measures database)
Seabirds	Seabirds	Seabirds inshore Seabirds offshore
Fish Benthic Fish Pelagic Fish Deep sea	Fish	Fish Benthic Fish Pelagic Fish Deep sea
Marine mammals & reptiles	Marine mammals & reptiles	Marine mammals Reptiles
Predominant Habitat (Litt rock)	Habitat Bottom fauna & flora	Habitats Bottom fauna and flora Bathymetry/ topography
Predominant Habitat (Sublitt rock)	Habitat Bottom fauna & flora	Habitats Bottom fauna and flora Bathymetry/ topography
Predominant Habitat (Infralitt rock)	Habitat Bottom fauna & flora	Habitats Bottom fauna and flora Bathymetry/ topography
Predominant Habitat (Circalitt rock)	Habitat Bottom fauna & flora	Habitats Bottom fauna and flora Bathymetry/ topography
Predominant Habitat (Litt sed)	Habitat Bottom fauna & flora Nutrients & oxygen Chemicals	Habitats Bottom fauna and flora Bathymetry/ topography Nutrients & oxygen Chemicals
Predominant Habitat (Sublitt sed)	Habitat Bottom fauna & flora Nutrients & oxygen Chemicals	Habitats Bottom fauna and flora Bathymetry/ topography Nutrients & oxygen Chemicals
Predominant Habitat (Deep sea bed)	Habitat Bottom fauna & flora Nutrients & oxygen Chemicals	Habitats Bottom fauna and flora Bathymetry/ topography Nutrients & oxygen Chemicals
Predominant Habitat (Pelagic water col)	Habitat Plankton Nutrients & oxygen Chemicals	Habitats Nutrients & oxygen Chemicals Plankton Salinity Temperature pH, pCO2

1.2 Approach

For our Integrated Assessment (IA, chapter 3), identification of indicators (chapter 4) and framework for the development and application of management strategies (chapter 5) we adopted the terminology as used in the DPSIR framework and the specifics of the state characteristics, pressures and impacts as they occur in the MSFD annex III. Throughout this document we use the phrase “Driver” as proposed in the DPSIR framework but instead of only applying to the different sectors we use the combination of sector and activity to describe the driver. For “Impact” we follow the DPSIR framework in that it is a change in State caused by human activity through a specific pressure. In order

to explicitly define this link we created impact chains for each existing link between specific Drivers, Pressures and States, thus: Impact chain = D-P-S.
In the IA the importance of each impact chain is assessed using the methodology described in the ODEMM Linkage framework. The relative importance of a specific impact chain reflects its contribution to the overall impact that caused the change in state and thus the failure to achieve the policy objectives. This then can be used to inform management in the choice, development and implementation of appropriate management strategies. Indicators are then required to show what the state of the ecosystem is in relation to the objectives and how the management strategies affect this state towards the achievement of objectives.

2 Integrated assessment

Given the multiple (national and international) policy needs for effective monitoring and management of the marine environment, there is a clear requirement for a tool that could be used to prioritise resources. Identifying the key pressures on marine ecosystem characteristics will allow management action to be focused on the most damaging activities and the ecosystem characteristics most vulnerable to them.

There are many different sectors that exploit and affect the marine environment, each of which exerts varying degrees of pressure on the ecological characteristics of the ecosystem through their activities. Here we apply an integrated assessment based on the methodology of Robinson and Knights [3] which is applied in European regional seas and further developed as part of this work-package.

The aim is to identify those human activities currently causing the key pressures on the regional sea ecosystems and are thus most likely to compromise the achievement of the targets set under the operational objectives identified in WP3. This will be based on a qualitative integrated assessment based on expert judgment but taking existing (regional) information into account. This assessment is limited to the objectives involving the state of the ecosystem and (i.e. MSFD Descriptors 1, 3, 4 and 6). In this chapter we focus on the marine species because the marine habitats and their associated assemblages are assessed and reported separately [4].

2.1 Methods

2.1.1 Pressure Assessment

We used the approach that is developed and described by Robinson and Knights [3]. Here we briefly introduce the main aspects, for more detail we refer to the original source.

Pressures are defined as “the mechanism through which an activity has an effect on any part of the ecosystem” [3]. Pressures can be physical (e.g. abrasion), chemical (e.g. introduction of synthetic components) or biological (e.g. introduction of microbial pathogens) and the same pressure can be caused by a number of different sectors and/or activities.

The ecological characteristics are ecologically coherent elements of an ecosystem, that group together more disparate taxonomic groups based on the view that a limited number of characteristics, would facilitate a coherent and integrated assessment across the ecosystem [3].

The sectors operating in the EU regions, i.e. Baltic Sea (Baltic), Black Sea (Black), Mediterranean Sea (Med) and Northeast Atlantic Ocean (NEA), were mapped against the pressures they exert which, in turn, are linked to the characteristics of the ecosystem that they affect (both pressures and characteristics occur as defined by Annex III of the Marine Strategy Framework Directive [2008/56/EC]). Associated information describing the linkages is presented in the Linkage Framework Userguide [5] and an accompanying excel linkage table [6] (Annex II). Using the linkage tables, it is possible to extract all sector/pressure combinations that affect a particular ecological characteristic (e.g. pelagic fish). Each linked driver-pressure-ecosystem characteristic defines what we call the “pressure pathway”.

The combinations shown by the linkage tables only describe the potential pressure pathways. In order to assess the actual relative threat caused by a particular sector/pressure on an ecological characteristic requires a weighting of the interaction. This, then should allow management to take appropriate action towards those sectors or sector/pressure combinations that contribute most to the (cumulative) pressure on that ecological characteristic. Following the approach of Robinson and Knights [3], for each region expert judgement was used to weigh these interactions in terms of:
(i) the generic sensitivity of an ecological characteristic to any sector/pressure combination, in terms of the likely degree of impact (DoI) (1) and its resilience (2);
(ii) the actual footprint of the sector/pressure combination in the region being assessed where it overlaps with the ecological characteristic, in terms of spatial extent (3) and frequency of occurrence (4);

(iii) the likely persistence (5) of the pressure in the environment (i.e., the length of time that the pressure continues to affect an ecosystem characteristic, after cessation of the activity causing it).

These five individual elements are treated independently in the assessment, e.g. degree of impact is not determined by the actual extent and/or frequency of the pressure. The categories used for the weighting of the interactions are shown in Annex I.

Two steps were distinguished in the consistency check : (1) Regional, where the preliminary results of the pressure were subjected to a consistency check within the region and (2) pan-European where the complete pressure assessment (preliminary pressure assessment) was subjected to a consistency check which ensured that regional differences in the results were not caused by regional differences in interpretations of the pressure assessment methodology. Observed regional differences can be either correct if a different situation was assessed correctly or false if a similar situation was assessed differently due to some misinterpretation. If the latter case occurred and one or more expert groups misinterpreted the situation it was studied in the validation step and reported in the results section of this report.
The following workshops took place as part of the quality control process:

1. Preliminary assessment by regional teams at workshop at Crete (February/March 2012)
2. Validation by IMARES and ULIV (March – May 2012)
3. Review by regional teams in workshop at Edinburgh (June 2012)
4. Finalisation by IMARES (June , 2012)

This process of consistency checking and validation resulted in the final pressure assessment presented in this document.

2.1.2 High threat combinations

The complete pressure assessment was then used to extract those sector/pressure combinations that pose the highest threat to a particular ecosystem characteristic. The following rules were used to identify these so-called 'high threat pressure pathways'.
extent = WP or WE, DOI=A or C and persistence=H or C,
extent = WP or WE, DOI=A and frequency=O, C or P,
extent = WP or WE, DOI=C and frequency=P or C.

2.2 Results

2.2.1 Linkage framework

The Linkage Framework Userguide [5] was used to define the sectors, pressures and ecological characteristics. The 25 pressures as listed in the Userguide were included in the assessment without adjustments. For the sectors and ecological characteristics some adjustments were made:

Sectors
The list of sectors [5] was used as a starting point for the assessment. The list was reviewed to ensure that the activities within a sector exert comparable pressures. A few adjustments were made: the sectors which involve the construction or placement of large structures (i.e. renewable energy, non-renewable energy (oil & gas), non-renewable energy (nuclear), telecommunications and coastal infrastructure) were split up into an construction phase and an operational phase because of the different pressures they exert. For the same reason the sector 'fishing' was divided into benthic trawling, pelagic trawling and fixed nets incl. potting and creeling. Finally, there was one sector that involved activities that exert different pressures; the sector renewable energy, involving tide, wave and wind energy. Considering the related pressures, hydro power stations (tide/wave) were grouped together into hydro power station construction and – operations. Renewable energy wind construction and –operations were grouped separately. In total, the pressure assessment includes 28 sectors, see Annex I.

Ecological characteristics

The Linkage Framework Userguide [5] provides a list of 17 ecological characteristics based on Annex III of the MSFD. From this list a selection was made, see Table 4. As mentioned before, the ecological characteristics within this study are limited to species only, as the habitat characteristics are assessed and reported separately [3]. A total of 5 groups were selected to represent the marine species: deep sea fish; benthic fish; pelagic fish; marine mammals and reptiles; seabirds.

Table 4. Selection of Ecological characteristics from the Linkage Framework Userguide [5]

Ecological characteristics (Annex III MSFD)	**Selection for the Pressure Assessment**
Topography/Bathymetry	Omitted because this is not an ecological feature
Temperature	Omitted because this is not an ecological feature
Salinity	Omitted because this is not an ecological feature
Nutrients & Oxygen	Omitted based on Commission Guidance Doc SEC 2011 1255 (Annex 5). Not relevant (pressure indicator)
pH, pCO2	Omitted because this is not an ecological feature
Habitat types	Omitted because this is assessed separately
Plankton	Omitted based on the Commission Guidance Doc SEC 2011 1255. Plankton is part of the habitat pelagic water column
Bottom fauna and flora	Omitted based on the Commission Guidance Doc SEC 2011 1255. Bottom fauna and flora is part of the habitat types
Fish	This includes both Teleosts and Elasmobranchs. Because of the different distribution and hence different overlap with sector/pressures this characteristic is divided into three groups: deep sea-; demersal-; and pelagic fish
Marine mammals & Reptiles	Marine mammals and reptiles can be combined into one group because of the same resilience, same general distribution and they are susceptible to the same pressures
Seabirds	Seabirds are included as a group as they are susceptible to the same pressures
Species listed under Community Legislation or Conventions (e.g. Habitats Directive)	Listed and other species of Community legislation & international agreements are not included as a separate group as they are considered as part of the relevant ecological characteristic
Non indigenous species	Omitted based on Commission Guidance Doc SEC 2011 1255 (Annex 5). This is a pressure and not an ecological characteristic. Once they are established they are considered as part of the relevant ecological characteristic (e.g. Pacific Oyster as part of "Bottom fauna and flora")
Chemicals	Omitted based on Commission Guidance Doc SEC 2011 1255 (Annex 5). Not relevant (pressure indicator)
Other notable features	No other notable features were defined

The sector/pressure and pressure/ecological characteristic combinations (i.e. links) were based on the ODEMM linkage tables [5]. Some adjustments were necessary because of the changes in ecological characteristics and sectors as explained above. The resulting combinations shown by the linkage tables (see Annex II) describe a potential interaction. Next step was to weigh these interactions, see section 'preliminary results and consistency check'.

2.2.2 Preliminary results and consistency check

As described in the methodology section, the complete pressure assessment (preliminary pressure assessment) was subjected to a consistency check. Results that were not consistent within the assessment were adjusted after agreement of all teams involved. This resulted in the final pressure assessment (see section final results).
To provide insight into intermediate results, robustness and variation of the different components of the pressure assessment, the following aspects will be described for each step of the assessment:

- Availability of information

- Interpretation by experts
- Consistency of preliminary results
- Variation among ecological characteristics, pressures, sectors
- Variation among regions
- Confidence of the assessment

2.2.2.1 Resilience

The generic resilience of the ecological characteristic is assessed based on its current status in the regional sea and categorised based on recovery times as follows:

- None (no recovery or >100yr) (N);
- Low (10 to <100 yr) (L);
- Medium (2 to <10 yr) (M);
- High (0 to <2 yr) (H).

For all ecological characteristic groups literature was used to derive useful information for the assessment of resilience [7-13]. Considerable variation in recovery time (i.e. resilience) exists between species within each ecological characteristic group.

With one exception, all ecological characteristics were determined to have a low recovery potential (recovery between 10 and 100 years). There is however considerable variation within the groups (e.g. between species).

Population recovery rates of deep sea fish decrease with increasing depth [10]. For two Atlantic grenadiers, time to recovery could range from over a decade to over a century [7]. This exceptional recovery time of more than 100 years was not considered by the experts to be representative for the group of deep sea fish, therefore a low recovery was chosen for this ecological characteristic.

Finfish stock is known to recover after 3-30 years with demersal fish generally showing longer recovery times than pelagic fish [9]. Among commercially exploited fish species, Clupeids take 5-10 years to recover stock biomass, whereas gadoids take more than 15 years to recover or show no recovery as far as could be observed. Some groups of large pelagic fish (e.g. Basking sharks and Tuna sp.) take more than 10 years to recover. An exception to the low resilience of ecological characteristics are demersal fish in the Black Sea with a medium recovery potential. This is due to the strong degradation of the fish community in the Black Sea [14].
Marine mammals like whales, seals and sea turtles show signs of recovery after several decades [9]. Therefore a low recovery (i.e. 10-100 years) is considered to be the appropriate classification for most marine mammals and turtles.

Many sea bird species required several decades before the first signs of signs of recovery [9], http://www.birdlife.org/datazone/species/BirdsInEuropeII). In this context the Fulmar is an interesting sea bird species due to its slow recovery rate and therefore suitable as a worst case (Fisher, 1952). After stopping the hunt on young Northern Fulmars populations in the North East Atlantic increased spectacularly within only a few decades [15]. It can therefore be concluded that sea birds have a low recovery potential (between 10 and 100 years).

As resilience is a species-specific characteristic it should be similar for all ecological characteristic groups between regions. This was confirmed by our consistency check. However the confidence of the resilience assessment varies considerably among the regions due to the difference in availability of knowledge concerning the sensitivity and resilience of the prevailing species (see Annex V).

2.2.2.2 Persistence

The persistence of the pressure should be categorised as:

- Continuous (the pressure never leaves the system or >100 yr) (C);
- High (10 to <100 yr) (H);
- Medium (2 to <10 yr) (M); or
- Low (0 to <2 yr) (L).

Published information on the persistence of pressure types is only available for part of the pressure types. The literature used for the assessment of pressure persistence is listed in Annex IV. For most of the pressures, the assessment of the persistence could be made with a fairly high level of agreement among the experts. For some pressure types, e.g. introduction of microbial pathogens and substrate loss, there was initial disagreement between experts.
The results of the preliminary assessment by the regional teams showed marked differences in the pressure persistence. The 4 most contentious pressure types were: introduction of microbial pathogens, marine litter, substrate loss, water flow rate change. These are elaborated below.

Microbial pathogens
Information on the survival of microbial pathogens in seawater is very scarce. Some information was found regarding aquaculture [16]. Experts assume a low survival for most microbial pathogen species, but with a high level of uncertainty. There is a risk that this is not valid for some microbial pathogen species. Because few (if any) cases were known to have occurred in practise according to available evidence the persistence was classified as low.

Marine litter
For marine ltter the classification of persistence differed between high (10 to 100 years) or continuous (> 100 years). There are differences in the type of litter produced by a particular activity. For example, plastic fishing nets persist for centuries, whereas aluminium drinks cans 10-100 yr. However, plastics, for example, are part of nearly all waste generated by the different activities and there is no possibility to differentiate on basis of type of litter (except for fishing nets). Times for breakdown range from weeks to hundreds of years, with an average life expectancy between 50 and 100 yr. In order to be precautionary it was decided to choose a high (10 to 100 years) persistence.

Substrate loss
There was broad agreement among the experts that substrate loss caused by permanent coastal infrastructure constructions is highly persistent. Substrate loss due to activities other than coastal infrastructure construction are assessed to have a medium persistence. However there are likely some sector-habitat combinations where this may be overly precautionary. This also depends on the environmental conditions. Assuming that the species are affected through a "loss of habitat" as reported by Aarts et al. (2004) and Turner et al. (1999) [17, 18] then the persistence would be how long it takes the habitat for that species (e.g. demersal fish) to recover following loss. The recovery of the majority of habitats used by demersal species is medium.

Water flow rate change
The preliminary assessments for water flow rate change yielded a persistence that could be low, medium, high or continuous. In the consistency check it was suggested that persistence depends on the activity, being permanent for coastal infrastructure and low or medium for other activities. Activities such as aggregates, navigational dredging, beach replenishment are scored as medium (2-10 yr) because dredged pits will often persist for more than 2 years [19] therefore changes in local water flow will also be affected. This was accepted by the regional teams.

Thus for the majority of the pressure types all sectors could be combined because of the same persistence score. The consistency check revealed that the consistency of the persistence scores is high. The persistence varies greatly among the pressure types but there is very little difference between the ecological characteristics. The persistence of a specific pressure does not differ between regions. The confidence of the assessment was usually high.

2.2.2.3 DoI

The degree of impact (DoI) of a driver-pressure on an ecological characteristic describes the generic severity of the interaction in terms of its effects on the ecological characteristic. Thus to score degree of impact assessors score the type of response of the ecological characteristic to the pressure type as either:

- Severe - Acute (A);
- Severe - Chronic (C); or
- Low severity (L).

In general, scoring the DoI was complicated. According to the guidelines for the pressure assessment [3] an acute DoI is described as " a high proportion of individuals are killed by the interaction of the pressure and the characteristic, which can occur after just one event. The DoI is considered to be chronic in case the interaction will eventually have severe consequences if it occurs often enough

and/or at high enough levels. The difference between acute and chronic is thus not based on the magnitude of impact but only on spatial and temporal scale and the intensity of the pressure. However, these aspects are only described in the guideline as 'one event'. The interpretation of 'one event', however, can vary considerably: e.g. in case of shipping this can be considered as one ship passing or all ships in the region. A Low severity interaction is described as an interaction that, irrespective of the frequency and magnitude of the event(s), never causes high levels of mortality within a given population. Without considering intensity, this can also be interpreted differently. The introduction of contaminants can in theory always cause mortality as toxicity is concentration dependent. Considering the intensity of the pressure it is however in many cases unlikely that this will cause mortality. The guidance for assessment of the DoI therefore requires definitions of 'one event' and it should describe how to regard intensity. The complexity of the DoI assessment varies among the pressure types. In the following paragraphs more information is provided for the assessment if DoI of pathways with five relatively complex pressure types.
DoI is determined by the pressure type and the sensitivity of the species. DoI is treated independently of frequency and extent so the DoI score should reflect the potential impact. The extent and frequency will account for whether it is actually likely that an impact occurs. The region does not play an important role as far as the same or comparable species are found in different regions (see **Error! eference source not found.**, Figure 3 and section Final results).
For many pressure types there is limited information in the literature about the sensitivity of species to those pressures. Therefore expert judgement plays a major role in the DoI assessment and was found to be difficult to reconcile as the interpretation of DoI strongly depends on the pressure type. For 4 pressures differences in DoI among the ecological characteristics are found, namely for barrier to species movement, death or injury by collision, introduction of microbial pathogens, substrate loss. Also the DoI of the pressures barrier to species movement and death or injury by collision were not consistent in the preliminary assessment. These are further discussed below. The variation in DoI among ecological characteristics is low (see Figure 4 and section Final results).

Introduction of microbial pathogens

Aquaculture is the most profound anthropogenic influence causing the introduction of microbial pathogens [20]. Other anthropogenic factors are: ballast water in ships, movement of bait by anglers and unintentional movement in other biotic or abiotic vectors, and offshore oil and gas industry through the movement of e.g. drilling rigs [20].
For introduction of microbial pathogens the preliminary assessment scored acute and low DoI on fish (both demersal and pelagic) depending on the activity, where shipping and aquaculture were assessed as causing an acute DoI. These activities are known to discharge microbes to the environment at relatively high concentrations and an impact may be caused by one event. Severe acute effects on demersal and pelagic fish could be possible in worst case situations. Disease can impact directly on wild populations and the ecosystem by changing host abundance and predator/prey populations, reducing genetic diversity and causing local extinctions [20]. There is however limited evidence of impacts on wild populations of fish (e.g. [21, 22]). After further discussions it was suggested that microbial introductions do not cause instantaneous mortality, as was initially assessed. Concentrations of microbes "build-up" resulting in mortality once a certain threshold is reached. This was therefore changed to a chronic DoI for all activities and not low or acute as initially assessed. This DoI applies to all activities, independent on the level of microbes. Intensity may be relevant to consider for this type of pressure, but intensity is not considered in the ODEMM approach.
The DoI on marine mammals and sea birds is estimated to be low. Emerging infectious diseases have been reported in several cetacean species and populations worldwide provoking large-scale die-offs, affecting reproduction and causing disfiguring skin diseases [23]. For instance there is evidence of increased infections of marine mammals in waters harbouring intense shrimp farming [23]. Anthropogenic environmental changes (biological and chemical pollution, climate change, fisheries, noise and heavy boat traffic) may increase the prevalence and severity of infectious illnesses in dolphins, porpoises and whales worldwide. A high prevalence of traumatic injuries, even minor skin lacerations by fisheries interactions and by collisions with vessels, combined with a compromised immune system create chances for opportunistic pathogens [23]. These are, however, indirect effects and thus the direct impact is assumed to be low.
It was decided to score the DoI on demersal and pelagic fish as chronic for all relevant activities releasing microbial pathogens. The confidence of this assessment is low.

Introduction of non-indigenous species

In the preliminary assessment a chronic DoI for fish was scored for aquaculture, fishing and shipping and a low DoI for all other activities. In the consistency check it was proposed to score a chronic DoI for all activities because a sufficient number of NIS are required to cause a problem. Chronic is a continuum between low and acute - the severity of the impact is then dictated by the 'intensity' or

number of individuals introduced but intensity is not dealt with in ODEMM. If mortality is instant, then DoI is acute, if mortality will never occur then DoI is low if neither of these applies then DoI is chronic. The experts agreed to change the DoI scores for fish to chronic for all activities.
According to Ramirez-Llodra et al (2011) [24] introduction of exotic species is possible and once established they can change the structure and function of deep sea communities. Aquaculture, shipping and benthic and pelagic trawling are recognised by OSPAR as vectors for initial introduction of non-indigenous species. In case of species establishment this could lead to severe chronic effects on demersal and pelagic fish. Aquaculture is seen as the most important vector followed by shipping [25]. Due to the variation in characteristics of the invasive species and environment being invaded the probability and severity of effects is difficult to predict. The confidence is therefore low.

Marine litter
The sectors fishing (especially ghost nets), shipping, tourism and land based industry are the main sources of marine litter [26]. The preliminary assessment produced all possible outcomes for the DoI of marine litter on all ecological characteristics, depending on the activities. This was based on the intensity of the litter production. The activities with a low intensity were assigned a low DoI, whereas the ones with a high intensity were assigned a chronic DoI. An acute DoI was expected from fishing through the so-called ghost nets. Further discussion among the experts resulted in the scoring of all fishing to be acute while the other activities give low scores for DoI because it is not expected that any type of litter causes mortality. However the possible effects of the “plastic soup” on marine organisms is not completely clarified yet and will be subject of study in the future. Available information found in the literature shows that:. Many species of demersal and pelagic fish were reported to ingest marine debris [27]. Studies in the deep sea are practically non-existent and an urgent assessment of the impact of micro-plastics on deep sea fauna is needed [24].
At least 32 species of cetaceans (43% of existing species worldwide) and all species of marine turtles were reported to ingest marine debris [27]. Rijnsdorp & Heessen [28] observed a considerable impact of litter produced by shipping on sea turtles.
More than 111 species of seabirds (or approximately 36% of the world’s seabird species) have been reported to ingest marine debris [27]. More than 90% of Northern Fulmars found dead on the Dutch coast have plastics in their stomach and there are no signs of reduction of the plastic in the stomachs [29].

Selective extraction of species
The preliminary assessment yielded acute and low DoI on all ecological characteristics, depending on the activities. This outcome was discussed because either species are removed or not therefore either an acute or no impact applies. Population-level impacts are possible for all activities and the likeliness of an impact to occur depends on the level of exposure that is determined by extent, frequency and intensity of the pressure caused by the activity. However intensity assessment is not part of ODEMM. The experts agreed that an acute DoI should be connected to all activities with possible acute impacts on individuals irrespective of the level of this impact. Available information found in literature is reported below:
There is substantial sensitivity of all types of fish (mortal effects) to fishing [28]. Deep sea trawling has had an impact on fish populations down to 3100 m as well as by-catch species [24]. Overfishing issues are particularly important for deep sea fish species which are often long lived with slow growth and delayed maturity making them poorly adapted to sustain heavy fishing pressure. The deep-sea gillnet fishery in the NEA occurs between 200 and 1800 m and these depths can have severe effects on certain stocks [30]. Many activities do not occur in the deep sea and therefore deep sea fish are not exposed to the concomitant pressures. However if exposed the degree of impact is acute. Demersal fish have a higher sensitivity index for aggregate extraction compared to benthopelagic fish [31]. The highest sensitivity occurs in coastal regions and where nursery and spawning areas of important commercial species occur [31]. Plaice and skate are the two fish species most adversely affected by dredging activity [32]. Many demersal fish species may be affected indirectly through the removal of benthos which is an important source of food [33]. At the present scale of dredging activity, there is no evidence of any licensed activity known to have a substantial impact on fish [33] but as this is scale-dependent an increase of activities may cause severe (chronic) impact . However, since this is an indirect effect it is not further considered in this assessment. Pelagic trawling is primarily used to exploit pelagic fish resources. However, as some species are known to have seasonal and diurnal vertical migrations they may be impacted by both pelagic and bottom trawls.
There is no direct effect of benthic trawling on marine mammals and turtles on the high seas according to Rijnsdorp & Heessen [28]. However by-catch in coastal seas is not negligible and can have an acute or low impact. Direct mortal effects of pelagic trawling on marine mammals and turtles is possible but negligible [28]. We assume that sensitivity for by-catch is low in coastal seas. Sea turtles are considered to be sensitive to gillnets, purse seine and longlines on high seas according to

Rijnsdorp & Heessen [28]. Some marine mammal species are also sensitive and by catch of harbour porpoise in gill nets is seen as a problem that needs to be solved.
Mortality of diving bird species through by-catch occurs and can be classified as an acute DoI. Gillnets and especially longline fisheries are a threat to offshore birds [34-36]. Effects of fishery through depletion of prey were observed for inshore and offshore bird species [35]. A specific example of this is the sandeel fishery [37]. However these are indirect effects and therefore not included in this assessment.

Substrate loss
In the preliminary assessment the DoI of substrate loss was assumed to be low for all relevant activities on fish. However after consultation this was modified as this pressure causes "habitat loss" which can have severe detrimental effects on deep sea fish, demersal fish and pelagic fish species [17, 18]. Specifically the loss of gravel beds which are spawning grounds for herring can affect the recruitment of the species. There is always some degree of mortality i.e. the carrying capacity of the region is reduced, immediately or certainly very shortly after the habitat is lost. Therefore the DoI on fish can be regarded as acute. The experts agreed in the preliminary assessment and the consistency check that the DoI of substrate loss on marine mammals and sea birds is low for all activities.

Barrier to species movement
Barrier to species movement caused by (hydro)power station operations can lead to different DoI, depending on the pathway, the activity and the ecological characteristic. An acute DoI was estimated for marine mammals exposed to (hydro)power station operations, whereas a chronic DoI was expected for demersal and pelagic fish and a low DoI for sea birds. In the case of other activities only chronic and low DoI were expected. The presence of (hydro)power stations can act as a physical barrier to sea mammals migrating between the sea and the river. This does apply to part of the marine mammals, namely harbour porpoise, dolphin, common seal. The different DoI score for marine mammals on the one hand and migratory demersal and pelagic fish on the other hand is questionable. The confidence in the assessment is low for these impact chains.

Death or injury by collision
Death or injury by collision was estimated as low for most pressure pathways. An acute DoI was only expected in the case of shipping, trawling, military and tourisms/recreation (boating) in combination with marine mammals and in the cases of wind farm operations and oil and gas operations in connection with sea birds. There is evidence from literature that injuries and mortalities and hence acute effects occurred through this pressure [38-43].
The confidence of the DoI assessment is low for the majority of the pathways. This is due to a lack of data and uncertainty in the assumptions of the experts.

2.2.2.4 Extent of overlap

Total spatial extent of each pressure exerted by those sectors was described using 1 of 6 possible categories (Figure 1b):

- Site (S);
- Locally patchy (LP);)
- Locally even (LE);
- Widespread patchy (WP);
- Widespread even (WE); or
- No Overlap in space and/or time (NO).

The regional teams have collected a lot of information in the distribution of the sectors/human activities and ecological characteristics on sea for the pressure assessment on habitats (see ODEMM Deliverable 1 [44]). This information was used for this assessment involving the other ecological characteristics and complemented with regional expertise and additional literature [25, 40, 45-47].
The extent of overlap between a sector/pressure and an ecological characteristic was assessed by the regional teams. As, at best, only information on the sector and/or the ecological characteristic is available this was done in two steps: (1) is the footprint of the pressure equal to that of the sector and (2) what is the overlap between the pressure and the ecological characteristic.
For the first step two categories of pressures are discriminated: ‘Non-dispersive pressure footprints’ which are equal to the size of the sector activity; and ‘Dispersive pressure footprints’ which are larger than the activity and thus harder to assess. Subsequently it is checked if the assessment was scored consistently for a particular pressure within a sector. A complicating factor for this was that there are

three factors determining the extent of overlap: sector; pressure; and ecological characteristic. Seven of the 24 pressure types can be seen as non-dispersive comprising: abrasion, barrier to species movement, death or injury by collision, electromagnetic changes, selective extraction of non-living resources and selective extraction of species.
Most pressure types can disperse to an unknown extent into parts of the water column or sediment beyond where the activity actually takes place. Another complication is that the environmental behaviour and therefore the dispersal of the pressures (e.g. chemical compounds, radionuclides, litter, silt, temperature) can be affected by several factors like bathymetry, water flow, temperature. In the validation of extent, scores were compared by analysing the variation across ecological characteristics and regions. The preliminary assessment revealed that there were many differences in extent scores between regions, including the majority of sectors and pressure types and all ecological characteristics. The regional teams reviewed the issues raised in the consistency check. The issues comprised proposed adjusted extent scores as well as requested information to decide on the appropriate extent scores. It is not feasible to provide a complete overview of all issues and discussions. This information is included in a number of excel files and stored by the work package leader (IMARES).
The most complicated pressure pathways for the assessment of extent were the following pressure: introduction of synthetic compounds, introduction of non-synthetic compounds, changes in siltation, input of organic matter, introduction of microbial pathogens, marine litter and underwater noise. The most complicated activities were aquaculture, (hydro) power station operations, infrastructure operations, tourism, fishing (benthic and pelagic trawling). This was based on the number of issues that was raised and discussed in the preliminary assessment, consistency check and final assessment. In general the knowledge about the distribution of the ecological characteristics is sufficient.
The issues were discussed in the workshop held in Edinburgh and followed by a re-assessment of the pathways suspected to be misinterpreted. It appeared that misinterpretation occurred relatively often. In most of those cases this led to an overestimation of the extent of overlap. These overestimations were found most often for some pressure pathways, most dispersive pressure types, including introduction of synthetic compounds, introduction of non-synthetic compounds, changes in siltation. So it can be concluded that the assessment of extent is complicated and should be discussed thoroughly with several experts. After elimination of the misinterpreted scores in the reassessment a considerable variation in extent overlap among the regions remains. This can be attributed to real differences in the extent of sectors and pressures among the 4 regional seas. Overall MED and NEA appear to have more high extent scores than BALTIC and BLACK, see Figure 3.
It is obvious that there is a high level of divergence in extent scores both between sectors and pressures. Variation among ecological characteristics indicates that most overlap occurs for demersal fish, followed in descending order by pelagic fish, marine mammals, seabirds and deep sea fish (see Figure 4).
After the consistency check and the discussion among the experts the extent score was given for with high confidence for most of the assessed pathways.

2.2.2.5 Frequency of occurrence

The frequency of occurrence was classified as either:

- Rare (R);
- Occasional (O);
- Common (C); or
- Persistent (P)

For each impact chain the frequency of occurrence is assessed together with the extent of overlap. Often the same literature was used for frequency and extent assessments. The consistency check revealed less misinterpretation of the frequency compared to the extent of overlap. There is considerable variation in frequency among sectors and among regions. This is mainly caused by differences in intensity of the sectors/activities, often being higher on the NEA, MEDITERRANEAN and BALTIC as compared to the BLACK, see Figure 3. In general, demersal and pelagic fish show higher frequency scores than marine mammals and seabirds, see Figure 4.

2.2.2.6 Summary

The conclusions from the preliminary assessment and the consistency check are summarised in Table 5. Most difficult steps in the assessment were the DoI and extent, which is reflected by the medium and low consistency of the preliminary results. This received much attention to eliminate misinterpretation.

Table 5. Overview of experience from the pressure assessment process (optional)

PA component	Availability information	Consistency preliminary results	Confidence
Resilience	Medium	High	Medium
Persistence	Medium	High	Mainly high
DoI	Medium	Medium	Mainly low
Extent	Medium	Low	Mainly high
Frequency	Medium	High	Mainly high

2.2.3 Final results

This report describes the main results of the pressure assessment. The complete assessment is available in an excel file [48] and included in Annex VI of this report. The generic sensitivity of an ecological characteristic to any sector/pressure combination (i.e. likely degree of impact and resilience) and the likely persistence of the pressure in the environment are also provided as background tables (Annexes III, IV and V).

A summary of the final results of the Pressure Assessment is presented in **Error! Reference source ot found.**. In total, 4860 potential driver-pressure-ecological characteristic combinations were assessed. The actual number of combinations where overlap between the pressure and ecological characteristic occurs is 2092 for all regions together. Most combinations (707) occur in the NEA, followed by the Baltic (559), the Mediterranean (446) and the Black Sea (380). Some sectors do not operate in all EU regions. The Baltic region has the largest numbers of sectors (26), whereas only 21 sectors are active in the Black Sea (see Figure 3).

The extent of overlap between pressures and ecological characteristics is mostly Site (47%) or Locally Patchy (39%). There are very few combinations that are Locally Even or Widespread Even (2% and 0 %, respectively). For the NEA and Mediterranean most extent scores are LP, whereas for the Baltic and Black Sea most extent scores are Site. The Mediterranean has relatively more WP scores compared to the other regions. There are no other major differences in extent of overlap between EU regions.
Overall for the 4 regions, the relative occurrence of the four frequency scores (Rare, Occasional, Common, Permanent) are comparable. However there are big differences between the four regions. The NEA has the most pathways with higher frequency scores (Permanent plus Common) and the Baltic Sea and the Black Sea have more pathways with low frequency (Rare plus Occasional).
Half the number of the total number of assessed pathways contains a pressure with a low persistence. Continuous or medium persistence is found in low, whereas an important part concerns high persistence. The variation among the 4 regions is small.
The degree of impact is low in the majority (53%) of the pathways. An acute DoI is assessed in a small part (13%) and chronic DoI takes the intermediate position (34%). There is relatively little variation among the four regions.
The resilience is low for each ecological characteristic in each region, except for one combination, namely demersal fish in the Black Sea.
In general there is very little variation among the ecological characteristics in the case of each of the 5 pressure assessment steps (Figure 4).
The distribution of the results of each assessment step for the pressure types are shown in Figure 5. It is clear that the pressure types differ in their contribution to the number as well as scores of each assessment step. The same applies to the sectors (also shown in this Figure).

Table 6. Pressure Assessment Summary

EU Region	Pressure Assessment Summary	Extent of Overlap	Frequency of Occurrence	Degree of Impact	Resilience (Recovery Time)	Persistence of Pressure
Baltic	559 Pressure Combinations (actual) of the 1080 (potential) evaluated	S (58%)	R (44%)	A (11%)	FDS (L)	L (55%)
	Sectors – 26;	LP (31%)	O (19%)	C (31%)	FDEM (L)	M (6%)
	Pressure Types - 21	LE (0%)	C (6%)	L (58%)	FPEL (L)	H (34%)
		WP (11%)	P (31%)		MAMMS (L)	C (5%)
		WE (0%)			BIRDS (L)	
Black	380 Pressure Combinations (actual) of the 1080 (potential) evaluated	S (63%)	R (41%)	A (14%)	FDS (L)	L (43%)
	Sectors – 21;	LP (25%)	O (37%)	C (38%)	FDEM (M)	M (8%)
	Pressure Types - 20	LE (4%)	C (7%)	L (48%)	FPEL (L)	H (41%)
		WP (6%)	P (15%)		MAMMS (L)	C (7%)
		WE (1%)			BIRDS (L)	
Med	446 Pressure Combinations (actual) of the 1350 (potential) evaluated	S (32%)	R (16%)	A (15%)	FDS (L)	L (46%)
	Sectors -23;	LP (44%)	O (20%)	C (37%)	FDEM (L)	M (4%)
	Pressure Types - 20	LE (0%)	C (40%)	L (49%)	FPEL (L)	H (45%)
		WP (24%)	P (24%)		MAMMS (L)	C (5%)
		WE (0%)			BIRDS (L)	
NEA	707 Pressure Combinations (actual) of the 1350 (potential) evaluated	S (39%)	R (11%)	A (12%)	FDS (L)	L (52%)
	Sectors - 25;	LP (48%)	O (27%)	C (32%)	FDEM (L)	M (7%)
	Pressure Types - 21	LE (2%)	C (33%)	L (56%)	FPEL (L)	H (31%)
		WP (10%)	P (29%)		MAMMS (L)	C (10%)
		WE (0%)			BIRDS (L)	
All regions	2081 Pressure Combinations (actual) of the 4860 (potential) evaluated	S (47%)	R (26%)	A (13%)	FDS (L)	L (50%)

Sectors – 27;	LP (39%)	O (25%)	C (34 %)	FDEM (L to M)	M (6%)
Pressure Types - 22	LE (2%)	C (23%)	L (53%)	FPEL (L)	H (37%)
	WP (12%)	P (26%)		MAMMS (L)	C (7%)
	WE (0%)			BIRDS (L)	

EU Regions: Baltic Sea (Baltic); Black Sea (Black); Mediterranean Sea (Med); Northeast Atlantic Ocean (NEA)

Extent of Overlap: S (Site); LP (Locally Patchy); LE (Locally Even); WP (Widespread Patchy); WE (Widespread Even)

Frequency of Occurrence: R (Rare); O (Occasional); C (Common); P (Persistent)

Degree of Impact: A (Acute); C (Chronic); L (Low)

Resilience: L (Low); M (Medium)

Persistence of Pressure: L (Low); M (Medium); H (High); C (Continuous)

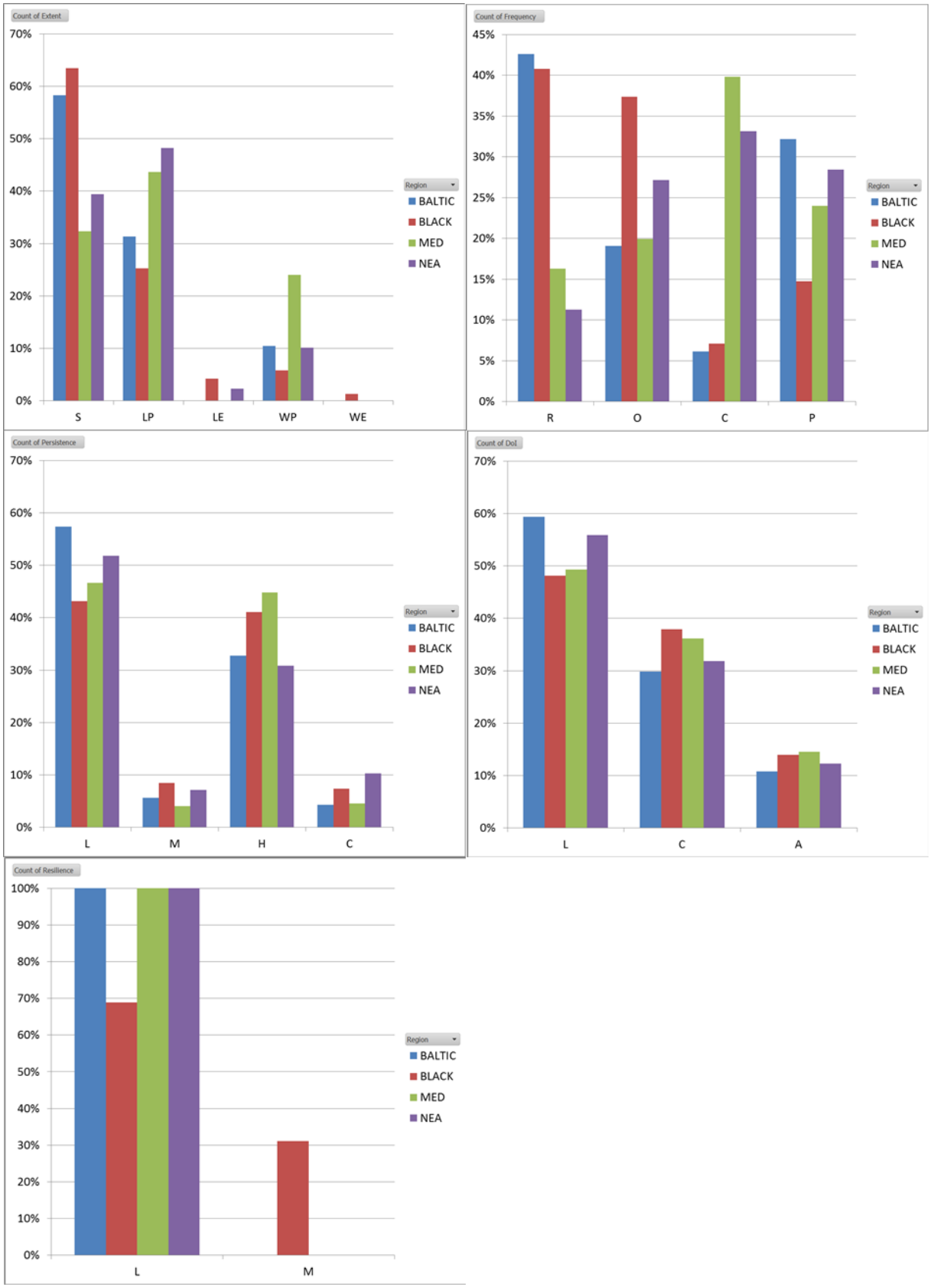

Figure 3. Pressure Assessment results (extent, frequency, pressure persistence, degree of impact, resilience), showing the regional differences

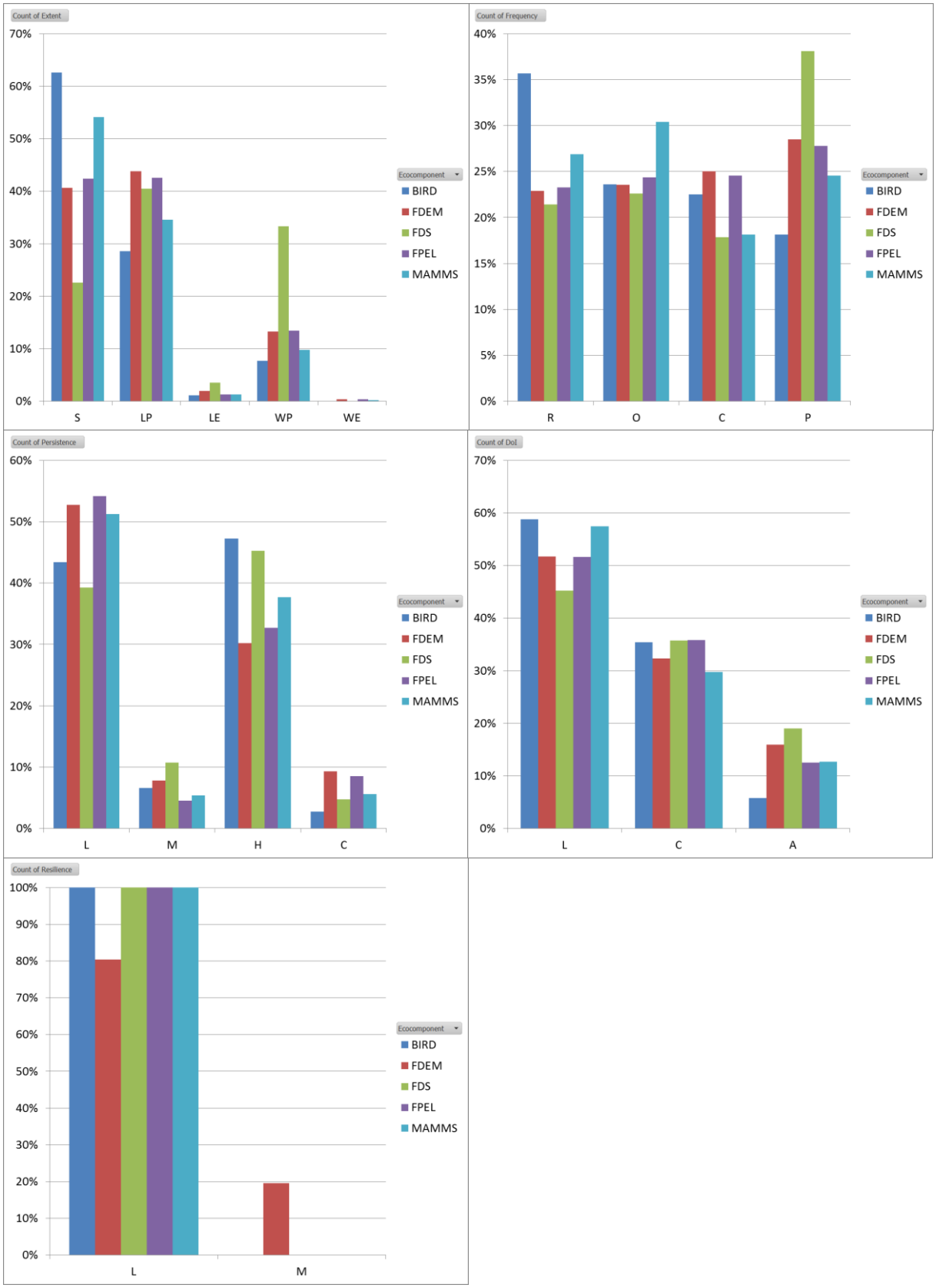

Figure 4. Pressure Assessment results (extent, frequency, pressure persistence, degree of impact, resilience), showing the differences per ecosystem component

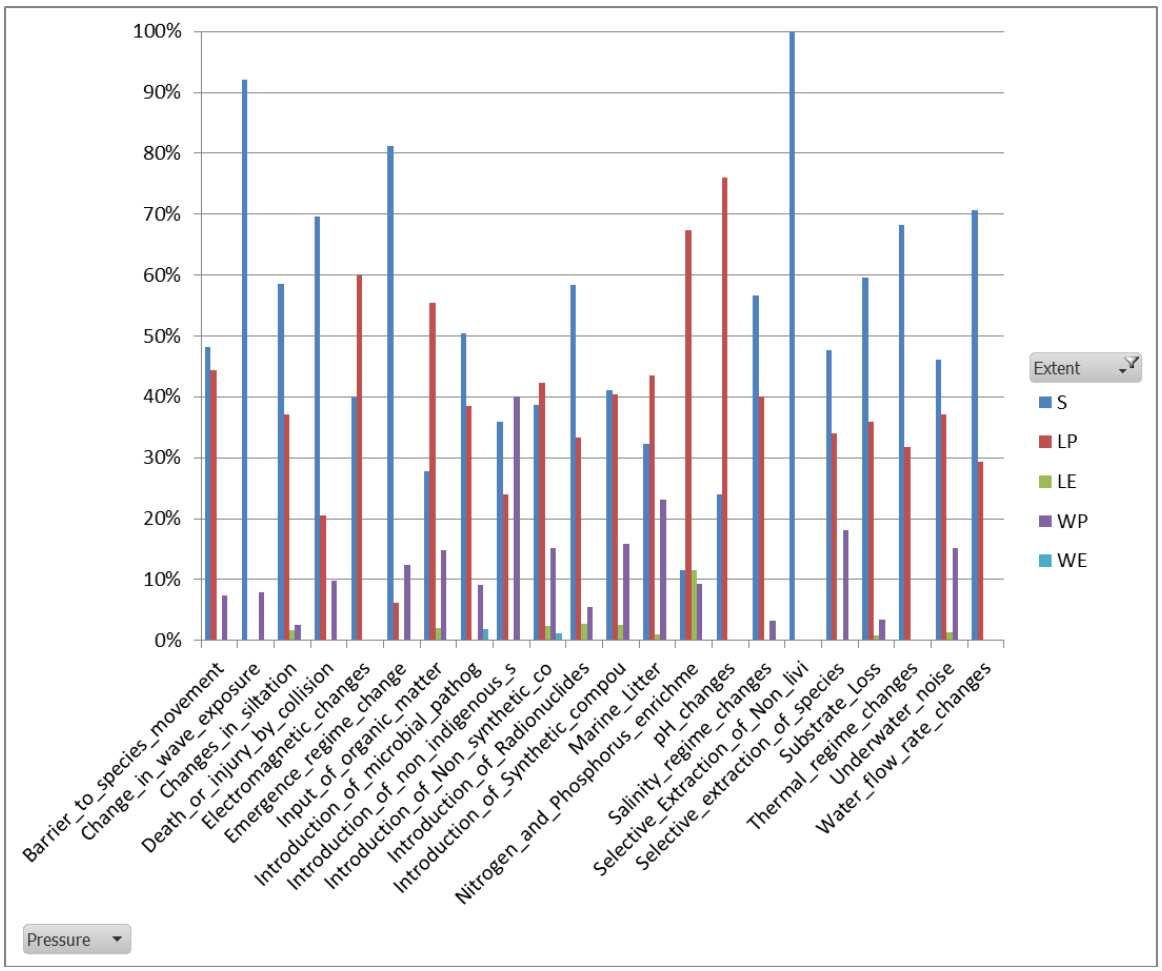

Figure 5. Extent of pressures

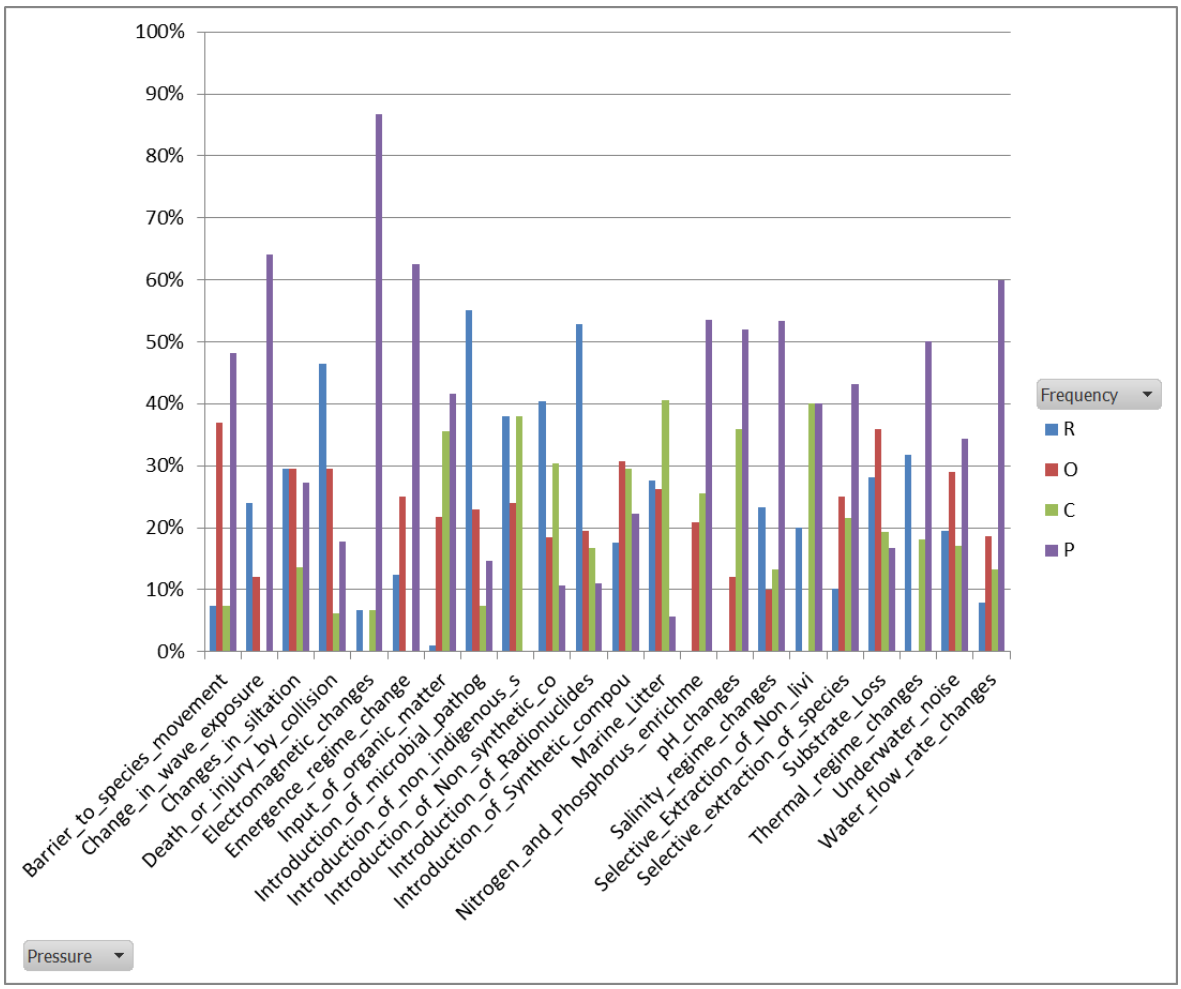

Figure 6. Frequency of pressures

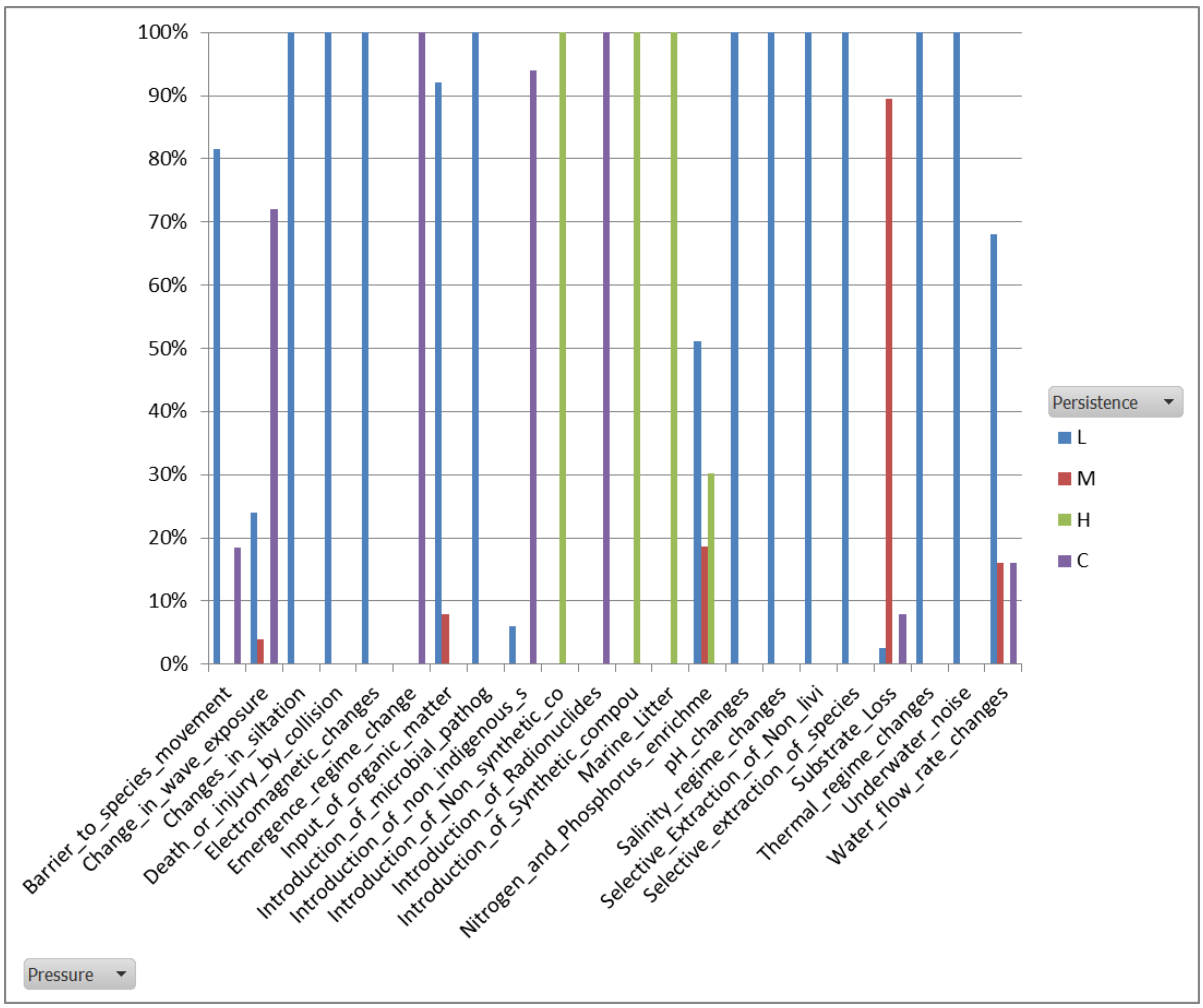

Figure 7. Persistence of pressures

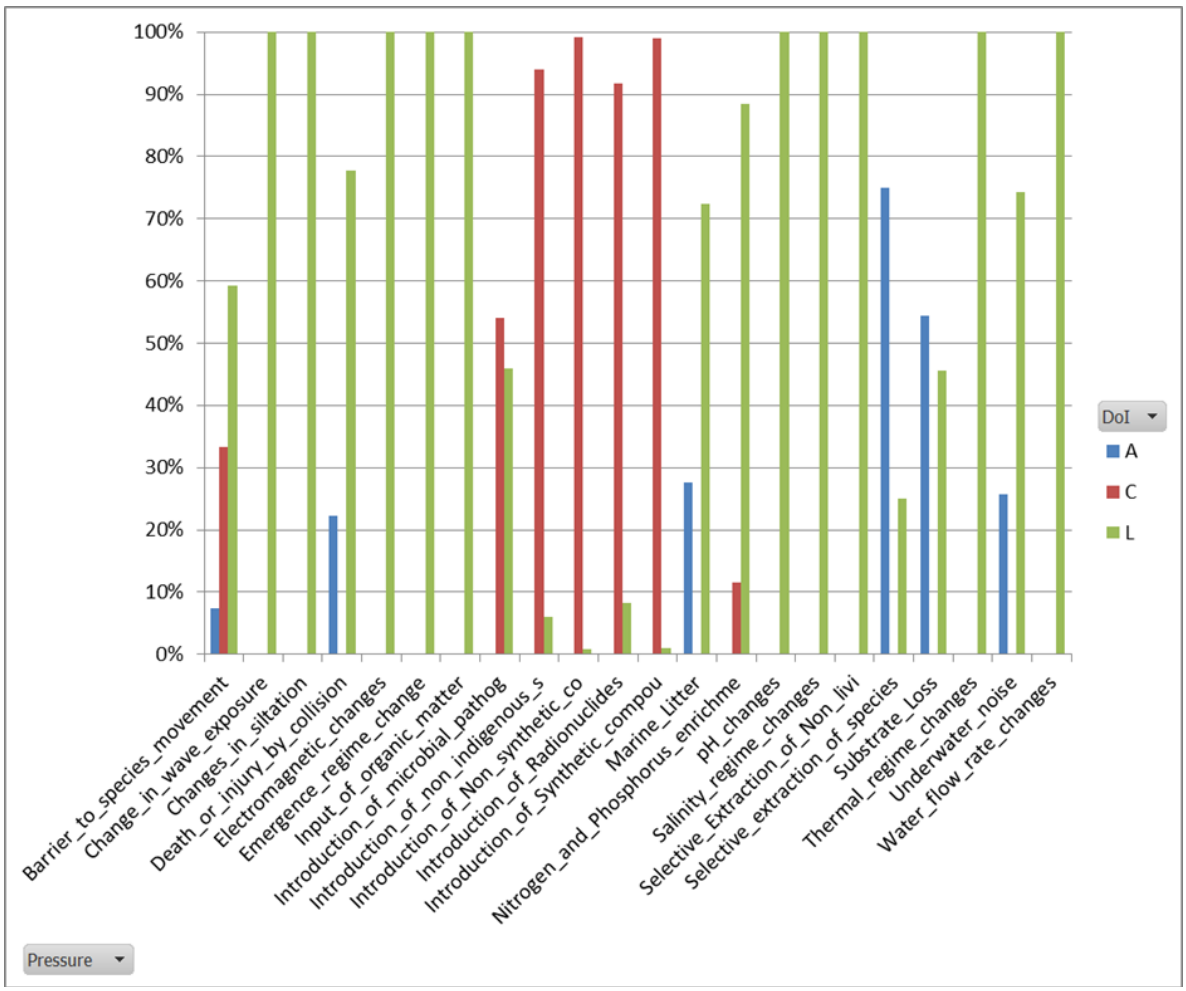

Figure 8. DoI of pressures

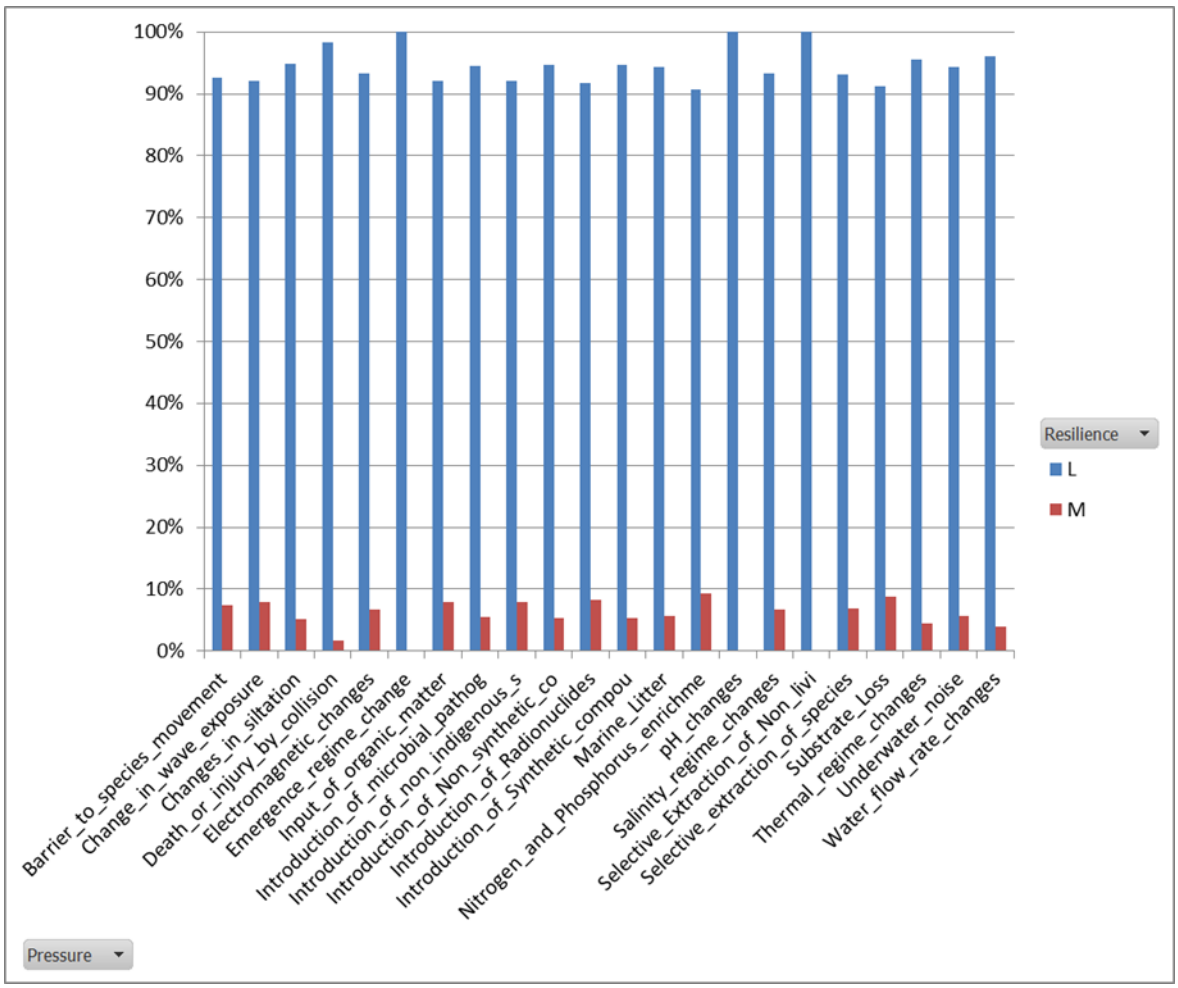

Figure 9. Resilience of ecological characteristics per pressure type

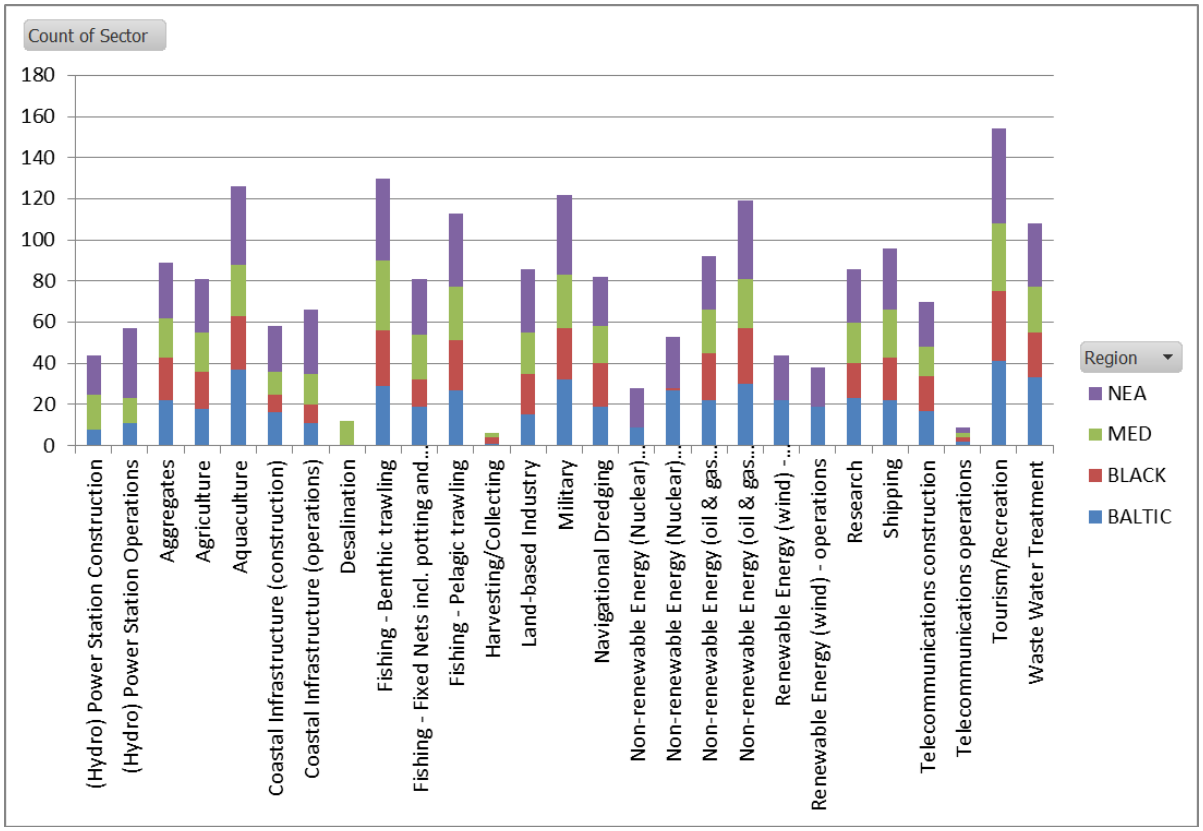

Figure 10. Number of pressure pathways per sector

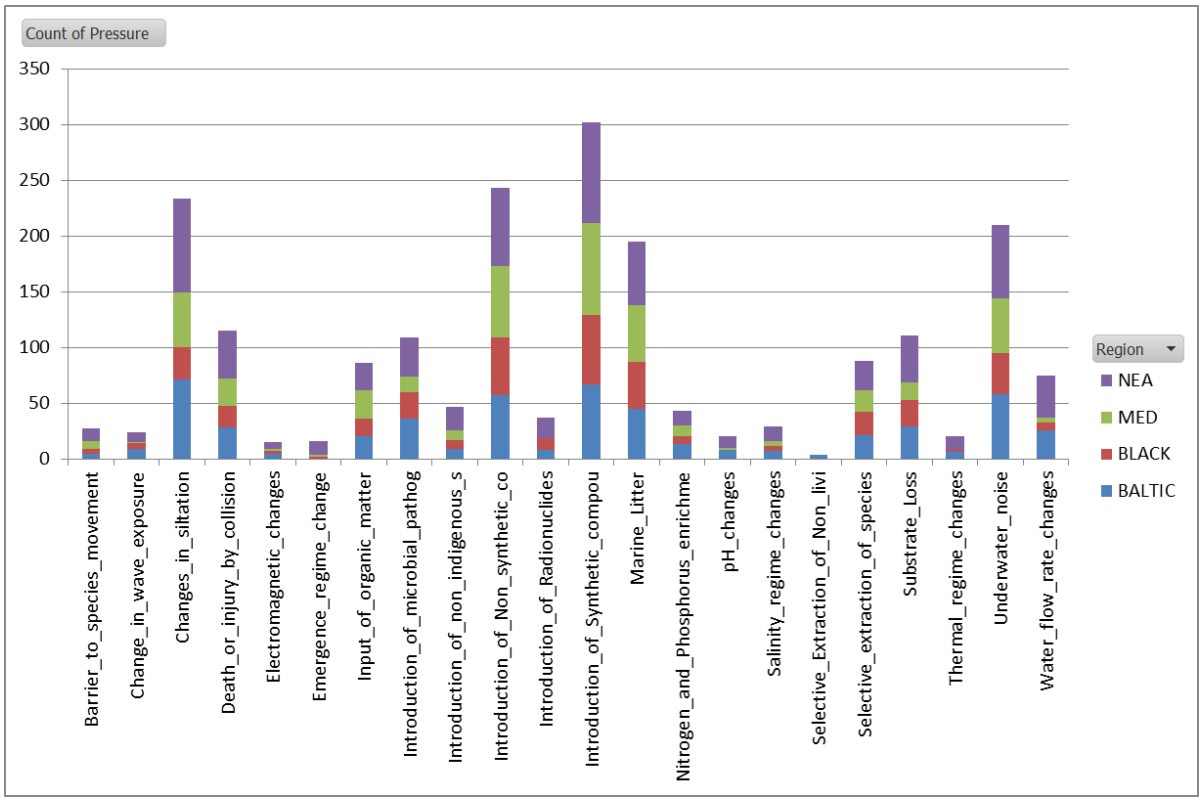

Figure 11. Number of pressure pathways per pressure type

2.3 Discussion and conclusion

When applying the methodology one issue emerged that needs consideration in any future assessments: the scoring of DoI. For this we recommend that for an acute score of DoI the impact on the individual level versus impact at the population level should be distinguished. In the present guidance document a "high proportion of individuals" is described. Depending on life-history characteristics an impact on a high proportion of individuals may or may not have an impact at the population level.

Also it should be noted that in the present guidance document the intensity of a pressure is not explicitly considered but is implicit in DoI score. This may be (partly) addressed through a proper definition of 'one event' per sector and/or sector–pressure combination, indicating at least the time scale and the spatial scale but possibly also some measure of intensity.

The DoI is based on the complete impact chain. If adjustments in the assessment are needed every impact chain has to be assessed separately. This has two disadvantages. The process is very time consuming and there is a higher chance of inconsistency.

Another issue is that scores of the different aspects that determine risk (e.g. extent, DoI) may be inter-related in the integrated assessment. One example follows from the lack of threshold values (lower limit) of the level of a pressure that causes an impact (reflected in the DoI) but also affects the scoring of the extent of overlap between the pressure and the ecological characteristic. An example of this are effects of pollution through chemical substances. The impact on a species depends on the concentration of the chemical substance and ideally the dose–response curve of the substance is known. Subsequently the lowest effect concentration (LOEC) or highest no effect concentration (NOEC) can be determined. These values can serve as threshold values for the exposure and therefore the extent of overlap. The concentrations below the LOEC or NOEC should be excluded in the determination of the extent of overlap. This problem also applies to other pressures like underwater noise or siltation. It should be noted that the sensitivity differs among ecological characteristics and therefore the LOEC or NOEC and thus extent may also differ. If available such thresholds should be provided and considered in relation to the definition of "event". One possible approach is to relate the intensity of the pressure to the sensitivity of an ecological characteristic by

application of the species sensitivity distribution [49]. A species sensitivity distribution (SSD) is a frequency distribution of No Effect Concentrations (NOEC) values for species within an ecosystem. Smit et al. (2008) and De Vries et al. (2008) [50, 51] determined the SSD for a number of pressure types which are also relevant for ODEMM, like siltation, sediment coverage (abrasion), and temperature. The advantage is that intensity can be included improving the quality of the impact estimation for the regional sea. The disadvantage is that much additional information is required that may not always be sufficiently available.

3 Indicators

Indicators are required within ODEMM WP4 to describe the status of the marine ecosystem components but also the drivers and pressures that are part of the impact chains (see chapter 2). These indicators also determine the requirements of any monitoring programme that may become part of the ODEMM management strategies.
To that end we compiled a database of potential regional indicators for the MSFD Descriptors, criteria and indicators as specified in MSFD [1]. This was based on the completed or often still on-going work in the member states covered by experts within the ODEMM project. Where possible we tried to link these indicators to the drivers/pressures that are part of the impact chains. Based on these links the indicators database is set up such that it can be merged with the database of impact chains developed as part of the IA.

3.1 Database

Within ODEMM task 4.2 a database of potential indicators was created. The database is based on the eleven MSFD descriptors and corresponding attributes and indicators as phrased in the Commission Decision (Annex 1) [52]. Often these indicators are not sufficiently developed to make them operational. For example, the indicator “distributional range” does not give any information on how distributional range can be determined and to which species it should apply. Using regional experts, the aim of this task was to obtain a database consisting of potential indicators for the different MSFD descriptors/attributes that can be applied in the different regions including some indication of their operational status

The regional experts have submitted a dataset for their region consisting of potential indicators for the MSFD indicators as phrased in the Commission Decision. For each potential indicator it is specified as clearly as possible what is measured and how it can be calculated, which ecosystem component(s) (

Table 3) it applies to, whether it applies to national, regional or European level, and its operational status (Table 7). The latter provides insight on how advanced an indicator is. The information collected from the different partners has been collated into one database of potential indicators (see Annex 8).

Table 7. Overview of the different options and corresponding definition that could be selected for the operational status of the potential indicators (Based on HELCOM).

Operational status	Definition
0	Clear gap, no suggested indicator
1	Indicator needs to be developed, operational* by 2018
2	No data, operational* by 2014 when MSFD monitoring starts
3	Data available now (2012) but no reference level**
4	Operational * now (2012)

* Operational: indicator + reference level**

** Reference level: science-based information that allows the setting of a target: This may be based on values reflecting (i) pristine condition, (ii) conditions under sustainable exploitation, (iii) start of time series, (iv) some other period

The next step was to ascertain whether all pathways defined in task 4.1 are also covered by the database of potential indicators. Therefore, it was assessed whether the key pressures used in the pressure assessment could be linked to the MSFD descriptors that have been used to set up the indicator database. Table 8 shows that all key pressures can be linked to a MSFD descriptor. In other words, the indicator database covers all key pressures that were identified in task 4.1.

Table 8. Overview of key pressures from the pressure assessment (task 4.1) and their direct linkage with MSFD descriptors

Key pressure (as defined in task 4.1)	Direct linkage MSFD descriptor
Abrasion	6 – Seafloor integrity
Barrier to species movement	1 – Biological diversity
Change in wave exposure	7 – Hydrographic conditions
Changes in siltation	7 – Hydrographic conditions
Death or injury by collision	3 – Commercial fish and shellfish
Electromagnetic changes	11 – Introduction of energy
Emergence regime change	7 – Hydrographic conditions
Input organic matter	5 – Eutrophication
Introduction of microbial pathogens	2 – Non indigenous species
Introduction of NIS	2 – Non indigenous species
Introduction of non-synthetic compounds	5 – Eutrophication
Introduction of radionuclides	8 – Contaminants
Introduction of synthetic compounds	8 – Contaminants
Marine litter	10 – Marine litter
Nitrogen and phosphorus enrichment	5 – Eutrophication
pH changes	7 – Hydrographic conditions
Salinity regime changes	7 – Hydrographic conditions
Selective extraction of non-living material	6 – Seafloor integrity
Selective extraction of species	3 – Commercial fish and shellfish
Smothering	6 – Seafloor integrity
Substrate loss	6 – Seafloor integrity
Thermal regime changes	7 – Hydrographic conditions
Underwater noise	11 – Introduction energy
Water flow rate changes	7 – Hydrographic conditions

The database shows that some potential indicators and/or their operational status are quite similar across regions, while others are not. For example, the proposed potential indicators for “population demographic characteristics” for the Baltic Sea (i.e. “blubber thickness of marine mammals” and “pregnancy rate of marine mammals”) differ from the proposed potential indicators for the North Sea (i.e. “grey seal pup production” and “harbour seal pup production”) (Table 9). For “size at first sexual maturation”, on the other hand, the different regions propose similar potential indicators (i.e. “probabilistic maturation reaction norm”) (Table 9) probably because this indicator is part of the Data Collection Framework (DCF). Furthermore, the database shows that the operational status of potential indicators may differ between regions. For example, the operational status of the potential indicator for “water transparency related to increase suspended algae, where relevant” for the Baltic Sea is higher than for other regions (Table 9). In other words, for this particular indicator the Baltic Sea is most advanced. Differences in potential indicators and/or their operational status between regions may be caused by (i) actual regional differences (e.g. choice of “keystone” species, availability of monitoring

programmes), (ii) the expertise of the partners that filled in the database (e.g. indicator was not considered in some regions, not aware of methodological progress) or (iii) mistakes (e.g. not appropriate for descriptor/criteria).

3.2 Extractions from the database

The database can be applied in order to extract selections of appropriate indicators from different perspectives:

1. Description of the status of operational objectives: which indicators are most appropriate to describe the status and progress towards achievement in relation to specific operational objectives (i.e. based on the MSFD descriptors and criteria)
2. As part of management strategies aimed toward achievement of operational objectives. This also involves a discussion of the consequences in terms of monitoring depending on the choice of management strategies. Which indicators need to be measured (as a minimum requirement) as part of the potential alternative management strategies toward achievement of a specific objective. These are the indicators relevant for the case studies (i.e. based on the descriptors foodweb and seafloor integrity) which will be applied elsewhere in WP4 as well as other ODEMM WP's.

3.2.1 Status of operational objectives

For each MSFD descriptor and its criteria (see Annex 1) we identified the indicators most appropriate in each of the MSFD regions. As this database is very extensive only an example of the potential indicators and their corresponding operational status is given in Table 9 for three criteria of respectively Descriptor 1 (1.3.1), Descriptor 3 (3.3.4) and Descriptor 5 (5.2.2).

Table 9. Some examples of potential indicators and corresponding operational status. For a full overview of the database see Annex 9

1.3.1 Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality)			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Marine mammals & Reptiles	Baltic Sea	Blubber thickness of marine mammals	3
	Baltic Sea	Pregnancy rate of marine mammals	3
	Black Sea	Seal populations	0
	Mediterranean	Seal populations	0
	Mediterranean	Turtles, dolphins	0
	North Sea	Annual calf production of Scottish east coast and Cardigan Bay area bottlenose dolphin populations	2
	North Sea	EcoQO seal populations	4
	North Sea	Grey seal pup production	4
	North Sea	Harbour seal pup production	2
3.3.4 Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Fish	Baltic	Probabilistic maturation reaction norm (i.e. the probability of maturing)	3
	Black Sea	Probabilistic maturation reaction norm (i.e. the probability of maturing)	0
	Mediterranean	Probabilistic maturation reaction norm (i.e. the probability of maturing)	0
	Mediterranean	N/A	0
	North Sea	Probabilistic maturation reaction norm (i.e. the probability of maturing)	3
5.2.2 Water transparency related to increase in suspended algae, where relevant			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Plankton	Baltic Sea	The summer-time water clarity measured as Secchi depth	4
	Black Sea	Coefficient of light attenuation	0 or 3
	Black Sea	Frequency of Noctiluca scintillans blooms	1 or 3
	Black Sea	Frequency of summer blooms of phytoplankton	1 or 3
	Mediterranean	N/A	0
	North Sea	N/A	

3.2.2 Case studies

Table 10 shows the indicators most relevant for the two case studies based on Descriptor 4 Foodweb and Descriptor 6 Seafloor integrity. Even though each Descriptor is only applied in some regions: Foodweb in the NEA, Baltic and Black Sea and Seafloor integrity in the NEA and Mediterranean we present the indicators proposed in all regions as an indicator proposed in one region may sometimes also be appropriate for another region. What the overview shows is that there are few indicators operational at present.

Table 10. Extraction of the potential indicators and corresponding operational status proposed for the different regions for MSFD descriptor "Food web"

4.1.1 Performance key predator species using their production per unit biomass (productivity)			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Fish	Baltic	N/A	0/1
	Black Sea	N/A	0
	Mediterranean	Abundance of key prey species	1
	Mediterranean	Abundance for few species	1
	North Sea	Abundance of sharks and rays, fish species with long negative trends and migrational species	1
Marine mammals & Reptiles	Baltic	Population growth rate	3
	Black Sea	Seal populations	0
	Mediterranean	Seal populations	0
	Mediterranean	N/A	0
	North Sea	EcoQO seal populations	4
	North Sea	Annual calf production of Scottish east coast and Cardigan Bay area bottlenose dolphin populations	2
	North Sea	Harbour seal pup production	2
	North Sea	Grey seal pup production	4
Seabirds	Baltic	Productivity	3
	Black Sea		
	Mediterranean		
	North Sea	Annual breeding success of kittiwakes (no. offspring per pair) at sampled colonies	2
4.2.1 Large fish (by weight)			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Fish	Baltic	Fish community trophic index	3
	Baltic	Proportion of piscivorous fish, non-piscivorous fish and cyprinids	3
	Baltic	Proportions of large fish	3
	Black Sea	N/A	2
	Black Sea	Proportion of large fish in the community	1
	Mediterranean	EcoQO proportion large fish	1
	Mediterranean	Proportions for a few species	1
	North Sea	EcoQO proportion large fish	4
	North Sea	Large fish indicator	2

Table 10. Continued

4.3.1 Abundance of functionally important selected groups/species			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Bottom fauna & flora	Baltic Sea		
	Black Sea	Morfofunctional index (index or relative macrophyte surface)	1
	Mediterranean		
	North Sea		
Fish	Baltic Sea		
	Black Sea		
	Mediterranean	Marine trophic index	1
	Mediterranean	N/A	1
	North Sea	Dietary functional group biomass	1
Habitat	Baltic Sea		
	Black Sea		
	Mediterranean		
	North Sea	Change of plankton functional types (life form) index	2
Marine mammals & Reptiles	Baltic Sea		
	Black Sea		
	Mediterranean	By-catch harbour porpoise	0
	Mediterranean	Seal populations	0
	North Sea	Abundance of harbour seals	4
	North Sea	Abundance of three inshore bottle nose dolphin populations	2
	North Sea	Abundance of harbour porpoises, white beaked dolphin, short beaked common dolphin, minke whale, bottle nose dolphin, long finned pilot whale	1
	North Sea	Relatively use of haulouts by grey and harbour seals	1
Plankton	Baltic Sea	Biomass of copepods, microphagous mesozooplankton	3
	Black Sea	Biomass of Menemiopsis leidyi (threshold defined)	4
	Black Sea	Biomass feeder zooplankton	1
	Mediterranean		
	North Sea		
Seabirds	Baltic		
	Black Sea		
	Mediterranean		
	North Sea	Species-specific trends in relative breeding annual abundance of breeding birds expressed as a percentage baseline	2
	North Sea	Species-specific trends in relative non-breeding annual abundance of breeding birds expressed as a percentage baseline	1

Table 11. Extraction of the potential indicators and corresponding operational status proposed for the different regions for MSFD descriptor "Seafloor integrity"

6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Habitat	Baltic	Blue mussel cover	3
	Black Sea	Abundance and extent	0
	Mediterranean	Abundance and extent	1
	North Sea	Area of sub tidal biogenic structures	2
	North Sea	Density of biogenic reef forming species	2
	North Sea	Surface area of seabed not impacted by human activity	1
6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Habitat	Baltic	Near bottom oxygen conditions	3
	Black Sea	Surface area of seabed not impacted by human activity last year	0
	Mediterranean	Surface area of seabed not impacted by human activity last year	1
	North Sea	Surface area of seabed not impacted by human activity last year	1
	North Sea	Impact/Vulnerability of habitat to 'Penetration and/or disturbance of the substrate below the surface of the seabed' (Physical damage)	2
	North Sea	Impact/Vulnerability of habitat to 'Penetration and/or disturbance of the substrate below the surface of the seabed' (Physical pressure)	2
	North Sea	Impact/Vulnerability of habitat to 'Shallow abrasion/penetration: damage to seabed surface and penetration' (Physical damage)	2
	North Sea	Impact/Vulnerability of habitat to 'Shallow abrasion/penetration: damage to seabed surface and penetration' (Physical pressure)	2
	North Sea	Impact/Vulnerability of habitat to 'Surface abrasion: damage to seabed surface features' (Physical damage)	2
	North Sea	Impact/Vulnerability of habitat to 'Surface abrasion: damage to seabed surface features' (Physical pressure)	2
6.2.1 Presence of particularly sensitive and/or tolerant species			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Bottom fauna & flora	Baltic	Lower depth distribution limit of macrophyte species	3
	Black Sea	Extent of vulnerable macrophyte species	1
	Mediterranean	Vulnerable benthos species	1
	North Sea	Abundance/biomass long-living & for bottom disturbance sensitive species and biogenic structures	1

Table 11. Continued

6.2.2 Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Bottom fauna & flora	Baltic	Average regional species richness	3
	Baltic	Multimetric macrozoobenthos indicators (BQI, MarBIT, DIK, BBI, ZKI, B)	3
	Baltic	Ratio perennial and annual macrophytes	3
	Black Sea	AMBI and M-AMBI index	1 (4 for WFD)
	Black Sea	BEQI	0
	Black Sea	Ecological Index (EI) for macrophyes	1 (4 for WFD)
	Black Sea	Shannon index for zoobenthos	1 or 3
	Mediterranean	Multidimensional biodiversity indices taking both incorporating species richness and evenness, e.g. Hill's indices	1
	North Sea	Diversity/richness long-living and for bottom disturbance sensitive species and biogenic structures	1
	North Sea	Condition long-living and for bottom disturbance sensitive species and biogenic structures	1
Habitat	Baltic		
	Black Sea		
	Mediterranean		
	North Sea	Change in plankton index: ratio between holoplankton & meroplankton	2
6.2.3 Proportion of biomass or number of individuals in the macrobenthos above some specified length/size			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Bottom fauna & flora	Baltic	N/A	0/1
	Black Sea	Length-frequency distribution bivalves	0
	Mediterranean	Length-frequency distribution bivalves	0
	Mediterranean	Length-frequency distribution decapod crustaceans & fish	0
	North Sea	Abundance/biomass long-living & for bottom disturbance sensitive species and biogenic structures	1
6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community			
Ecosystem component	**Region**	**Potential indicator**	**Operational status**
Bottom fauna & flora	Baltic	Size-distribution of long-lived macrozoobenthic species	3
	Black Sea		
	Mediterranean	N/A	0
	North Sea	N/A	0

3.3 Indicator requirements and selection

At present only few indicators are operational (see Table 12 and Figure 12) making the choice of which indicators to select a fairly straightforward exercise and it needs to be acknowledged that for several criteria of descriptors no indicators are available.
If reference levels or at least reference directions become available the scientific basis is established to set target levels and several more descriptors/criteria can be included in the assessment of ecosystem status as well as the pressures acting on it in relation to the operational objectives.
For those indicators for which no data are available new monitoring programmes need to be developed and implemented if it is desired to assess the (progress towards) achievement of the objectives. An overview of the type of information collected in various existing monitoring programmes is given in the report of WGECO [53]. Such an overview together with the indicators that require new monitoring programmes should be the basis to develop monitoring programmes that deliver the required information most efficient. As more indicators become operational (in some regions several are already proposed for the same criterion) the process of indicator selection becomes important. Possible criteria for indicator selection and an approach for their application are presented in chapter 3.3.3.

Table 12. Overview of number of proposed specific indicators with operational status 3 and 4 per region

Ecosystem components	Status 3	Status 4
Baltic Sea	56	8
Black Sea	40 (partly status 3: 5)	25 (partly status 4: 11)
Mediterranean Sea	7 (partly status 3: 5)	5 (partly status 4: 3)
North East Atlantic	7	32 (partly status 4: 4)

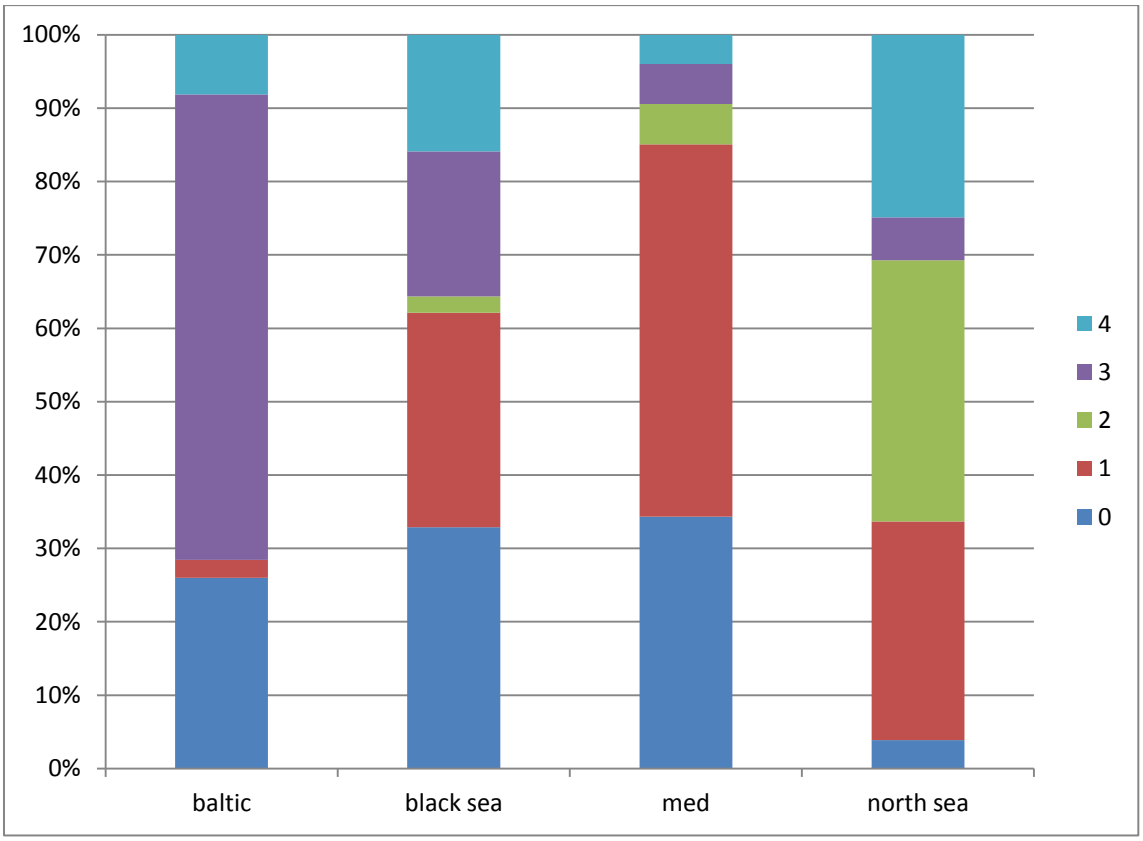

Figure 12. Operational status of indicators as percentages over the total amount of indicators per regional area. If more than one score for operational status was given we used the most conservative (i.e. 2-3 becomes 2)

3.3.1 Reference levels

For indicators to support management decision making, the relationship between the current value and/or trend of the indicator and the value and/or trend of the indicator associated with meeting the operational objective needs to be known. The value and/or trend associated with meeting the operational objective can be a limit or target reference point, trajectory or direction. When indicators are used to guide management of target fish stocks, there is a tradition of setting reference points. However, in other fields, a reference point may not be specified and a required trajectory or direction guides decision making. The difference between the value of, or trend in, an indicator and a reference point, trajectory or direction is a measure of the performance of management (e.g. Sainsbury et al. (2002) [54]). Achievement of the reference points, trajectories or directions for state will, by definition, mean that operational objectives are met.

3.3.2 Selection criteria

Ultimately, the database of potential indicators will help to determine a number of selection criteria to evaluate which indicators are most appropriate to assess the progress and track changes within the ecosystem. Kershner et al. (2011) [55] recommend a set of 19 criteria that can be used to evaluate the suitability of ecosystem indicators (Table 13). All indicators can be individually scored according to the scientific support that is available into three categories (i.e. criteria score):
1 = Indicators with peer-reviewed publications providing consistent and strong findings for its support
0.5 = Indicators with peer-reviewed documents or expert opinion providing limited support
0 = Indicators with no peer-reviewed evidence, evidence against, or conflicting support

Some criteria that have been defined by Kershner et al. (2011) [55] may be more important than others. Therefore, the criteria have been weighted according to their relative importance into five different categories (i.e. 1=essential; 0.75=important; 0.5=moderate; 0.25=slightly moderate; 0=negligible). As such a weighting exercise will depend on who will be using the indicators (e.g. public vs. scientists), two weighting methods have been developed. The first method highlights scientific concerns, while the second method highlights the public considerations (Table 14).

Each indicator can be scored by multiplying the criteria score with their corresponding criteria weights (i.e. weighting score scientific concerns or weighting score public considerations) and summing across all criteria. The scores of all indicators may guide the selection of a set of indicators that are useful and complementary to each other.

Table 13. Nineteen criteria that can be used to evaluate marine species and food web indicators grouped into categories; primary considerations, data consideration, other considerations and post-hoc analysis (Based on Table 3 from Kershner et al. (2011) [55])

Primary Considerations
1) **Theoretically-sound (TS)** – Scientific, peer-reviewed findings should demonstrate that indicators act as reliable surrogates for ecosystem key attribute(s).
2) **Relevant to management concerns (RM)** – Indicators should provide information related to specific management goals and strategies.
3) **Responds predictable and is sufficiently sensitive to changes in a specific ecosystem key attribute(s) (REA)** – indicators should respond unambiguously to variation in the ecosystem key attribute(s) they are intended to measure, in a theoretically- or empirically-expected direction.
4) **Responds predictable and is sufficiently sensitive to changes in management action(s) or pressure(s) (RMAP)** – Management actions or other human-induced pressures should cause detectable changes in the indicators, in a theoretically- or empirically-expected direction, and it should be possible to distinguish the effects of other factors on the response.
5) **Linkable to scientifically-defined reference points and progress targets (LT)** – It should be possible to link indicator values to quantitative or qualitative reference points and target reference points, which imply positive progress toward ecosystem goals.
Data Considerations
6) **Concrete (C)** – Indicators should be directly measurable.
7) Historical data or information available (HD) – Indicators should be supported by existing data to facilitate current status evaluation (relative to historic levels) and interpretation of future trends.
8) **Operationally simple (OS)** – The methods for sampling, measuring, processing, and analyzing the indicator data should be technically feasible.
9) **Numerical (N)** – Quantitative measurements are preferred over qualitative, categorical measurements, which in turn are preferred over expert opinions and professional judgements.
10) **Broad spatial coverage (BSC)** – Ideally, data for each indicator should be available throughout its range.
11) **Continuous time series (CTS)** – Indicators should have been sampled on multiple occasions, preferably without substantial time-gaps between sampling.
12) **Spatial and temporal variation understood (STV)** – Diel, seasonal, annual, and decadal variability in the indicators should ideally be understood, as should spatial heterogeneity or patchiness in indicator values.
13) **High signal-to-noise ratio (HSN)** – It should be possible to estimate measurements and process uncertainty associated with each indicator, and to ensure that variability in indicator values does not prevent detection of significant changes.
Other Considerations
14) **Understood by the public and policy makers (UP)** – Indicators should be simple to interpret, easy to communicate, and public understanding should be consistent with technical definitions.
15) **History of public documenting (HR)** – Indicators already should signal changes in ecosystem attributes before they occur, and ideally with sufficient lead-time to allow for a management response.
16) **Cost-effective (CE)** – Sampling, measuring, processing, and analyzing the indicator data should make effective use of limited financial resources.
17) **Anticipatory or leading indicator (A)** – A subset of indicators should signal changes in ecosystem attributes before they occur, and ideally with sufficient lead-time to allow for a management response
18) **Regionally/nationally/internationally compatible (CM)** – indicators should be comparable to those used in other geographic locations, in order to contextualize ecosystem status and changes in status.
Post-hoc Analysis
19) **Complements existing indicators** – This criterion is applicable in the selection of a suite of indicators, performed after the evaluation of individual indicators in a post-hoc analysis. Sets of indicators should be selected to avoid redundancy, increase the complementary of the information provided, and to ensure coverage of key attributes.

Table 14. Weighting of criteria according to their relative importance highlighting scientific concerns and highlighting public considerations (1=essential; 0.75=important; 0.5=moderate; 0.25=slightly moderate; 0=negligible) (Based on Table 4 from Kershner et al. (2011) [55])

Criteria (from Table x.8)	Weighting score	
	Scientific	Public
TS	1	0.5
RM	0.75	1
REA	1	0.5
RMAP	1	0.5
LT	0.75	0.75
C	1	0.75
HD	0.5	1
OS	0.5	1
N	1	1
BSC	0.5	0.5
CTS	0.5	1
STV	0.5	0
HSN	0.5	0
UP	0	1
HR	0	0.5
CE	0	0.5
A	0.5	0
CM	0	0.25

4 Management measures

In order to fulfil the second WP4 objective, i.e. “Develop a range of realistically feasible management strategies or options for these activities, using different types of measures and tools, to achieve regional Operational Objectives” this section presents an inventory of the existing and possible measures that can be used to achieve the goals of the MSFD. These measures should satisfy the list presented in Annex VI of the MSFD (see box below) and should link to the “human activities most likely to compromise the operational objectives” (First WP4 Objective, Chapter 2) as well as the pressures through which they impact on the ecosystem characteristics (based on Annex III of the MSFD, see Chapter 1.1). These measures were then collated in a database and used to develop a framework allowing the selection of the most appropriate management measures and their evaluation in a standardized way across regions. To that end we characterized the specific measures in the database using more generic descriptions of the measures.

ANNEX VI

Programmes of measures

(referred to in Articles 13(1) and 24)

(1) Input controls: management measures that influence the amount of a human activity that is permitted.
(2) Output controls: management measures that influence the degree of perturbation of an ecosystem component that is permitted.
(3) Spatial and temporal distribution controls: management measures that influence where and when an activity is allowed to occur.
(4) Management coordination measures: tools to ensure that management is coordinated.
(5) Measures to improve the traceability, where feasible, of marine pollution.
(6) Economic incentives: management measures which make it in the economic interest of those using the marine ecosystems to act in ways which help to achieve the good environmental status objective.
(7) Mitigation and remediation tools: management tools which guide human activities to restore damaged components of marine ecosystems.
(8) Communication, stakeholder involvement and raising public awareness.

Firstly all measures were classified into a hierarchical framework which is essentially a combination of the Annex VI types of measures (see box) and another, slightly different but comparable, typology based on ARCADIS (2012) [56] and that distinguishes between physical measures which may be carried out by any stakeholder and three types of instruments usually created at the governmental level (slightly modified from original):

- Physical measures
- Regulatory instruments
- Economic instruments
- Social instruments

This framework consists of two distinct aspects of a measure and distinguishes between the Annex VI measures (1)-(8):

a) The primary aim of the measures which influences either the human activity (1) or the ecosystem component and the degree to which it is perturbed (2).
b) The mechanism through which the aim is achieved. This may involve any of the other types of Annex VI measures (3)-(8) which are merged with the ARCADIS (2012) [56] typology into a hierarchy of potential tools that can be used to achieve the step 1 aim.

for which more detail is provided below.

Aim

For the characterisation of the aim of each measure we distinguished the measures based on (1) the part of the impact chain (Driver-Pressure-State) the measure was supposed to act upon and (2) whether the focus was on input control or output control. For the former we distinguish between a

focus on the element (i.e. driver, pressure or state) or a combination of two consecutive elements (e.g. Reduce impact driver x-pressure y). In case of input control the measure acts specifically on the input of that specific element of the impact chain (e.g. Restrictions on driver x) while output control mitigates the effects of that specific element down the chain, either generic (e.g. Reduce impact driver x) or through a specific link (e.g. Reduce impact driver x-pressure y). The intention was to limit the number of different categories and use standard terms that reflect both the positioning of the measure along the impact chain and the type of control. These standard terms are introduced below moving from a focus on the Driver towards a focus on the State.

- **Restrictions on driver x**: These measures put a restriction on the input of the driver without any consideration of how this driver affects the system, e.g. ”Restrictions on fishing”
- **Reduce impact driver x**: These measures put a restriction on the output of the driver specifically aimed at reducing the impact it has on the system but involving more than one single pressure, e.g. ”Reduce impact fishing-seafloor”
- **Reduce impact driver x-pressure y**: These measures put a restriction on the driver specifically aimed at reducing the impact it has on the system through one single pressure, e.g. ”Reduce impact shipping-NIS”
- **Reduce pressure y**: These measures aim at reducing the input of a pressure into the system. This may be caused by several drivers, and may affect several characteristics of state, e.g. ”Reduce noise”
- **Reduce effects pressure y**: These measures aim at reducing the effects of a pressure that is already in the system, e.g. ”Reduce effects pollution”
- **Conservation state characteristic c**: The measures are specifically aimed at the conservation of a specific characteristic of state (e.g. ”Conservation habitat”) or without the specification the ecosystem in general (i.e. ”Conservation”) . It may involve protection and/or restoration.

Mechanism

The mechanism is characterized by a hierarchy based on the merger of typologies from various sources.

- Physical measures
    - Remediation
        - Remediation: cleaning
    - Research
    - Traceability/Labelling
    - Technical
    - Infrastructure
    - Management coordination
        - Management coordination: marine spatial planning
        - Management coordination: monitoring
        - Management coordination: protocol
- Regulatory instruments
    - Spatial and temporal distribution controls
        - Spatial and temporal distribution controls: zoning
    - Mitigation: legislation/enforcement
    - Mitigation: licences/permits
    - Management coordination
        - Management coordination: ecosystem approach
        - Management coordination: marine spatial planning
        - Management coordination: monitoring
        - Management coordination: protocol
        - Management coordination: rights-based Management
- Economic instruments
    - Economic: penalties/enforcement
    - Economic: taxes or subsidies
- Social instruments
    - Social: stakeholder involvement
    - Social: education and raising public awareness
    - Social: community action

Some of which are elaborated below:

Physical measures consist of technical, technological or research oriented measures which have a direct impact on the environment. These are often implemented as nearly all impacts can be mitigated by applying best available technologies (BAT). OSPAR often uses BAT as a baseline for reducing harmful contaminants. Much can be expected from new fishing techniques, new techniques to reduce underwater noise or the ecological landscaping of mining burrows. The assessment of costs and effects of physical measures tend to be more straightforward compared to the evaluation of policy instruments, because there is a more direct link between the action and the result (however still related to a specific context). It should be clear that there is a link with policy instruments. If there is an obligation to imply a certain technical measure, it should be regarded as a regulatory instrument. The implementation of certain technical measures can be encouraged by subsidies, which in turn can be supported by resources generated by taxes/levies. If an information campaign promotes the application of the technical measure, it should be regarded as a social instrument. It is sometimes difficult to categorize a measure as a technical measure or as a regulatory measure, e.g. in situations where there is no information if the measure is already imposed by authorities or whether private stakeholders can take it voluntarily. Examples of such measures are:

- Detailed location planning (cables, pipelines, drilling)
- Delineation of extraction zones
- Seabed restoration or aftercare measures
- Removal of man-made constructions
- Monitoring activities

For the inventory, measures regarding planning or location instruments (first two bullets from the above listed measures) are considered as regulatory instruments as these are often embedded in environmental permitting procedures, initiated by authorities. The latter three have been classified as technical or research oriented measures for the purposes of this inventory. These measures might be executed by either the polluter or (funded) by the authorities e.g. monitoring activities (post-operational, seismic surveys, monitoring activities to enhance knowledge – research - on impacts and required future measures, …) and are as such not necessarily regulatory instruments. It is of note that authorities often impose these measures and make them mandatory which then turns them into regulatory instruments. Therefore some of the “Management coordination” measures are considered both under the Physical measures and the Regulatory measures.
Research can be seen as a separate type of measure. The more we know the more cost-effective measures can be designed and implemented.

Regulatory instruments including traditional command-and-control (CAC) instruments, have a direct influence on the behaviour of actors by imposing rules that limit or prescribe the actions of the target group. Examples of such instruments are regulation (including spatial and temporal controls, zoning), norms and standards, bans. Spatial controls and/or zoning to less vulnerable areas can be very effective to mitigate location-specific pressures, such as the physical and biological disturbance of the sea bottom. Zoning has however limited possibilities for improving water quality, decreasing marine litter or improving most fish populations.
Often larger interventions are subject to an Environmental Impact Assessment and to licensing. There is still scope to apply this instrument to more interventions and to increase monitoring (see Management coordination: monitoring). An example is sand mining. The requirement of an EIA is coupled to the volume and surface area for sand mining but not to its potential ecological effect, which depends mainly on location-specific conditions. So smaller but potentially harmful sand mining activities go without adequate assessments of the effects.

These instruments have a legal basis and enforcement and control is a key element in the success of the instrument.

Economic or market-based instruments are defined by the OECD as tools that ‘affect estimates of the costs and benefits of alternative actions open to economic agents'. The common underlying rationale is to modify the behaviour and decisions of actors and individuals to enhance the protection of the environment, to secure an optimal level of pollution or to achieve optimum rates of resource use and depletion, e.g. inspired by the polluter-pays principle. Or to put it more simply, if a tool affects the cost or price in the market, it is a market-based / economic instrument. This definition focuses on the economic signals and incentives. If it changes the cost or price of a good (e.g. plastic bags), service

(e.g. waste collection), activity (e.g. waste dumping), input (e.g. pollution), or output (e.g. materials) then it is a market-based instrument. Economic instruments have both an incentive-effect and a revenue-raising effect, with the relative importance depending on the ability of the market to respond to the “price signal”. Examples of such instruments are fee-based systems, subsidies, liability and compensation regimes and trading systems. Subsidies are often easy to implement as the (political) acceptance is high. Subsidies can involve significant use of government finance and their success relies on the behaviour of the target group. The other risk of subsidies is that they may turn out to be environmentally harmful – e.g. if subsidies for fishing gear lead to increased fishing effort and depleted stocks this would be an example of an environmentally harmful subsidy in the marine case.

Social instruments, like economic instruments influence or provoke the desired behaviour indirectly. A key feature of this type of instruments is the voluntary aspect of actions. Polluters or stakeholders are stimulated to take actions based upon own motivation, often through information (education, training) or awareness raising campaigns. Good or bad image building and associated perception from society (e.g. through communication or certification) can provide important incentives to adapt behaviour.

4.1 Database

The framework described in the previous chapter was then applied to characterize the existing and possible specific measures that emerged from the inventory based on various literature sources reviewed in ARCADIS (2012) and DHV (2011) [56, 57] and expert consultations.
In addition each of these specific measures was linked to one or more elements of the impact chain (i.e. Driver, Pressure and State). Only those linkages were included in the database where that specific element (or combination of elements) is targeted by the measure. This may involve more than one manifestations of the same element (e.g. several drivers like fisheries and shipping) or a combination of different elements, e.g. pressure (e.g. marine litter) in combination with a driver (e.g. shipping).
The database is constructed out of two parts; one containing an inventory of specific measures, each characterized by an aim and a mechanism (see Annex 9). In order to give some idea of the availability of measures table 15 gives the number of measures per combination of aim and mechanism. The second part of the database contains the aim linked to one or more elements of the impact chain, i.e. Driver, Pressure and State (see Annex 10).

Table 15: Number of measures per combination of aim and mechanism as they occur in Annex 9.

Aim \ Mechanism	economic: penalties/enforcement	economic: taxes or subsidies	infrastructure	management coordination	management coordination: marine spatial planning	management coordination: monitoring	management coordination: protocol	management coordination: rights based management	management coordination:monitoring	mitigation: legislation/enforcement	mitigation: licenses/permits	physical measures	regulatory instruments	remediation	remediation: cleaning	remediation:cleaning	restoration/compensation	social instruments	social: certification	social: community action	social: education and raising public awareness	Social: stakeholder involvement	social:education and raising public awareness	social:stakeholder involvement	spatial and temporal distribution controls:zoning	technical	traceability/labelling	Grand Total
Conservation ecosystem characteristic: hydrographical conditions																										2		2
Conservation ecosystem characteristic: fish														1											1	1		3
Conservation ecosystem characteristic: habitat																	3											3
conservation ecosystem characteristic: habitat restoration																										1		1
Conservation ecosystem characteristic: marine mammals							1																					1
Conservation ecosystem characteristic: water quality																										1		1
Nature conservation										1													1					2
reduce pollution			1			1																						2
reduce atmospheric emission		2						1																				3
reduce effects litter																			4									4
Reduce effects NIS										1				1		1										1		4
reduce effects pollution						1									1	6												8
reduce impact aggregates and dredging						1																				1		2
reduce impact aggregates and dredging: changes in siltation																										1		1
reduce impact aggregates and dredging: sea floor integrity																										2		2
reduce impact aggregates and dredging: seafloor impact																										1		1
reduce impact aggregates and dredging:disturbance																									1			1
reduce impact agriculture				1																								1
reduce impact agriculture:eutrophication																		1				1				4		6
reduce impact agriculture:pollution																						1						1
Reduce impact aquaculture											1								1						1	3		6
reduce impact aquaculture:introduction NIS										1																		1
Reduce impact fishing		2						3		1									2							1		9
reduce impact fishing																										1		1
reduce impact fishing: bycatch		1																								2		3
reduce impact fishing: seafloor impact										1																2		3
reduce impact fishing:										2																		2

selective fishing																										
reduce impact fishing: selective fishing									1																	1
reduce impact fishing:litter		1																1	1					1	1	5
reduce impact human activities					2																1		4	1		8
reduce impact land based industry:eutrophication																								2		2
reduce impact land based industry:litter		2							1			1												1		5
reduce impact non-renewable energy (oil & gas operations): disturbance																								1		1
reduce impact non-renewable energy (oil & gas operations): pollution						2																				2
reduce impact renewable energy (operations):collision hazard							1																			1
reduce impact renewable energy (construction): noise		1																						3		4
reduce impact renewable energy (operations)																								1		1
reduce impact renewable energy (operations): noise																								1		1
reduce impact renewable energy (operations): thermal pollution																								1		1
Reduce impact shipping		1																				1	2			4
reduce impact shipping: introduction NIS							1		1	2													1	1		6
Reduce impact shipping:emission								1																		1
reduce impact shipping:litter		1	2																							3
reduce impact shipping:noise																								3		3
reduce impact shipping:pollution		1							1															1		3
Reduce impact tourism/ recreation		1																								1
reduce impact tourism/recreation: litter			1																							1
reduce impact waste water treatment			2	1					1															1		5
reduce impact waste water treatment: eutrophication																								1		1
reduce impact waste water treatment:pollution																								1		1
reduce introduction NIS									2								1									3
reduce litter		5	1																		1			1		8
Reduce noise						1						1												2		4
reduce pollution	3		1	1					5		1												1			12
restriction on non-renewable Energy (oil & gas construction)																							1			1
restriction on telecommunications (construction)																							1			1
Restrictions on aggregates and dredging		1							1														5			7
restrictions on construction																							1			1
Restrictions on fishing		3							2														4	1		10
restrictions on human activities										3													4			7
restrictions on tourism/recreation		1																								1
		1																							1	2
Grand Total	**3**	**24**	**8**	**3**	**2**	**5**	**4**	**5**	**1**	**23**	**4**	**1**	**2**	**2**	**1**	**7**	**3**	**1**	**4**	**5**	**1**	**2**	**3**	**1**	**27**	**48**	**2**	**192**

4.2 Applications using the database

In this section we present only those applications that involve the database described in Chapter 4. Applications that involve combinations of this database with other databases (i.e. described in Chapters 2 and 3) are presented in the Synthesis (Chapter 5).
Table 156 is a matrix that gives the number of measures per combination of sector and pressure.

Table 156. Number of measures per driver-pressure combination

Pressure \ Sector	(Hydro) Power Station Construction	(Hydro) Power Station Operations	Aggregates	Agriculture	Aquaculture	Carbon sequestration	Coastal defense	Coastal Infrastructure (construction)	Coastal Infrastructure (operations)	Desalination	Fishing - Benthic trawling	Fishing - Fixed Nets incl. potting and creeling	Fishing - Pelagic trawling	Harvesting/Collecting	Land-based Industry	Military	Navigational Dredging	Non-renewable Energy (Nuclear) Construction	Non-renewable Energy (Nuclear) Operations	Non-renewable Energy (oil & gas construction)	Non-renewable Energy (oil & gas operations)	Renewable Energy (wind) - construction	Renewable Energy (wind) - operations	Research	Shipping	Telecommunications construction	Telecommunications operations	Tourism/Recreation	Waste Water Treatment	Grand Total
Abrasion	7	6	9	7	7	6	6	7	6	6	9	9	9	6	6	6	9	7	6	8	7	7	7	6	7	8	7	7	6	204
Barrier_to_ species_ movement	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Change_in_ wave_exposure	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Changes_in_ siltation	6	5	8	6	6	5	5	6	5	5	7	7	7	5	5	5	8	6	5	7	6	6	6	5	6	7	6	6	5	172
Death_or_ injury_by_ collision	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	7	5	6	7	6	6	5	171
Disturbance	6	5	8	6	6	5	5	6	5	5	7	7	7	5	5	5	8	6	5	7	7	6	6	5	7	7	6	7	5	175
Electromagnetic_ changes	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Emergence_ regime_change	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Input_of_ organic_matter	10	9	11	11	10	9	9	10	9	9	11	11	11	9	9	9	11	10	9	11	11	10	10	9	12	11	10	10	11	292
Introduction of other substances	10	9	11	11	10	9	9	10	9	9	11	11	11	9	9	9	11	10	9	11	11	10	10	9	12	11	10	10	11	292

Introduction_of_microbial_pathogens	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Introduction_of_non_indigenous_species	8	7	9	8	9	7	7	8	7	7	9	9	9	7	7	7	9	8	7	9	8	8	8	7	9	9	8	8	7	230
Introduction_of_Non_synthetic_compounds	10	9	11	11	10	9	9	10	9	9	11	11	11	9	9	9	11	10	9	11	11	10	10	9	12	11	10	10	11	292
Introduction_of_Radionuclides	9	8	10	9	9	8	8	9	8	8	10	10	10	8	8	8	10	9	8	10	10	9	9	8	11	10	9	9	10	262
Introduction_of_Synthetic_compounds	10	9	11	11	10	9	9	10	9	9	11	11	11	9	9	9	11	10	9	11	11	10	10	9	12	11	10	10	11	292
Marine_Litter	8	7	9	8	8	7	7	8	7	7	10	10	10	7	8	7	9	8	7	9	8	8	8	7	9	9	8	10	7	235
Nitrogen_and_Phosphorus_enrich	7	6	8	8	7	6	6	7	6	6	8	8	8	6	7	6	8	7	6	8	8	7	7	6	9	8	7	7	9	207
pH_changes	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Salinity_regime_changes	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Selective_Extraction_of_Non_livi	6	5	8	6	6	5	5	6	5	5	7	7	7	5	5	5	8	6	5	7	6	6	6	5	6	7	6	6	5	172
Selective_extraction_of_species	7	6	8	7	7	6	6	7	6	6	10	10	10	6	6	6	8	7	6	8	7	7	7	6	7	8	7	7	6	205
Smothering	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Substrate_Loss	7	6	9	7	7	6	6	7	6	6	9	9	9	6	6	6	9	7	6	8	7	7	7	6	7	8	7	7	6	204
Thermal_regime_changes	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	6	7	6	6	7	5	6	7	6	6	5	172
Underwater_noise	7	6	8	7	7	6	6	7	6	6	8	8	8	6	6	6	8	7	6	8	7	8	8	6	8	8	7	7	6	202
Water_flow_rate_changes	6	5	7	6	6	5	5	6	5	5	7	7	7	5	5	5	7	6	5	7	6	6	6	5	6	7	6	6	5	170
Grand Total	**184**	**158**	**215**	**189**	**185**	**158**	**158**	**184**	**158**	**158**	**215**	**215**	**215**	**158**	**160**	**158**	**215**	**184**	**159**	**210**	**191**	**185**	**187**	**158**	**200**	**210**	**184**	**187**	**171**	**5309**

5 Synthesis

This is where the high-threat impact chains (Chapter 2) are linked to the appropriate indicators (Chapter 3) and management measures (Chapter 4) through the components that make up the pathways (i.e. sectors, pressures, ecosystem characteristics). This combination allows a first assessment of the following research questions:

- Management of human activities: which measures are most appropriate to mitigate the effects of specific activities (i.e. driver-pressure combinations).
- Management of human activities with a focus on the achievement of specific operational objectives: which measures are most appropriate to mitigate those human activities that compromise a specific operational objective. These are the extractions used for the case studies applied elsewhere in WP4 as well as other ODEMM WP's.

5.1 Specificity Score

We calculated a specificity score (*SC*) per region to reflect how specific the measure is targeted on one or more impact chains. To that end we used the IA (see Chapter 2) and identified the total number of linkages (*NT*) per region. Merging the measures database with the IA allowed us to establish how many impact chains were affected by the measure (*NM*). The specificity score is then calculated as:

$$SC = 100 * (\frac{NM}{NT})$$

which results in relatively specific measures with low scores (minimum=0) and relatively generic measures with high scores (maximum=100). For each aim the SC was based on an average across the 4 regions. Figure 13 shows the average specificity scores per measures revealing both very specific as well as generic measures.

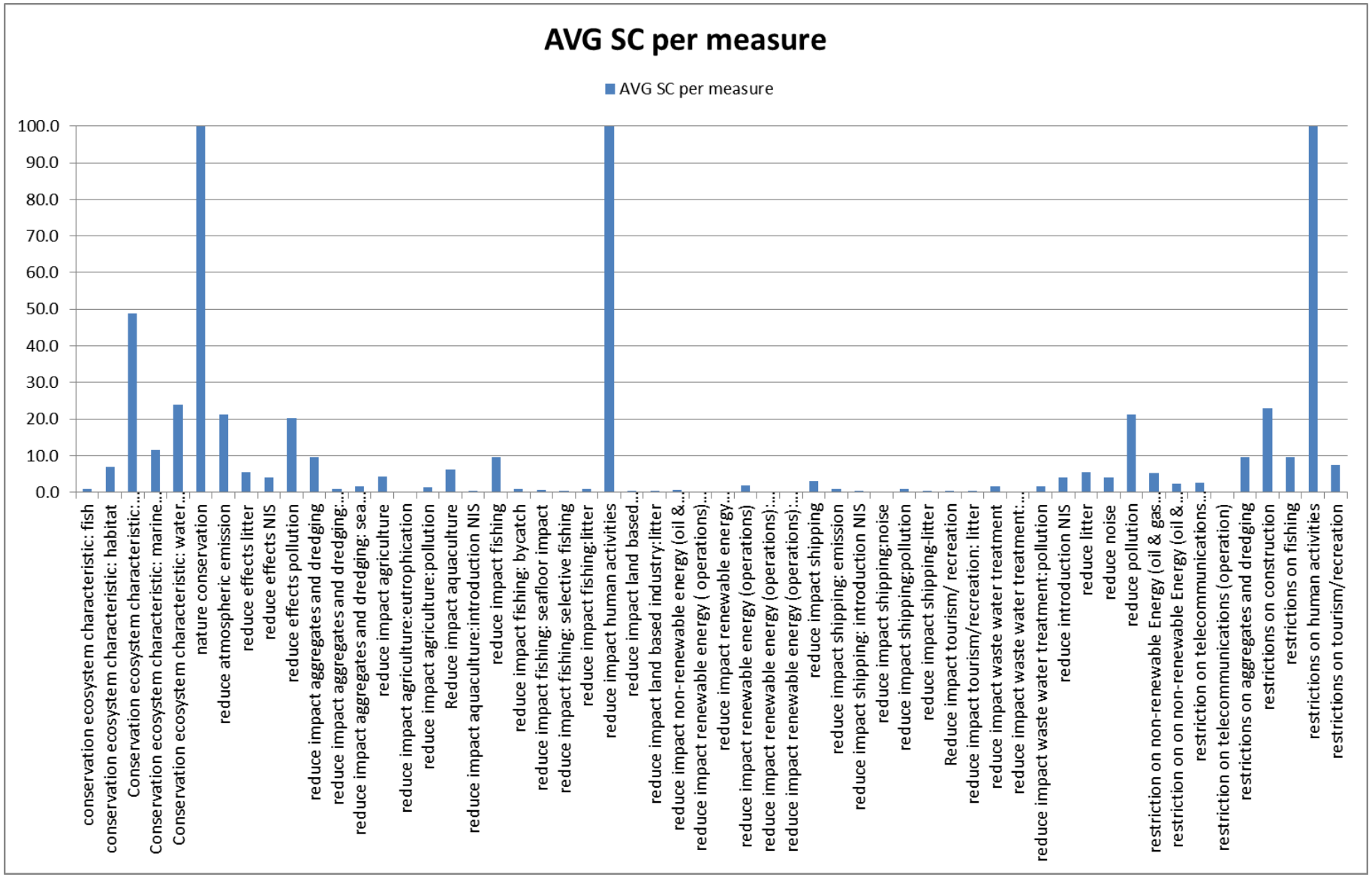

Figure 13. Averaged specificity score per measure (aim)

5.1 Appropriate measures per driver-pressure combination

In order to identify which measures are most appropriate to mitigate the effects of specific human activities (i.e. driver-pressure combinations) the IA database was merged with the measures database and the measures linked to the high-threat chains were considered most appropriate. In this section only the measures relevant for the case studies, i.e. descriptor 4 (Foodweb) and descriptor 6 (Sea floor integrity), are shown. In the tables below, an overview is given of the number of measures per driver-pressure combination for the two descriptors. To limit the output, only measures (aim) with an average SC of below 10 were selected. In Annex 11a and 11b the list of measures per driver-pressure combination is given for respectively the Foodweb and Seafloor Integrity case studies.

Table 16. Number of measures per driver-pressure combination for descriptor 4 Foodweb (only measures with mean SC > 10)

Pressure / Driver	Aggregates	Agriculture	Aquaculture	Coastal Infrastructure (construction)	Fishing - Benthic trawling	Fishing - Fixed Nets incl. potting and creeling	Fishing - Pelagic trawling	Land-based Industry	Military	Navigational Dredging	Non-renewable Energy (oil & gas construction)	Non-renewable Energy (oil & gas operations)	Research	Shipping	Telecommunications construction	Tourism/Recreation	Waste Water Treatment	Grand Total
Abrasion	4				12					4				2		2		24
Changes_in_siltation	3	2	1		2													8
Death_or_injury_by_collision														4				4
Input_of_organic_matter		6	1		4											1	2	14
Introduction_of_microbial_ Pathogens														1				1
Introduction_of_non_ indigenous_s			8		12		4		4				2	16				46
Introduction_of_Non_synthetic_compound s		2	1		6		8				1	2		12			4	36
Introduction_of_Synthetic_ compounds		6	1		8	2	8				2			12			4	43
Marine_Litter			3		20	5	20							4		10		62
Nitrogen_and_Phosphorus_ enrich		4	1					1								1		7
Selective_Extraction_of_ Non_livi	3																	3
Selective_extraction_of_ species			2		18	5	20						1					46
Smothering	2		1		4					2								9
Substrate_Loss			2	4	10						4				2	2		24
Thermal_regime_changes											1							1
Underwater_noise									1									1
Water_flow_rate_changes											1							1
Grand Total	**12**	**20**	**21**	**4**	**96**	**12**	**60**	**1**	**5**	**6**	**9**	**2**	**3**	**51**	**2**	**16**	**10**	**330**

Table 17. Number of measures per driver-pressure combination for descriptor 6 Sea floor integrity (only measures with mean SC > 10)

Pressure \ Driver	Aggregates	Agriculture	Aquaculture	Coastal Infrastructure (construction)	Fishing - Benthic trawling	Land-based Industry	Military	Navigational Dredging	Non-renewable Energy (oil & gas construction)	Research	Shipping	Telecommunications construction	Tourism/Recreation	Waste Water Treatment	Grand Total
Abrasion	4				12			4			2		2		24
Changes_in_siltation	3	2	1		2										8
Input_of_organic_matter		6	1		4								1	2	14
Introduction_of_microbial_pathogens											1				1
Introduction_of_non_indigenous_s			8		12		2			2	16				40
Introduction_of_Non_synthetic_compounds		2			2				1		3			2	10
Introduction_of_Synthetic_compounds		6	1		6				2		9			2	26
Marine_Litter			3		20						4		10		37
Nitrogen_and_Phosphorus_enrich		4	1			1							1		7
Selective_Extraction_of_Non_livi	3														3
Selective_extraction_of_species					12										12
Smothering	2		1		4			2							9
Substrate_Loss			2	4	8				4			2	2		22
Thermal_regime_changes									1						1
Water_flow_rate_changes									1						1
Grand Total	**12**	**20**	**18**	**4**	**82**	**1**	**2**	**6**	**9**	**2**	**35**	**2**	**16**	**6**	**215**

5.2 Appropriate measures to achieve an objective

In this section we approach the selection of appropriate management measures from a different perspective, i.e. with the aim of achieving a specific objective as reflected by the MSFD descriptors.
Similar to section 5.1 we used the high-threat chains to identify what we considered the appropriate measures per descriptor. Table 18 was used to link the descriptors to the chains through the ecosystem components. For the presentation of the results we focused on the descriptors relevant for the case studies, i.e. Foodweb (D4) and Seafloor integrity (D6).
For descriptor 4 Foodwebs, measures were extracted from the high-threat impact chains using the following ecosystem components: Plankton, Bottom fauna and flora, Fish (Benthic, Deep sea and Pelagic) Marine mammals and Reptiles and Seabirds (inshore and offshore) (for results see Table 19). For descriptor 6, Seafloor integrity, measures were extracted from the high-threat impact chains using the ecosystem component Habitats (for results see Table 20). The AVG SC in both tables gives the averaged specificity score (SC, see paragraph 5.1) taken over the 4 different regional areas. The SC shows relatively specific measures (low scores (minimum=0)) and relatively generic measures (high scores (maximum=100)).

Table 18. Translation table for ecosystem components to descriptors

COM DEC Codes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MSFD Descriptors	Biodiversity	Non-indigenous species	Commercial fish & shellfish	Foodwebs	Eutrophication	Sea-floor integrity	Hydrographic conditions	Contaminants	Fish and Seafood Contaminants	Marine Litter	Energy introduction (incl. noise)
Ecosystem components											
Topography/Bathymetry											
Temperature							X				
Salinity							X				
Nutrients & Oxygen					X		X				
pH, pCO2							X				
Predominant Habitat Type	X				X	X					
Special Habitat Types	X				X						
Habitat Types Meriting Special Reference	X				X						
Plankton	X	X		X	X						
Bottom fauna and flora	X	X	X	X	X				X	X	
Fish	X	X	X	X	X				X	X	X
Marine mammals & Reptiles	X	X		X						X	X
Seabirds	X	X		X						X	X
Species listed under Community Legisation or Conventions	X			X						X	X
Non-indigenous/exotic spp.		X									
Chemicals								X	X*		

Table 19. high-threat measures Descriptor 4 Foodwebs

Ecosystem_components	Measures (aim)	AVG SC
Fish Pelagic	conservation ecosystem characteristic: fish	1
Bottom fauna and flora	conservation ecosystem characteristic: habitat	7
Marine mammals	Conservation ecosystem characteristic: marine mammals	12
Bottom fauna and flora	Conservation ecosystem characteristic: water quality	24
Bottom fauna and flora	nature conservation	100
Bottom fauna and flora	reduce atmospheric emission	21
Bottom fauna and flora	reduce effects litter	5
Bottom fauna and flora	reduce effects NIS	4
Bottom fauna and flora	reduce effects pollution	20
Bottom fauna and flora	reduce impact aggregates and dredging	10
Bottom fauna and flora	reduce impact aggregates and dredging: changes in siltation	1
Bottom fauna and flora	reduce impact aggregates and dredging: sea floor integrity	2
Bottom fauna and flora	reduce impact agriculture	4
Bottom fauna and flora	reduce impact agriculture:pollution	1
Bottom fauna and flora	Reduce impact aquaculture	6
Bottom fauna and flora	reduce impact aquaculture:introduction NIS	1
Plankton	reduce impact fishing	10
Bottom fauna and flora	reduce impact fishing: bycatch	1
Bottom fauna and flora	reduce impact fishing: seafloor impact	1
Fish Pelagic	reduce impact fishing: selective fishing	0
Bottom fauna and flora	reduce impact fishing:litter	1
Bottom fauna and flora	reduce impact human activities	100
Plankton	reduce impact land based industry:eutrophication	1
Fish Deep sea	reduce impact non-renewable energy (oil & gas operations) : pollution	1
Bottom fauna and flora	reduce impact shipping	3
Bottom fauna and flora	reduce impact shipping: emission	1
Bottom fauna and flora	reduce impact shipping: introduction NIS	1
Bottom fauna and flora	reduce impact shipping:pollution	1
Bottom fauna and flora	reduce impact shipping-litter	1
Bottom fauna and flora	Reduce impact tourism/ recreation	1
Bottom fauna and flora	reduce impact tourism/recreation: litter	1
Bottom fauna and flora	reduce impact waste water treatment	2
Bottom fauna and flora	reduce impact waste water treatment:pollution	2
Bottom fauna and flora	reduce introduction NIS	4
Bottom fauna and flora	reduce litter	5
Fish Benthic	reduce noise	4
Bottom fauna and flora	reduce pollution	21
Bottom fauna and flora	restriction on non-renewable Energy (oil & gas construction)	5
Fish Deep sea	restriction on on non-renewable Energy (oil & gas operation)	2
Bottom fauna and flora	restriction on telecommunications (construction)	3
Bottom fauna and flora	restrictions on aggregates and dredging	10
Bottom fauna and flora	restrictions on construction	23
Plankton	restrictions on fishing	10

Bottom fauna and flora	restrictions on human activities	100
Bottom fauna and flora	restrictions on tourism/recreation	7

Table 20. high-threat measures Descriptor 6 Seafloor integrity

Ecosystem_components	Measures (aim)	AVG SC
Habitats	conservation ecosystem characteristic: habitat	7
Habitats	Conservation ecosystem characteristic: water quality	24
Habitats	nature conservation	100
Habitats	reduce atmospheric emission	21
Habitats	reduce effects litter	5
Habitats	reduce effects NIS	4
Habitats	reduce effects pollution	20
Habitats	reduce impact aggregates and dredging	10
Habitats	reduce impact aggregates and dredging: changes in siltation	1
Habitats	reduce impact aggregates and dredging: sea floor integrity	2
Habitats	reduce impact agriculture	4
Habitats	reduce impact agriculture:pollution	1
Habitats	Reduce impact aquaculture	6
Habitats	reduce impact aquaculture:introduction NIS	1
Habitats	reduce impact fishing	10
Habitats	reduce impact fishing: bycatch	1
Habitats	reduce impact fishing: seafloor impact	1
Habitats	reduce impact fishing:litter	1
Habitats	reduce impact human activities	100
Habitats	reduce impact land based industry:eutrophication	1
Habitats	reduce impact shipping	3
Habitats	reduce impact shipping: emission	1
Habitats	reduce impact shipping: introduction NIS	1
Habitats	reduce impact shipping:pollution	1
Habitats	reduce impact shipping-litter	1
Habitats	Reduce impact tourism/ recreation	1
Habitats	reduce impact tourism/recreation: litter	1
Habitats	reduce impact waste water treatment	2
Habitats	reduce impact waste water treatment:pollution	2
Habitats	reduce introduction NIS	4
Habitats	reduce litter	5
Habitats	reduce pollution	21
Habitats	restriction on non-renewable Energy (oil & gas construction)	5
Habitats	restriction on telecommunications (construction)	3
Habitats	restrictions on aggregates and dredging	10
Habitats	restrictions on construction	23
Habitats	restrictions on fishing	10
Habitats	restrictions on human activities	100
Habitats	restrictions on tourism/recreation	7

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7 Annexes

Annex 1: MSFD descriptors, attributes and indicators

MSFD descriptors and corresponding attributes and indicators as phrased in the Commission Decision (EC, 2010)

1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions
    - 1.1. Species distribution
        - 1.1.1. Distributional range
        - 1.1.2. Distributional pattern within the latter, where appropriate
        - 1.1.3. Area covered by the species (for sessile/benthic species)
    - 1.2. Population size
        - 1.2.1. Population abundance and/or biomass, as appropriate
    - 1.3. Population condition
        - 1.3.1. Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality)
        - 1.3.2. Population genetic structure, where appropriate
    - 1.4. Habitat distribution
        - 1.4.1. Distributional range
        - 1.4.2. Distributional pattern
    - 1.5. Habitat extent
        - 1.5.1. Habitat area
        - 1.5.2. Habitat volume, where relevant
    - 1.6. Habitat condition
        - 1.6.1. Condition of typical species and communities
        - 1.6.2. Relative abundance and/or biomass, as appropriate
        - 1.6.3. Physical, hydrological and chemical conditions
    - 1.7. Ecosystem structure
        - 1.7.1. Composition and relative proportions of ecosystem components (habitats and species)
2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem
    - 2.1. Abundance and state characterisation of non-indigenous species, in particular invasive species
        - 2.1.1. Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading such species
    - 2.2. Environmental impact of invasive non-indigenous species
        - 2.2.1. Ratio between invasive non-indigenous species and native species in some well-studied taxonomic groups (e.g. fish, macroalgae, molluscs) that may provide a measure of change in species composition (e.g. further to the displacement of native species)
        - 2.2.2. Impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock
    - 3.1. Level of pressure of the fishing activity
        - 3.1.1. Fishing mortality (F)
        - 3.1.2. Ratio between catch and biomass index (hereinafter 'catch/biomass ratio')
    - 3.2. Reproductive capacity of the stock
        - 3.2.1. Spawning Stock Biomass (SSB)
        - 3.2.2. Biomass indices
    - 3.3. Population age and size distribution
        - 3.3.1. Proportion of fish larger than the mean size of first sexual maturation
        - 3.3.2. Mean maximum length across all species found in research vessel surveys
        - 3.3.3. 95% percentile of the fish length distribution observed in research vessel surveys
        - 3.3.4. Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity
    - 4.1. Productivity (production per unit biomass) of key species or trophic groups
        - 4.1.1. Performance key predator species using their production per unit biomass (productivity)
    - 4.2. Proportion of selected species at the top of food webs
        - 4.2.1. Large fish (by weight)
    - 4.3. Abundance/distribution of key trophic groups/species
        - 4.3.1. Abundance of functionally important selected groups/species

Annex 1: Continued

- 5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters
  - 5.1. Nutrient levels
    - 5.1.1. Nutrient concentration in the water column
    - 5.1.2. Nutrient ratios (silica, nitrogen and phosphorus), where appropriate
  - 5.2. Direct effects of nutrient enrichment
    - 5.2.1. Chlorophyll concentration in the water column
    - 5.2.2. Water transparency related to increase in suspended algae, where relevant
    - 5.2.3. Abundance of opportunistic macroalgae
    - 5.2.4. Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities
  - 5.3. Indirect effects of nutrient enrichment
    - 5.3.1. Abundance of perennial seaweeds and seagrasses (e.g. fucoids, eelgrass and Neptune grass) adversely impacted by decrease in water transparency
    - 5.3.2. Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned
- 6. Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected
  - 6.1. Physical damage, having regard to substrate characteristics
    - 6.1.1. Type, abundance, biomass and areal extent of relevant biogenic substrate
    - 6.1.2. Extent of the seabed significantly affected by human activities for the different substrate types
  - 6.2. Condition of benthic community
    - 6.2.1. Presence of particularly sensitive and/or tolerant species
    - 6.2.2. Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species
    - 6.2.3. Proportion of biomass or number of individuals in the macrobenthos above some specified length/size
    - 6.2.4. Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community
- 7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems
  - 7.1. Spatial characterisation of permanent alterations
    - 7.1.1. Extent of area affected by permanent alterations
  - 7.2. Impact of permanent hydrographical changes
    - 7.2.1. Spatial extent of habitats affected by permanent alteration
    - 7.2.2. Changes in habitats, in particular the functions provided (e.g. spawning, breeding and feeding areas, and migration routes of fish, birds and mammals), due to altered hydrographical conditions
- 8. Concentrations of contaminants are at levels not giving rise to pollution effects
  - 8.1. Concentration of contaminants
    - 8.1.1. Concentration of the contaminants mentioned above, measured in the relevant matrix (such as biota, sediment and water) in a way that ensures comparability with the assessments under Directive 2000/60/EC
  - 8.2. Effects of contaminants
    - 8.2.1. Levels of pollution effects on the ecosystem components concerned, having regard to the selected biological processes and taxonomic groups where a cause/effect relationship has been established and needs to be monitored
    - 8.2.2. Occurrence, origin (where possible), extent of significant acute pollution events (e.g. slicks from oil and oil products) and their impact on biota physically affected by this pollution
- 9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards
  - 9.1. Levels, number and frequency of contaminants
    - 9.1.1. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels
    - 9.1.2. Frequency of regulatory levels being exceeded

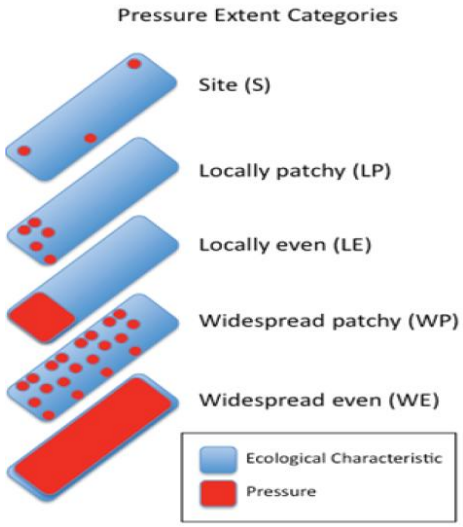
Annex 1: Continued

10. Properties and quantities of marine litter do not cause harm to the coastal marine environment
10.1. Characteristics of litter in the marine and coastal environment
10.1.1. Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source
10.1.2. Trends in the amount of litter in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source
10.1.3. Trends in the amount, distribution and, where possible, compositions of micro-particles (in particular micro-plastics)
10.2. Impacts of litter on marine life
10.2.1. Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis)
11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment
11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds
11.1.1. Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re $1\mu Pa^2.s$) or as peak sound pressure level (in dB re $1\mu Pa_{peak}$) at one metre, measured over the frequency band 10 Hz to 10 kHz
11.2. Continuous low frequency sound
11.2.1. Trend in the ambient noise level within 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1µPa RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate

Annex 2 Pressure Assessment Categories

Source: Pressure Assessment Guidance Document (Robinson et al., 2011)

1 **Spatial Extent**:
Site (S);
Locally patchy (LP);
Locally even (LE);
Widespread patchy (WP);
Widespread even (WE); or
No Overlap in space and/or time (NO).



2 **Frequency of occurrence:**
Rare (R);
Occasional (O);
Common (C); or
Persistent (P)

3 **Degree of Impact:**
Severe - Acute (A): direct high mortality (one event);
Severe - Chronic (C): high mortality after frequent / continuous pressure; or
Low severity (L): no mortality.

4 **Resilience (recovery time):**
None (no recovery or >100yr) (N);
Low (10 to <100 yr) (L);
Medium (2 to <10 yr) (M); or
High (0 to <2 yr) (H).

Resilience of an ecological characteristic will not vary between sector/pressures.

5 **Pressure Persistence:**
Continuous (the pressure never leaves the system or >100 yr) (C);
High (10 to <100 yr) (H);
Medium (2 to <10 yr) (M); or
Low (0 to <2 yr) (L).

Persistence of a pressure should not vary between sectors.

Annex 3 Linkage tables for the Pressure Assessment

Sector / pressure combinations

Sectors	Pressures																						
	Abrasion	Barrier_to_species_movement	Change_in_wave_exposure	Changes_in_siltation	Death_or_injury_by_collision	Electromagnetic_changes	Emergence_regime_change	Input_of_organic_matter	Introduction_of_microbial_pathog	Introduction_of_non_indigenous_s	Introduction_of_Non_synthetic_co	Introduction_of_Radionuclides	Introduction_of_Synthetic_compou	Marine_Litter	Nitrogen_and_Phosphorus_enrichme	pH_changes	Salinity_regime_changes	Selective_Extraction_of_Non_livi	Selective_extraction_of_species	Smothering	Substrate_Loss	Thermal_regime_changes	Underwater_noise	Water_flow_rate_changes
(Hydro) Power Station Construction	X			X									X	X						X	X		X	
(Hydro) Power Station Operations		X	X	X			X				X		X				X	X				X	X	X
Aggregates	X			X				X			X	X	X					X	X	X	X		X	X
Agriculture				X				X	X		X		X		X	X	X							X
Aquaculture	X			X				X	X	X	X		X	X	X	X			X	X	X		X	
Carbon sequestration	X			X	X						X		X	X		X				X	X		X	
Coastal Infrastructure (construction)	X		X	X			X											X		X	X		X	X
Coastal Infrastructure (operations)	X		X	X			X		X	X			X	X			X					X	X	X
Desalination				X				X			X		X			X	X	X				X		X
Fishing - Benthic trawling	X			X	X			X	X	X	X		X	X					X	X	X		X	
Fishing - Fixed Nets incl. potting and creeling		X						X					X	X					X				X	X
Fishing - Pelagic trawling					X			X	X	X	X		X	X	X				X				X	
Harvesting/Collecting	X		X	X															X	X	X			X
Land-based Industry				X					X		X	X	X	X	X	X	X					X		X
Military	X	X		X	X				X	X	X	X	X	X							X		X	
Navigational Dredging	X			X				X			X	X	X					X		X	X		X	X
Non-renewable Energy (Nuclear) Construction	X			X									X	X						X	X		X	
Non-renewable Energy (Nuclear) Operations				X							X	X	X				X	X				X		X
Non-renewable Energy (oil & gas construction)	X			X	X						X		X							X	X		X	
Non-renewable Energy (oil & gas operations)	X			X	X			X	X		X	X	X	X				X		X			X	

Sectors	Pressures																							
	Abrasion	Barrier_to_species_movement	Change_in_wave_exposure	Changes_in_siltation	Death_or_injury_by_collision	Electromagnetic_changes	Emergence_regime_change	Input_of_organic_matter	Introduction_of_microbial_pathog	Introduction_of_non_indigenous_s	Introduction_of_Non_synthetic_co	Introduction_of_Radionuclides	Introduction_of_Synthetic_compou	Marine_Litter	Nitrogen_and_Phosphorus_enrichme	pH_changes	Salinity_regime_changes	Selective_Extraction_of_Non_livi	Selective_extraction_of_species	Smothering	Substrate_Loss	Thermal_regime_changes	Underwater_noise	Water_flow_rate_changes
Renewable Energy (wind) - construction	X			X	X						X		X							X	X		X	
Renewable Energy (wind) - operations		X	X	X	X	X	X										X	X					X	X
Research	X			X	X				X	X			X						X	X			X	
Shipping	X				X				X	X	X		X	X									X	
Telecommunications construction	X			X	X									X						X	X		X	
Telecommunications operations						X																		
Tourism/Recreation	X			X	X			X	X	X	X		X	X	X	X		X	X	X	X		X	X
Waste Water Treatment				X				X	X	X	X		X		X	X	X					X		X

Pressure / ecological characteristic combinations

Pressures	Ecological characteristics				
	BIRD	FDEM	FDS	FPEL	MAMMS
Abrasion					
Barrier_to_species_movement	X	X		X	X
Change_in_wave_exposure	X	X		X	X
Changes_in_siltation	X	X	X	X	X
Death_or_injury_by_collision	X	X	X	X	X
Electromagnetic_changes		X	X	X	X
Emergence_regime_change	X	X		X	X
Input_of_organic_matter	X	X	X	X	X
Introduction_of_microbial_pathogens	X	X		X	X
Introduction_of_non_indigenous_species	X	X	X	X	X
Introduction_of_Non_synthetic_compounds	X	X	X	X	X
Introduction_of_Radionuclides	X	X	X	X	X
Introduction_of_Synthetic_compounds	X	X	X	X	X
Marine_Litter	X	X	X	X	X
Nitrogen_and_Phosphorus_enrichment		X	X	X	X
pH_changes		X		X	X
Salinity_regime_changes	X	X		X	X
Selective_Extraction_of_Non_living resources		X		X	X
Selective_extraction_of_species	X	X	X	X	X
Smothering					
Substrate_Loss	X	X	X	X	X
Thermal_regime_changes	X	X		X	X
Underwater_noise	X	X	X	X	X
Water_flow_rate_changes	X	X		X	X

Sector presence in the EU regions

Sector	Region			
	Baltic Sea	**Black Sea**	**Mediterra-nean Sea**	**North East Atlantic**
(Hydro) Power Station Construction	X		X	X
(Hydro) Power Station Operations	X		X	X
Aggregates	X	X	X	X
Agriculture	X	X	X	X
Aquaculture	X	X	X	X
Carbon sequestration				
Coastal Infrastructure (construction)	X	X	X	X
Coastal Infrastructure (operations)	X	X	X	X
Desalination			X	
Fishing - Benthic trawling	X	X	X	X
Fishing - Fixed Nets incl. potting and creeling	X	X	X	X
Fishing - Pelagic trawling	X	X	X	X
Harvesting/Collecting	X	X	X	X
Land-based Industry	X	X	X	X
Military	X	X	X	X
Navigational Dredging	X	X	X	X
Non-renewable Energy (Nuclear) Construction	X			X
Non-renewable Energy (Nuclear) Operations	X			X
Non-renewable Energy (oil & gas construction)	X	X	X	X
Non-renewable Energy (oil & gas operations)	X	X	X	X
Renewable Energy (wind) - construction	X			X
Renewable Energy (wind) - operations	X			X
Research	X	X	X	X
Shipping	X	X	X	X
Telecommunications construction	X	X	X	X
Telecommunications operations	X	X	X	X
Tourism/Recreation	X	X	X	X
Waste Water Treatment	X	X	X	X

Ecological characteristic presence in the EU regions

Ecological characteristic	Region			
	Baltic Sea	**Black Sea**	**Mediterra-nean Sea**	**North East Atlantic**
Deep sea fish			X	X
Demersal fish	X	X	X	X
Pelagic fish	X	X	X	X
Marine mammals & reptiles	X	X	X	X
Seabirds	X	X	X	X

Annex 4 Background table for the Degree of Impact

Degree of Impact

Pressure	Sector	Deep sea fish	Demersal fish	Pelagic fish	Marine mammals & reptiles	Seabirds
Abrasion (mortality/change in physical properties)	All	NR	NR	NR	NR	NR
Barrier to species movement	(Hydro) Power Station Operations	NR	C	C	A	NR
	Fishing - Fixed Nets incl. potting and creeling	NR	C	C	L	NR
	Military	NR	L	L	L	NR
	Renewable Energy (wind) - operations	NR	NR	NR	L	C
Changes in wave exposure	All	NR	L	L	L	NR
Changes in siltation	All	L	L	L	L	L
Death or injury by collision	Fishing - Benthic trawling; Pelagic trawling	L	L	L	A	L
	Military; Shipping, Tourism/recreation	NR	L	L	A	L
	Non-renewable Energy (oil & gas construction); Renewable Energy (wind) – construction; Research; Telecommunications construction	NR	L	L	L	L
	Renewable Energy (wind) – operations; Non-renewable Energy (oil & gas operations)	NR	L	L	L	A
Electromagnetic changes	All	L	L	L	L	NR
Emergence regime change	All	NR	L	L	L	L
Input of organic matter	All	L	L	L	NR	NR
Introduction of microbial pathogens	All	NR	C	C	L	L
Introduction of non-indigenous spp. and translocations	All	C	C	C	NR	NR
Introduction of Non-synthetic compounds	All	C	C	C	C	C
Introduction of other substances	All	NR	NR	NR	NR	NR
Introduction of Radionuclides	All	C	C	C	C	C
Introduction of Synthetic compounds	All	C	C	C	C	C
Marine litter	Fishing - Benthic trawling; pelagic trawling; Fixed Nets incl. potting and creeling	A	A	A	A	A
	Other sectors	L	L	L	L	L
Nitrogen and Phosphorus enrichment	Agriculture; Tourism/Recreation; Waste Water Treatment	NR	C/L	C/L	NR	NR
	Aquaculture; Fishing - Pelagic	NR	L	L	NR	NR

Pressure	Sector	Deep sea fish	Demersal fish	Pelagic fish	Marine mammals & reptiles	Seabirds
	trawling; Land-based Industry					
pH changes	All	NR	L	L	L	NR
Salinity regime changes	All	NR	L	L	L	NR
Selective Extraction of Non-living Resources	All	NR	L	L	L	NR
Selective extraction of species	Fishing – Fixed nets incl. potting and creeling	A	A	A	A	A
	Fishing – Benthic trawling; Fishing - Pelagic trawling	A	A	A	A	L
	Aquaculture; Research; Tourism/recreation	A	A	A	L	L
Smothering	All	NR	NR	NR	NR	NR
Substrate Loss (permanent construction/sealing)	All	A	A	A	L	L
Thermal regime changes	All	NR	L	L	L	L
Underwater noise	(Hydro) Power Station Construction; Coastal infrastructure construction; Military; Non-renewable Energy (Nuclear) Construction; Renewable Energy (wind) - construction	NR	A	A	A	L
	(Hydro) Power Station Operations; Aggregates; Aquaculture; Coastal Infrastructure (operations); Navigational Dredging; Renewable Energy (wind) – operations; Research; Tourism/Recreation	NR	L	L	L	L
	Fishing - Benthic trawling; pelagic trawling; Fixed Nets incl. potting and creeling; Non-renewable Energy (oil & gas operations); Shipping; Telecommunications construction	L	L	L	L	L
	Non-renewable Energy (oil & gas construction)	A	A	A	A	L
Water flow rate changes	All	NR	L	L	L	L

A = Acute C = Chronic L = Low NO = no effect,

L	Low
C	Chronic
A	Acute
NR	Not relevant (no overlap)

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Annex 5 Background table for the Pressure Persistence

Persistence

Pressure	Sector	Deep sea fish	Demersal fish	Pelagic fish	Marine mammals & reptiles	Seabirds
Abrasion (mortality/change in physical properties)	All	NR	NR	NR	NR	NR
Barrier to species movement	(Hydro)power stations	NR	C	C	C	C
	Other sectors	NR	L	L	L	L
Changes in siltation	All	L	L	L	L	L
Changes in wave exposure	Coastal infrastructure	NR	C	C	C	NR
	All but coastal infrastructure	NR	H/M/L	L	L	NR
Death or injury by collision	All	L	L	L	L	L
Electromagnetic changes	All	L	L	L	L	NR
Emergence regime change	Coastal infrastructure, (hydro)powerstations	NR	C	C	C	C
	Renewable energy (wind) operations	NR	NR	NR	NR	NR
Input of organic matter	All	M	L	L	NR	NR
Introduction of microbial pathogens	All	NR	L	L	L	L
Introduction of non-indigenous spp. and translocations	All	C	C	C	NR	NR
Introduction of Non-synthetic compounds	All	H	H	H	H	H
Introduction of other substances	All	NR	NR	NR	NR	NR
Introduction of Radionuclides	All	C	C	C	C	C
Introduction of Synthetic compounds	All	H	H	H	H	H
Marine Litter	All	H	H	H	H	H
Nitrogen and Phosphorus enrichment	All	M	H/M/L	H/M/L	H/M/L	H/M/L
pH changes	All	NR	L	L	NR	NR
Salinity regime changes	All	NR	L	L	L	NR
Selective Extraction of Non-living Resources	All	NR	L	L	NR	NR
Selective extraction of species	All	L	L	L	L	L
Smothering	All	NR	NR	NR	NR	NR
Substrate Loss (permanent construction/sealing)	Coastal infrastructure (construction)	NR	C	C	C	C
	All but coastal infrastructure	NR	M	M	M	M
Thermal regime changes	All	NR	L	L	L	NR
Underwater noise	All	L	L	L	L	L

Pressure	Sector	Deep sea fish	Demersal fish	Pelagic fish	Marine mammals & reptiles	Seabirds
Water flow rate changes	Coastal infrastructure	NR	C	C	C	C
	Aggregates, Navigational dredging	NR	M	M	M	M
	Others	NR	L	L	L	L

L	Low (0 to < 2 yr)
M	Medium (2 to < 10 yr)
H	High (10 to <100 yr)
C	Continuous (the pressure never leaves the system or >100 yr)
NR	Not relevant (no overlap)

Literature Persistence

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Annex 6 Background table for Resilience

Resilience

Region	Deep fish	Demersal fish	Pelagic fish	Marine mammals	Seabirds
NEA	L	L	L	L	L
BALTIC SEA	NR	L	L	L	L
BLACK SEA	NR	M	L	L	L
MEDITERRANEAN SEA	L	L	L	L	L

L	Low (10 to 100 yr)
M	Medium (2 to 10 yr)
H	High (0 to 2 yr)
NR	Not relevant because the ecocomponent is not found

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Confidence of resilience assessment

Region	Deep sea fish	Demersal fish	Pelagic fish	Marine mammals	Seabirds
NEA	Medium	High	High	High	High
BALTIC SEA	NR	Low	Low	Low	Low
BLACK SEA	NR	Low	Low	Low	High
MEDITERRANEAN SEA	High	Medium	Medium	High	Low

Annex 7 Final Pressure Assessment Results

Small subset showing the sector aggregates for the Baltic region and the sector fishing – benthic trawling for the North East Atlantic.

Region	Sector	Pressure	Eco char	Ext.	Fr.	DoI	Res.	Persist.
BALTIC	Aggregates	Abrasion	BIRD	NO				
BALTIC	Aggregates	Abrasion	FDEM	NO				
BALTIC	Aggregates	Abrasion	FPEL	NO				
BALTIC	Aggregates	Abrasion	MAMMS	NO				
BALTIC	Aggregates	Changes_in_siltation	BIRD	LP	C	L	L	L
BALTIC	Aggregates	Changes_in_siltation	FDEM	LP	C	L	L	L
BALTIC	Aggregates	Changes_in_siltation	FPEL	LP	C	L	L	L
BALTIC	Aggregates	Changes_in_siltation	MAMMS	LP	C	L	L	L
BALTIC	Aggregates	Input_of_organic_matter	BIRD	LP	C	L	L	L
BALTIC	Aggregates	Input_of_organic_matter	FDEM	S	C	L	L	L
BALTIC	Aggregates	Input_of_organic_matter	FPEL	LP	C	L	L	L
BALTIC	Aggregates	Input_of_organic_matter	MAMMS	LP	C	L	L	L
BALTIC	Aggregates	Intr._of_Non_synthetic_co	BIRD	LP	R	C	L	H
BALTIC	Aggregates	Intr._of_Non_synthetic_co	FDEM	LP	R	C	L	H
BALTIC	Aggregates	Intr._of_Non_synthetic_co	FPEL	LP	R	C	L	H
BALTIC	Aggregates	Intr._of_Non_synthetic_co	MAMMS	LP	R	C	L	H
BALTIC	Aggregates	Intr._of_Radionuclides	BIRD	NO				
BALTIC	Aggregates	Intr._of_Radionuclides	FDEM	NO				
BALTIC	Aggregates	Intr._of_Radionuclides	FPEL	NO				
BALTIC	Aggregates	Intr._of_Radionuclides	MAMMS	NO				
BALTIC	Aggregates	Intr._of_Synthetic_compou	BIRD	LP	O	C	L	H
BALTIC	Aggregates	Intr._of_Synthetic_compou	FDEM	LP	O	C	L	H
BALTIC	Aggregates	Intr._of_Synthetic_compou	FPEL	LP	O	C	L	H
BALTIC	Aggregates	Intr._of_Synthetic_compou	MAMMS	LP	O	C	L	H
BALTIC	Aggregates	Sel._Extraction_of_Non_livi	BIRD	NO				
BALTIC	Aggregates	Sel._Extraction_of_Non_livi	FDEM	NO				
BALTIC	Aggregates	Sel._Extraction_of_Non_livi	FPEL	NO				
BALTIC	Aggregates	Sel._Extraction_of_Non_livi	MAMMS	NO				
BALTIC	Aggregates	Sel._extraction_of_species	BIRD	NO				
BALTIC	Aggregates	Sel._extraction_of_species	FDEM	S	P	A	L	L
BALTIC	Aggregates	Sel._extraction_of_species	FPEL	NO				
BALTIC	Aggregates	Sel._extraction_of_species	MAMMS	NO				
BALTIC	Aggregates	Smothering	BIRD	NO				
BALTIC	Aggregates	Smothering	FDEM	NO				
BALTIC	Aggregates	Smothering	FPEL	NO				
BALTIC	Aggregates	Smothering	MAMMS	NO				
BALTIC	Aggregates	Substrate_Loss	BIRD	LP	C	L	L	M
BALTIC	Aggregates	Substrate_Loss	FDEM	LP	C	A	L	M
BALTIC	Aggregates	Substrate_Loss	FPEL	NO				
BALTIC	Aggregates	Substrate_Loss	MAMMS	LP	C	L	L	M
BALTIC	Aggregates	Underwater_noise	BIRD	LP	P	L	L	L
BALTIC	Aggregates	Underwater_noise	FDEM	LP	P	L	L	L
BALTIC	Aggregates	Underwater_noise	FPEL	LP	P	L	L	L
BALTIC	Aggregates	Underwater_noise	MAMMS	LP	P	L	L	L
BALTIC	Aggregates	Water_flow_rate_changes	BIRD	NO				
BALTIC	Aggregates	Water_flow_rate_changes	FDEM	NO				
BALTIC	Aggregates	Water_flow_rate_changes	FPEL	NO				
BALTIC	Aggregates	Water_flow_rate_changes	MAMMS	NO				
NEA	Fishing - Benthic trawling	Abrasion	BIRD	NO				

Region	Sector	Pressure	Eco char	Ext.	Fr.	DoI	Res.	Persist.
NEA	Fishing - Benthic trawling	Abrasion	FDEM	NO				
NEA	Fishing - Benthic trawling	Abrasion	FDS	NO				
NEA	Fishing - Benthic trawling	Abrasion	FPEL	NO				
NEA	Fishing - Benthic trawling	Abrasion	MAMMS	NO				
NEA	Fishing - Benthic trawling	Changes_in_siltation	BIRD	NO				
NEA	Fishing - Benthic trawling	Changes_in_siltation	FDEM	WP	P	L	L	L
NEA	Fishing - Benthic trawling	Changes_in_siltation	FDS	LP	P	L	L	L
NEA	Fishing - Benthic trawling	Changes_in_siltation	FPEL	WP	P	L	L	L
NEA	Fishing - Benthic trawling	Changes_in_siltation	MAMMS	LP	P	L	L	L
NEA	Fishing - Benthic trawling	Death_or_injury_by_collision	BIRD	S	R	L	L	L
NEA	Fishing - Benthic trawling	Death_or_injury_by_collision	FDEM	WP	P	L	L	L
NEA	Fishing - Benthic trawling	Death_or_injury_by_collision	FDS	WP	P	L	L	L
NEA	Fishing - Benthic trawling	Death_or_injury_by_collision	FPEL	NO				
NEA	Fishing - Benthic trawling	Death_or_injury_by_collision	MAMMS	LP	O	A	L	L
NEA	Fishing - Benthic trawling	Input_of_organic_matter	BIRD	NO				
NEA	Fishing - Benthic trawling	Input_of_organic_matter	FDEM	WP	C	L	L	L
NEA	Fishing - Benthic trawling	Input_of_organic_matter	FDS	WP	C	L	L	M
NEA	Fishing - Benthic trawling	Input_of_organic_matter	FPEL	WP	C	L	L	L
NEA	Fishing - Benthic trawling	Input_of_organic_matter	MAMMS	NO				
NEA	Fishing - Benthic trawling	Intr._of_microbial_pathog	BIRD	NO				
NEA	Fishing - Benthic trawling	Intr._of_microbial_pathog	FDEM	NO				
NEA	Fishing - Benthic trawling	Intr._of_microbial_pathog	FDS	NO				
NEA	Fishing - Benthic trawling	Intr._of_microbial_pathog	FPEL	NO				
NEA	Fishing - Benthic trawling	Intr._of_microbial_pathog	MAMMS	NO				
NEA	Fishing - Benthic trawling	Intr._of_non_indigenous_s	BIRD	NO				
NEA	Fishing - Benthic trawling	Intr._of_non_indigenous_s	FDEM	WP	C	C	L	C
NEA	Fishing - Benthic trawling	Intr._of_non_indigenous_s	FDS	LP	O	C	L	C
NEA	Fishing - Benthic trawling	Intr._of_non_indigenous_s	FPEL	WP	C	C	L	C
NEA	Fishing - Benthic trawling	Intr._of_non_indigenous_s	MAMMS	NO				
NEA	Fishing - Benthic trawling	Intr._of_Non_synthetic_co	BIRD	S	C	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Non_synthetic_co	FDEM	WP	C	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Non_synthetic_co	FDS	LP	R	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Non_synthetic_co	FPEL	WP	C	C	L	H
NEA	Fishing - Benthic trawling	Intr_ of_Non_synthetic_co	MAMMS	WP	C	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Synthetic_compou	BIRD	S	C	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Synthetic_compou	FDEM	WP	C	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Synthetic_compou	FDS	LP	O	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Synthetic_compou	FPEL	WP	C	C	L	H
NEA	Fishing - Benthic trawling	Intr._of_Synthetic_compou	MAMMS	WP	C	C	L	H
NEA	Fishing - Benthic trawling	Marine_Litter	BIRD	S	C	A	L	H
NEA	Fishing - Benthic trawling	Marine_Litter	FDEM	WP	C	A	L	H
NEA	Fishing - Benthic trawling	Marine_Litter	FDS	WP	C	A	L	H
NEA	Fishing - Benthic trawling	Marine_Litter	FPEL	LP	C	A	L	H
NEA	Fishing - Benthic trawling	Marine_Litter	MAMMS	LP	C	A	L	H
NEA	Fishing - Benthic trawling	Sel._extraction_of_species	BIRD	NO				
NEA	Fishing - Benthic trawling	Sel._extraction_of_species	FDEM	WP	P	A	L	L
NEA	Fishing - Benthic trawling	Sel._extraction_of_species	FDS	WP	P	A	L	L
NEA	Fishing - Benthic trawling	Sel._extraction_of_species	FPEL	NO				
NEA	Fishing - Benthic trawling	Sel._extraction_of_species	MAMMS	S	P	A	L	L
NEA	Fishing - Benthic trawling	Smothering	BIRD	NO				
NEA	Fishing - Benthic trawling	Smothering	FDEM	NO				
NEA	Fishing - Benthic trawling	Smothering	FDS	NO				
NEA	Fishing - Benthic trawling	Smothering	FPEL	NO				

Region	Sector	Pressure	Eco char	Ext.	Fr.	DoI	Res.	Persist.
NEA	Fishing - Benthic trawling	Smothering	MAMMS	NO				
NEA	Fishing - Benthic trawling	Substrate_Loss	BIRD	LP	P	L	L	M
NEA	Fishing - Benthic trawling	Substrate_Loss	FDEM	WP	P	A	L	M
NEA	Fishing - Benthic trawling	Substrate_Loss	FDS	NO				
NEA	Fishing - Benthic trawling	Substrate_Loss	FPEL	WP	P	A	L	M
NEA	Fishing - Benthic trawling	Substrate_Loss	MAMMS	S	P	L	L	M
NEA	Fishing - Benthic trawling	Underwater_noise	BIRD	NO				
NEA	Fishing - Benthic trawling	Underwater_noise	FDEM	WP	P	L	L	L
NEA	Fishing - Benthic trawling	Underwater_noise	FDS	LP	P	L	L	L
NEA	Fishing - Benthic trawling	Underwater_noise	FPEL	WP	P	L	L	L
NEA	Fishing - Benthic trawling	Underwater_noise	MAMMS	WP	P	L	L	L

Annex 8 Indicators proposed for each Descriptor-Attribute-Indicator according to the MSFD and ecosystem component

Descriptor Attribute Indicator	Ecosystem component	Proposed specific indicator
1.1.1	Benthic flora and fauna	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.1	Birds	Distribution of wintering seabird populations
1.1.1	Bottom fauna and flora	priority species, vulnerable benthos species, posidonia
1.1.1	Bottom fauna and flora	vulnerable benthos fauna species (AMBI and M-AMBI, Shannon Diversty Index) ; vulnerable benthos flora species (Ecological Inex - EEI)
1.1.1	Fish	declining fish species
1.1.1	Fish	Distributional range of Fish (Continental Shelf Seas and Shelf-edge seas)
1.1.1	Fish	Temporal development of Baltic coastal fish communities and key species
1.1.1	Fish	threat indicator for fish
1.1.1	Marine mammals & Reptiles	all currently present marine mammals
1.1.1	Marine mammals & Reptiles	Distribution of harbour porpoise
1.1.1	Marine mammals & Reptiles	Marine mammals & Reptiles
1.1.1	Marine mammals and reptiles	Distributional range of harbour seal, and distributional range of breeding grey seal
1.1.1	Plankton	N/A
1.1.1	Plankton	Phytoplankton and zooplankton diversity
1.1.1	Plankton	Phytoplankton and zooplankton diversity (proposed specific indicators: index of Menhinic and Index of Sheldon, Integrated

		Biological Index - IBI)
1.1.1	Plankton	Phytoplankton and zooplankton diversity (proposed specific indicators: Microflagellates+Euglenophiceae+Cyanophiceae - MEC % of total abunance, index of Menhinic and Index of Sheldon, Integrated Biological Index - IBI)
1.1.1	Plankton	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.1	Seabirds	Distributional range of breeding seabirds, coastal breeding waterbirds, non-breeding waterbirds, and non-breeding shorebirds.
1.1.1	Seabirds	vulnerable bird species
1.1.2	Bottom fauna and flora	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.2	Bottom fauna and flora	vulnerable benthos species
1.1.2	Fish	declining fish species
1.1.2	Fish	Distributional range of Fish (Continental Shelf Seas and Shelf-edge seas)
1.1.2	Fish	threat indicator for fish
1.1.2	Marine mammals & Reptiles	all currently present marine mammals
1.1.2	Marine mammals & Reptiles	Distributional pattern within range of harbour porpoises, bottle nose dolphins, long fin pilot whales, white beaked dolphin, short beaked common dolphin, minke whales in the summer, harbour seals, and grey seal breeding
1.1.2	Plankton	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.2	Seabirds	Distributional pattern of breeding seabirds, coastal breeding waterbirds, non-breeding waterbirds, seabirds at sea, and non-breeding shorebirds; Indicator will be further developed
1.1.2	Seabirds	vulnerable bird species
1.1.3	Bottom fauna and flora	Blue mussel cover
1.1.3	Bottom fauna and flora	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.3	Bottom fauna and flora	vulnerable benthos species (Cystseira barbata, Zostera noltii, Mytilus galloprovincialis)
1.1.3	Fish	declining fish species: species X

1.1.3	Fish	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.3	Fish	threat indicator for fish
1.1.3	Marine mammals & Reptiles	all currently present marine mammals
1.1.3	Marine mammals & Reptiles	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.3	Seabirds	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.1.3	Seabirds	vulnerable bird species
1.2.1	birds	Abundance of wintering populations of seabirds
1.2.1	Bottom fauna and flora	Cladophora length
1.2.1	Bottom fauna and flora	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.2.1	Bottom fauna and flora	species abundance and biomass (bottom fauna and flora)
1.2.1	Bottom fauna and flora	vulnerable benthos species
1.2.1	Fish	all stocks
1.2.1	Fish	declining fish species: species X
1.2.1	Fish	declining fish species:sturgeon/demersial
1.2.1	Fish	Fish population abundance
1.2.1	Fish	Offshore fish populations and communities
1.2.1	Fish	Population abundance of fish, and fish population biomass
1.2.1	Fish	Salmon smolt production capacity
1.2.1	Fish	Sea trout parr density, quality of spawning habitats
1.2.1	Fish	threat indicator for fish
1.2.1	Marine mammals & Reptiles	Abundance of three inshore bottle nose dolphins, harbour porpoises, bottle nose dolphins, long fin pilot whales, white beaked dolphin, short beaked common dolphin, minke whales in the summer, harbour seals, and grey seal breeding

1.2.1	Marine mammals & Reptiles	all currently present marine mammals
1.2.1	Marine mammals & Reptiles	all marine mammals, i.e. Odontoceti.
1.2.1	Marine mammals & Reptiles	Population growth rate of marine mammals
1.2.1	Plankton	N/A
1.2.1	Plankton	Refer to indicators in attributes 1.4 and 1.6 (Habitats)
1.2.1	Plankton	species abundance and biomass (phyto-, zooplankton)
1.2.1	Plankton	species abundance and biomass, target developed only for Bac:Din biomass ratio (in spring)
1.2.1	Seabirds	Species-specific trends in relative breeding and non-breeding abundance
1.2.1	Seabirds	vulnerable bird species
1.3.1	Birds	White-tailed eagle productivity
1.3.1	Fish	EcoQO proportion large fish
1.3.1	Fish	Mean metric length of key fish species
1.3.1	Fish	proportion large fish
1.3.1	Fish	Proportion of mature fish
1.3.1	Marine mammals	Annual calf production of Scottish east coast and Cardigan Bay area bottlenose dolphin populations
1.3.1	Marine mammals	Grey seal pup production
1.3.1	Marine mammals	Harbour seal pup production
1.3.1	Marine mammals & Reptiles	Blubber thickness of marine mammals
1.3.1	Marine mammals &	EcoQO seal populations

	Reptiles	
1.3.1	Marine mammals & Reptiles	Pregnancy rate of marine mammals
1.3.1	Seabirds	Annual breeding success of kittiwakes
1.3.1	Seabirds	Breeding failure of seabird species sensitive to food availability
1.3.1	Seabirds	Seabird adult survival
1.3.2	Fish	probabilistic maturation reaction norm (i.e. the probability of maturing)
1.3.2	Marine mammals	Harbour seal genetics
1.4.1	Habitat	Based on EUNIS level 3 habitat maps
1.4.1	Pelagic habitats	Change of plankton functional types (life form) index
1.4.1	Rock and biogenic reef habitats	Distributional range of habitat
1.4.1	Sediment habitats	Distributional range of habitat
1.4.2	Habitat	Based on EUNIS level 3 habitat maps
1.4.2	Pelagic habitats	Change of plankton functional types (life form) index
1.4.2	Rock and biogenic reef habitats	Distributional pattern of habitat
1.4.2	Sediment habitats	Distributional pattern of habitat
1.5.1	Habitat	Based on EUNIS level 3 habitat maps
1.5.1	Habitat	Lower depth distribution limit of macrophyte species
1.5.1	Rock and biogenic reef habitats	Area of subtidal biogenic structures, intertidal rock habitats, subtidal rock habitats, littoral chalk habitats, and sea caves

1.5.1	Sediment habitats	Area of sediment habitat
1.5.2	Habitat	Based on EUNIS level 3 habitat maps
1.6.1	Bottom fauna and flora	Lower depth distribution limit of macrophyte species
1.6.1	Bottom fauna and flora	Population structure of long-lived macrozoobenthic species
1.6.1	Bottom fauna and flora	vulnerable benthos species
1.6.1	Fish	Fish community diversity
1.6.1	Fish	Proportion of large fish in the community
1.6.1	Pelagic habitats	Change of plankton functional types (life form) index
1.6.1	Rock and biogenic reef habitats	Abundance of typical species on biogenic reef
1.6.1	Rock and biogenic reef habitats	Boulder turning index
1.6.1	Rock and biogenic reef habitats	Density of biogenic reef forming species
1.6.1	Rock and biogenic reef habitats	Epifaunal indicator species
1.6.1	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Penetration and/or disturbance of the substrate below the surface of the seabed' (Physical pressure)
1.6.1	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Removal of non-target species' (Biological pressure)
1.6.1	Rock and	Impact/Vulnerability of habitat to 'Removal of target species' (Biological pressure)

	biogenic reef habitats	
1.6.1	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Shallow abrasion/penetration: damage to seabed surface and penetration' (Physical pressure)
1.6.1	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Surface abrasion: damage to seabed surface features' (Physical pressure)
1.6.1	Rock and biogenic reef habitats	Intertidal community indicator (MarClim)
1.6.1	Rock and biogenic reef habitats	Intertidal species composition & abundance
1.6.1	Rock and biogenic reef habitats	Kelp depth and kelp park depth
1.6.1	Rock and biogenic reef habitats	Sponge diversity
1.6.1	Rock and biogenic reef habitats	Subtidal species composition & abundance (sponge anthozoan community)
1.6.1	Sediment habitats	Impact/Vulnerability of habitat to 'Penetration and/or disturbance of the substrate below the surface of the seabed' (Physical damage)
1.6.1	Sediment habitats	Impact/Vulnerability of habitat to 'Removal of non-target species' (Biological pressure)
1.6.1	Sediment habitats	Impact/Vulnerability of habitat to 'Removal of target species' (Biological pressure)
1.6.1	Sediment habitats	Impact/Vulnerability of habitat to 'Shallow abrasion/penetration: damage to seabed surface and penetration' (Physical damage)
1.6.1	Sediment habitats	Impact/Vulnerability of habitat to 'Surface abrasion: damage to seabed surface features' (Physical damage)

1.6.1	Sediment habitats	Infaunal Quality Index
1.6.1	Sediment habitats	Opportunistic macroalgae
1.6.1	Sediment habitats	Saltmarsh WFD classification tool
1.6.1	Sediment habitats	Sediment profile imaging
1.6.1	Sediment habitats	WFD seagrass tool
1.6.2	Bottom fauna and flora	vulnerable benthic species
1.6.2	Bottom fauna and flora	vulnerable benthos species
1.6.2	Fish	Abundance of fish key trophic groups
1.6.2	Pelagic habitats	Phytoplankton biomass
1.6.2	Pelagic habitats	Zooplankton biomass
1.6.3	All	Hhydrogen sulphide depth
1.6.3	All	Water transparency, Inorganic N, Inorganic P, Si, Chl a
1.6.3	All	Water transparency, Inorganic N, P, Si, Chl a
1.6.3	Bottom fauna and flora	vulnerable benthos species
1.6.3	Sediment habitats	Sediment profile imaging
1.6.3		Near bottom oxygen conditions
1.6.3		Water transparency, Inorganic N, Inorganic P, Chl a
1.7.1	All	Ecosystem regime state in the Baltic Proper, Gulf of Riga, Gulf of Finland, and the Bothnian Sea
1.7.1	All	Fish community trophic index
1.7.1	Bottom fauna and flora	Multidimensional biodiversity indices taking both incorporating species richness and evenness, e.g. Hill's indices

1.7.1	Fish	Fish relative abundance
1.7.1	Fish	Multidimensional biodiversity indices taking both incorporating species richness and evenness, e.g. Hill's indices
1.7.1	Pelagic habitats	change in all pelagic indicators for D1, D4, D5.2.4, D6
1.7.1	Plankton	Multidimensional biodiversity indices taking both incorporating species richness and evenness, e.g. Hill's indices
1.7.1	Plankton	N/A
1.7.1	Seabirds	Bird Value
1.7.1	Seabirds	N/A
2.1.1	All	Abundance and distribution of non-indigenous invasive species, focused on M.leidyi and Rapana venosa
2.1.1	All	Trends in arrivals of new non-indigenous species
2.1.1	Bottom fauna and flora	Abundance and distribution of non-indigenous invasive species
2.1.1	Bottom fauna and flora	number of species and abundance
2.1.1	Bottom fauna and flora	risk of introduction of NIS
2.1.1	Bottom fauna and flora	Trends in arrival of new non-indigenous species
2.1.1	Fish	Abundance and distribution of non-indigenous invasive species
2.1.1	Fish	number of species and abundance
2.1.1	Fish	risk of introduction of NIS
2.1.1	Fish	Trends in arrival of new non-indigenous species
2.1.1	Plankton	Abundance and distribution of non-indigenous invasive species
2.1.1	Plankton	number of species and abundance
2.1.1	Plankton	risk of introduction of NIS
2.1.1	Plankton	Trends in arrival of new non-indigenous species
2.2.1	Bottom fauna and flora	between invasive non-indigenous species and native species
2.2.1	Bottom fauna and flora	Ratio between invasive non-indigenous species and native species

2.2.1	Bottom fauna and flora	ratio NIS/IS
2.2.1	Fish	ratio NIS/IS
2.2.1	Plankton	ratio NIS/IS
2.2.2	All	Biopollution index
2.2.2	Bottom fauna and flora	Impacts of NIS
2.2.2	Bottom fauna and flora	to be determined, depending on impact
2.2.2	Fish	Impacts of NIS
2.2.2	Fish	to be determined, depending on impact
2.2.2	Plankton	abundance M. Leidyi (4 g m-3)
2.2.2	Plankton	Biopollution index
2.2.2	Plankton	Impacts of NIS
2.2.2	Plankton	to be determined, depending on impact
3.1.1	Bottom fauna and flora	Fishing mortality F
3.1.1	Fish	Fishing mortality F (for assessed species only)
3.1.2	Bottom fauna and flora	catch/biomass ratio
3.1.2	Bottom fauna and flora	indicator not used
3.1.2	Fish	catch/biomass ratio
3.1.2	Fish	indicator not used
3.2.1	Bottom fauna and flora	SSB (for selection of species)
3.2.1	Fish	SSB (for selection of species)
3.2.2	Bottom fauna and flora	Biomass indices
3.2.2	Bottom fauna and flora	Spawning stock biomass

3.2.2	Fish	Biomass indices
3.2.2	Fish	Spawning stock biomass
3.3.1	Fish	indicator not used
3.3.1	Fish	proportion of fish larger than mean size
3.3.1	Fish	proportion of fish larger than mean size (demersal fish)
3.3.1	Fish	Proportion of fish larger than the mean size of first sexual maturation
3.3.2	Fish	indicator not used
3.3.2	Fish	not a suitable indicator
3.3.3	Fish	95 percentile
3.3.3	Fish	indicator not used
3.3.4	Fish	probabilistic maturation reaction norm (i.e. the probability of maturing)
4.1.1	Birds	Annual breeding success of kittiwakes
4.1.1	Fish	abundance of key prey species
4.1.1	Marine mammals	Annual calf production of Scottish east coast and Cardigan Bay area bottlenose dolphin populations
4.1.1	Marine mammals	harbour seal pup and grey seal pup production
4.1.1	Marine mammals	population growth rate
4.1.1	Marine mammals & Reptiles	EcoQO seal populations
4.1.1	White-tailed eagle	productivity
4.2.1	Fish	EcoQO proprotion of large fish
4.2.1	Fish	Fish community trophic index
4.2.1	Fish	Large fish indicator
4.2.1	Fish	Proportion of piscivorous fish, non-piscivorous fish and cyprinids
4.2.1	Fish	Proportions of large fish
4.3.1	Birds	Species-specific trends in relative breeding and non-breeding abundance

4.3.1	Fish	Dietary functional group biomass
4.3.1	Fish	Marine Trophic Index
4.3.1	Macrophytes	Index of relative surface
4.3.1	Marine mammals	Abundance of harbour seals, three inshore bottle nose dolphin populations, harbour porpoises, white beaked dolphin, short beaked common dolphin, minke whale, bottle nose dolphin, long finned pilot whale
4.3.1	Marine mammals	Relative use of haulouts by grey and harbour seals
4.3.1	Marine mammals & Reptiles	EcoQO by-catch harbour porpoise
4.3.1	Marine mammals & Reptiles	EcoQO seal populations
4.3.1	Phytoplankton	Proportion of Diatoms from the total biomass
4.3.1	Zoobenthos	Proportion of Polychaeta to the total biomass
4.3.1	Zooplankton	Biomass of copepods
4.3.1	Zooplankton	Biomass of fooder zooplankton
4.3.1	Zooplankton	Biomass of microphagous mesozooplankton
5.1.1	Nutrients & Oxygen	DIN winter - spring means
5.1.1	Nutrients & Oxygen	DIN winter means
5.1.1	Nutrients & Oxygen	Nitrate and phosphates concentrations
5.1.1	Nutrients & Oxygen	TRIX index
5.1.1	Nutrients & Oxygen	Winter surfacfe concentration of dissolved inorganic nitrogen
5.1.1	Nutrients & Oxygen	Winter surfacfe concentration of dissolved inorganic phosphorus
5.1.1	Nutrients and oxygen	dissolved inorganic nitrogen and phosphorous concentration

5.1.2	Nutrients & Oxygen	DIN/DIP ratio winter means
5.1.2	Nutrients & Oxygen	DIN/DIP ratio winter-spring means
5.1.2	Nutrients & Oxygen	N/P ratio
5.1.2	Nutrients & Oxygen	N/Si and P/Si ratio in spring
5.1.2	Nutrients & Oxygen	OXYRISK index
5.1.2	Nutrients and oxygen	indicator not used
5.2.1	Nutrients and oxygen	chlorophyll 90 percentile in the growing season
5.2.1	Plankton	(90percentile growing season)
5.2.1	Plankton	90 percentile summer value
5.2.1	Plankton	90percentile growing season
5.2.1	Plankton	Chlorophyll concentration in the water column
5.2.1	Plankton	Summer phytoplankton, measured by chlorophyll a concentration
5.2.2	Nutrients and oxygen	indicator not used
5.2.2	Plankton	Frequency of N.scintillans blooms
5.2.2	Plankton	Frequency of summer blooms of phytoplankton
5.2.2	Plankton	not applicable
5.2.2	Plankton	The summer-time water clarity measured as Secchi depth
5.2.2	Plankton	water clarity measured as Secchi depth
5.2.3	Bottom fauna and flora	Cladophora length
5.2.3	Nutrients and oxygen	WFD opportunistic macroalgae tool
5.2.3	Plankton	not applicable

5.2.4	Nutrients and oxygen	eutrophication relevant plankton index
5.2.4	Pelagic habitats	Change of plankton functional types (life form) index
5.2.4	Plankton	Diatom - dinoflagellate ratio during spring bloom
5.2.4	Plankton	Extent of cyanobacterial blooms
5.2.4	Plankton	frequency of bloom/diatom to dinoflagellate ratio
5.2.4	Plankton	frequency of Phaeocystis blooms
5.3.1	Bottom fauna and flora	abundance of macrophytes and seegrasses (EEI)
5.3.1	Bottom fauna and flora	Biomass of Cystoseira barbata
5.3.1	Bottom fauna and flora	Ecological Inex (EI) for macrophyts
5.3.1	Bottom fauna and flora	Lower depth distribution limit of macrophyte species
5.3.1	Bottom fauna and flora	not applicable
5.3.1	Bottom fauna and flora	WFD macroalgae and seagrass tools
5.3.2	Nutrients & Oxygen	concentration of oxygen in water
5.3.2	Nutrients & Oxygen	Frequency of hypoxia (oxygenn saturation < 25%)
5.3.2	Nutrients & Oxygen	minimum concentration of oxygen in bottom water
5.3.2	Nutrients & Oxygen	Oxygen (concentrations/5 percentile) in bottom waters
5.3.2	Nutrients & Oxygen	Volume-specific oxygen dept
6.1.1	Habitat	abundance and extent
6.1.1	Habitat	Blue mussel cover

6.1.1	Rock and biogenic reef habitats	Area of subtidal biogenic structures
6.1.1	Rock and biogenic reef habitats	Density of biogenic reef forming species
6.1.2	Habitat	Near bottom oxygen conditions
6.1.2	Habitat	surface area of seabed not impacted by human activity last year
6.1.2	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Penetration and/or disturbance of the substrate below the surface of the seabed' (Physical pressure)
6.1.2	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Shallow abrasion/penetration: damage to seabed surface and penetration' (Physical pressure)
6.1.2	Rock and biogenic reef habitats	Impact/Vulnerability of habitat to 'Surface abrasion: damage to seabed surface features' (Physical pressure)
6.1.2	Sediment habitats	Impact/Vulnerability of habitat to 'Penetration and/or disturbance of the substrate below the surface of the seabed' (Physical damage)
6.1.2	Sediment habitats	Impact/Vulnerability of habitat to 'Shallow abrasion/penetration: damage to seabed surface and penetration' (Physical damage)
6.1.2	Sediment habitats	Impact/Vulnerability of habitat to 'Surface abrasion: damage to seabed surface features' (Physical damage)
6.2.1	Bottom fauna and flora	Lower depth distribution limit of macrophyte species
6.2.1	Bottom fauna and flora	vulnerable benthos species
6.2.1		indicator not used
6.2.2	Bottom fauna and flora	AMBI and M-AMBI, Shannon Index
6.2.2	Bottom fauna and flora	Average regional species richness

6.2.2	Bottom fauna and flora	BEQI
6.2.2	Bottom fauna and flora	Ecological Inex (EI) for macrophyts
6.2.2	Bottom fauna and flora	Multidimensional biodiversity indices taking both incorporating species richness and evenness, e.g. Hill's indices
6.2.2	Bottom fauna and flora	Multimetric macrozoobenthos indicators (BQI, MarBIT, DKI, BBI, ZKI, B)
6.2.2	Bottom fauna and flora	Ratio of perennial and annual macrophytes
6.2.2	Pelagic habitats	Change of plankton functional types (life form) index
6.2.3	Bottom fauna and flora	length-frequency distribution bivalves
6.2.4	Bottom fauna and flora	Size-distribution of long-lived macrozoobenthic species
6.2.4		indicator not used
7.1.1	Habitat	surface area
7.2.1	Habitat	surface area
8.1.1	Chemicals	concentraties in water and sediment
8.1.1	Chemicals	concentraties in water, sediment or biota
8.1.1	Chemicals	concentrations of substances in water, sediment or biota
8.1.1	Chemicals	Measurements of contaminants in mussel/bivalve, TBT/imposex index
8.1.1	Chemicals	Measurements of contaminants in sediment: PAHs, (PBDE, HBCDD, PFOS, PCB, Dioxins)
8.1.1	Chemicals	Measurements of contaminants in water: 17-alpha-ethinylestradiol (EE2)
8.1.1	Chemicals	Mesurements of contaminants in fish: PBDE, HBCDD, PFOS, PCB, Dioxins, PAHs, metals, cesium-137
8.2.1	Bottom fauna	Antioxidant activity
8.2.1	Chemicals	Biological/ecological effects of contaminants
8.2.1	Chemicals	EcoQO on imposex
8.2.1	Chemicals	selection of bioassays
8.2.1	Chemicals	Use of biological assays: general stress indicator (LMS) for various mussel and fish species, fish disease index as general

		indicaror, genotoxicity indicator as index for cytogenic damage (bivalves and fish), reproductive disorder indivator for eelpout.
8.2.2	Chemicals	EcoQO on oiled guillemot
8.2.2	Chemicals	Illegal discharges of oil
8.2.2	Chemicals	Oilspills & oil discharges (satellite)
9.1.1	Bottom fauna and flora	Acetycoholin-esterase inhibition
9.1.1	Bottom fauna and flora	contaminants in fish and seafood
9.1.1	Bottom fauna and flora	Levels of contaminants in fish and seafood
9.1.1	Bottom fauna and flora	Measurements of contaminants in mussels (and in some cases crustaceans): PAHs, Hg, Cd, Pd
9.1.1	Fish	contaminants in fish and seafood
9.1.1	Fish	Levels of contaminants in fish and seafood
9.1.1	Fish	Mesurements of contaminants in fish: PBDE, HBCDD, PFOS, PCB, Dioxins, PAHs, metals, cesium-137
9.1.2	Bottom fauna and flora	frequency of levels being exceeded
9.1.2	Bottom fauna and flora	Frequency of the measured levels being exceeded
9.1.2	Bottom fauna and flora	No indicators proposed
9.1.2	Fish	frequency of levels being exceeded
9.1.2	Fish	No indicators proposed
10.1.1	Birds	EcoQO plastic particles in fulmar stomachs
10.1.1	Pressure	amount of litter on beaches/coastline
10.1.1	Pressure	Quanity of visable litter items
10.1.2	Birds	EcoQO plastic particles in fulmar stomachs
10.1.2	Pressure	amount of floating, or sea-floor litter
10.1.2	Pressure	Trend of visable litter items
10.1.3	Pressure	No indicators proposed

10.2.1	Birds	EcoQO plastic particles in fulmar stomachs
10.2.1	Birds	Trends in amount of plastic particles in fulmar stomach
11.1.1	Pressure	Impacts of anthropogenic underwater noise on marine mammals *
11.1.1	Pressure	Proportion of days and distruvtion of impulsive sound
11.2.1	Pressure	Trends in ambient noise

Annex 9. Specific management measures and their characterization in terms of Aim and Mechanism

Management measure: Aim	Management measure: Mechanism	Management measure: Specific
Nature conservation	social:education and raising public awareness	Attraction of eco-tourism in coastal Natura 2000 areas.
Nature conservation	mitigation: legislation/enforcement	Well-defined requirements for contractors of large projects regarding nature conservation legislations (e.g. environmental control area)
restrictions on construction	spatial and temporal distribution controls:zoning	Spatial designation of a non-building zone of 2km (landwards) from the coastline
restrictions on tourism/recreation	economic: taxes or subsidies	User fees for tourism (e.g. diving , fishing and sailing)
reduce impact renewable energy (operations): thermal pollution	technical	Decrease discharge of thermal energy
Conservation ecosystem characteristic: hydrographical conditions	technical	Restoring salt water-fresh water transition zones
Conservation ecosystem characteristic: hydrographical conditions	technical	Restoring circulation in anoxic lagoons
reduce impact non-renewable energy (oil & gas operations) : pollution	management coordination: monitoring	Control on brine discharges by creation of gas storage facilities
reduce impact renewable energy (operations)	technical	Limitations on density of wave and tidal energy device arrays
Conservation ecosystem characteristic: fish	spatial and temporal distribution controls:zoning	Installation of breakwaters for fish reproduction and growth
Conservation ecosystem characteristic: fish	remediation	Bioremediation or biomanipulation measures, such as release of predatory fish
Conservation ecosystem characteristic: habitat	restoration/compensation	Managed realignment in coastal areas to restore coastal habitats
Conservation ecosystem	restoration/compensation	Habitat creation as compensation for port development (e.g. in Natura 2000 areas)

characteristic: habitat		
Conservation ecosystem characteristic: habitat	restoration/compensation	Seabed restoration/aftercare measures to speed recovery or improve certainty of recovery
Conservation ecosystem characteristic: marine mammals	management coordination: protocol	Action plan for conservation of marine mammals (e.g. harbour porpoises)
reduce impact human activities	spatial and temporal distribution controls:zoning	Spatio-temporal limitations during essential life history stages of protected species for sectors , e.g. no nourishment during breeding season or near lactating seals
Conservation ecosystem characteristic: water quality	technical	Installing hard substrate for algae and shellfish as a natural filter to improve the water quality in the harbour
Reduce effects NIS	remediation	Eradication of invasive, nonindigenous mammals in seabird colonies
reduce impact agriculture:eutrophication	Social: stakeholder involvement	Establishment of an agricultural forum to address marine eutrophication
reduce impact waste water treatment: eutrophication	technical	Additional P- and N-reduction Water Treatment Plants
reduce impact land based industry:eutrophication	technical	Reduction of the amount of phosphates in detergents
reduce effects pollution	remediation:cleaning	Bioremediation of oil spills
reduce effects pollution	remediation:cleaning	Chemical cleaning of oil spills
reduce effects pollution	remediation:cleaning	Mechanical cleaning of oil spills
reduce impact non-renewable energy (oil & gas operations) : pollution	management coordination: monitoring	System for identification of oil spills from offshore installations
Reduce effects pollution	remediation:cleaning	Mechanical remediation of contaminated sediments
Reduce effects pollution	remediation:cleaning	Remediation contaminated sediments by the use of micro-organisms
Reduce effects pollution	remediation:cleaning	Stabilization/solidification of contaminated sediments
Reduce impact aquaculture	social: certification	ASC labeled fish
Reduce impact aquaculture	technical	Integrated aquaculture (INTAQ)
Reduce impact aquaculture	mitigation: licenses/permits	License system for (sustainable) aquaculture (e.g. fin-fish farming)

Reduce impact aquaculture	spatial and temporal distribution controls:zoning	Spatial regulation of production areas of fish (aquaculture) near areas where wild migratory fish are present
Reduce impact aquaculture	technical	Higher quality of aquaculture feeds, so that less feed is needed (to reduce waste)
Reduce impact aquaculture	technical	Bioremediation or biomanipulation measures, such as mussel farming or adding bivalves to fish farms
Reduce impact fishing	social: certification	Ecolabeling for fisheries
Reduce impact fishing	social: certification	MSC labeled fish
Reduce impact fishing	management coordination: rights based management	Community catch quotas; individual non-transferable or transferable catch quotas
Reduce impact fishing	management coordination: rights based management	Individual non-transferable or transferable effort quotas,
Reduce impact fishing	management coordination: rights based management	Apply territorial use rights in fisheries
Reduce impact fishing	technical	Competitions to stimulate innovations for (selective / smart) gear solutions
Reduce impact human activities	social:education and raising public awareness	Active dissemination of research findings to the public
Reduce impact human activities	spatial and temporal distribution controls:zoning	Spatial closed areas offshore windparks
Reduce impact human activities	management coordination: marine spatial planning	Coastal Area Management Programmas as an integrated sustainable management tool for planning and development activities
Reduce impact human activities	management coordination: marine spatial planning	Integrated approach (not in a sectoral way) for marine spatial planning and management, ICZM
Reduce impact human activities	spatial and temporal distribution controls:zoning	Spatio-temporal zoning of sectorial use in coastal and marine environments
Reduce impact human activities	spatial and temporal distribution controls:zoning	Spatial application of Environmental Impact Zones/buffer zones around the project site
reduce litter	economic: taxes or subsidies	Port reception fees
reduce litter	social:education and raising public awareness	Labelling of products to raise consumer awareness, e.g. \marine litter logo\""
Reduce impact shipping	social:stakeholder involvement	Clean Shipping Index
Reduce impact shipping	spatial and temporal distribution	Spatial designation of no anchor zones on protected shellfish areas

	controls:zoning	
Reduce impact shipping	spatial and temporal distribution controls:zoning	Spatial designation of no-mooring zone or inversely special mooring zones (e.g. to protect eelgrass beds, Posidonia oceanica beds)
Reduce impact shipping:emission	management coordination: rights based management	Spatial designation of NOx emission and creation of a control area (under MARPOL, Annex VI)
Reduce impact shipping	economic: taxes or subsidies	Ship berthing fees
Reduce impact tourism/ recreation	economic: taxes or subsidies	User fees for tourism (e.g. diving , fishing and sailing)
reduce impact waste water treatment	management coordination	Water management to reduce the discharge of agricultural nutrients and pesticides
reduce impact waste water treatment	infrastructure	Investment for building, extension or rehabilitation of Waste Water Treatment Plants
reduce impact agriculture:eutrophication	social instruments	Training/certification for spreading and transporting manure
reduce impact agriculture	management coordination	Improved fertilizer and manure management
reduce impact waste water treatment	infrastructure	Establishing additional waste water treatment plants
reduce impact waste water treatment	mitigation: legislation/enforcement	Implementing National Programme for Priority Construction of Urban Wastewater Treatment Plants
reduce impact agriculture:eutrophication	technical	Limit discharge of agricultural nutrients by soil tillage methods
reduce impact agriculture:eutrophication	technical	Limit discharge of agricultural nutrients by catch crops
reduce impact agriculture:eutrophication	technical	Anaerobic digestion of manure (biogas) to reduce N leaching (technical measure), biogas production from manure
reduce impact agriculture:eutrophication	technical	Ditch dams and ditch filters to reduce phosphorous leakage from arable land (technical measure)
reduce impact waste water treatment	technical	Improving the function, storage and efficiency of combined sewage overflows and surface water drains
reduce pollution	management coordination	Improved pesticides management
reduce litter	technical	Introduce modern landfill techniques

reduce pollution	management coordination: monitoring	Pollution control of rivers, supported by monitoring system for water quality
reduce litter	economic: taxes or subsidies	Award-based incentives for coastal villages with Integrated Waste Management (IWM)
reduce effects litter	social: community action	Voluntary campaign on litter; do it your self beaches
reduce effects litter	social: community action	Voluntary campaign; beach cleanup
reduce effects litter	social: community action	Voluntary campaign on litter; diving against debris
reduce effects litter	social: community action	Collection of fished litter (fishing for litter scheme)
reduce impact tourism/recreation: litter	infrastructure	Improved facilities for beach litter deposit
Reduce litter	infrastructure	Improved infrastructure for recycling to decrease marine litter
reduce impact shipping:litter	infrastructure	Provision and use of port reception facilities for wastes generated during operation of ships
reduce litter	economic: taxes or subsidies	Charging for waste services including landfills
	economic: taxes or subsidies	Plastic levy to finance beach cleanups
reduce atmospheric emission	economic: taxes or subsidies	Reduction NOx tax when contributing to NOx fund
reduce impact land based industry:litter	economic: taxes or subsidies	Deposit-refund programmes on plastic and glass bottles
reduce impact land based industry:litter	economic: taxes or subsidies	Subsidies to decrease marine litter by smarter products packing
reduce impact fishing:litter	social: education and raising public awareness	Awareness programs to mitigate ALDFG (abandoned, lost or otherwise discarded fishing gear, ghostfishing) impacts
reduce impact fishing:litter	social: community action	Retrieval of lost or abandoned fishing gear
reduce impact fishing:litter	economic: taxes or subsidies	Deposits on fishing gear
reduce impact fishing:litter	technical	Biodegradable fishing gear to reduce litter
reduce impact fishing:litter	traceability/labelling	Name tags on fishing gear
reduce impact land based industry:litter	mitigation: legislation/enforcement	Regulation on manufacturing industry to improve recyclability (reduce litter)
reduce impact land based industry:litter	technical	Smarter products/packing to decrease marine litter

reduce impact shipping:litter	infrastructure	Free waste water service for cruise ships in ports
reduce impact shipping:litter	economic: taxes or subsidies	Financial and technical support for the installation of waste management systems on board of ships
reduce introduction NIS	social: certification	MAC certification for aquarium organisms
reduce introduction NIS	mitigation: legislation/enforcement	Ban on import keeping and sale of known invasive species
reduce introduction NIS	mitigation: legislation/enforcement	Prohibit imports, keeping and sale of captivated invasive species
reduce effects NIS	mitigation: legislation/enforcement	Regulations on the introduction of hard substrates in soft sediment areas (minimize stepping stones for NIS)
reduce effects NIS	technical	Installation of migration barriers for invasive species
reduce impact shipping: introduction NIS	management coordination:monitoring	Screening of international imports via hulls and ballast water for disease + hitch-hikers (live+dead)
reduce impact aquaculture:introduction NIS	mitigation: legislation/enforcement	Ban on aquaculture with (new) non-indigeneous species
reduce effects NIS	remediation:cleaning	Pole and cover stones inspectation and cleaning of NIS
reduce impact shipping: introduction NIS	mitigation: legislation/enforcement	Mandatory hull cleaning large ships
reduce impact shipping: introduction NIS	technical	Ballast water treatment
reduce impact shipping: introduction NIS	management coordination: protocol	Quarantine measures for mammals on vessels visiting important island seabird colonies
reduce impact shipping: introduction NIS	spatial and temporal distribution controls:zoning	Spatio-temporal restrictions to the discharge of ballast water
reduce impact shipping: introduction NIS	mitigation: legislation/enforcement	Mandatory use of biosecure treatment facilities in marinas
Reduce noise	regulatory instruments	Reduction of the use of sonar
reduce noise	technical	Ramp-up procedure during construction and other noisy activities
reduce impact renewable	technical	Implementation of silent gear boxes in turbines

energy (operations): noise		
reduce impact renewable energy (construction): noise	economic: taxes or subsidies	Subsidies for alternatives to monopiles to avoid under water sound
reduce impact renewable energy (construction): noise	technical	Soft start construction to reduce sound effects on mobile fauna
reduce impact renewable energy (construction): noise	technical	Pile sleeves to absorb sound of monopile construction
reduce noise	technical	Bubble curtains to absorb sound from construction sites
reduce impact renewable energy (construction): noise	technical	Gravity based foundations instead of monopiles to prevent piling or to decrease sound production
reduce noise	management coordination: protocol	Enforcing JNCC marine mammal protocol seismics
reduce impact shipping:noise	technical	Ship quietening by quiet hull designs
reduce impact shipping:noise	technical	Ship quietening by diesel-electric propulsion
reduce impact shipping:noise	technical	Ship quietening by fixed-pitch propellers
reduce impact land based industry:eutrophication	technical	Development of substitutes for phosporus in detergents
conservation ecosystem characteristic: fish	technical	Catching non-economically profitable fish species to remove nutrients
reduce impact agriculture:pollution	Social: stakeholder involvement	Establishment of an agricultural forum to address effects pesticides
reduce impact shipping:pollution	mitigation: legislation/enforcement	Stricter enforcement for the movement off hazardous substances and materials to prevent marine pollution by vessels
Reduce pollution	mitigation: legislation/enforcement	Decrease discharge of sewage water by stricter enforcement of regulations

Reduce pollution	economic: penalties/enforcement	Decrease discharge of sewage water through higher penalties
Reduce pollution	economic: penalties/enforcement	Higher penalties for polluters
Reduce pollution	economic: penalties/enforcement	Higher penalties on excessive discharge of sewage water from passenger ships and ferries
reduce atmospheric emission	management coordination: rights based management	Transferable emission quota (within sea basin)
Reduce pollution	physical measures	Prevent aquatic pollution from landfill sites
Reduce pollution	mitigation: legislation/enforcement	Extending dumping bans on lipophylic substances
Reduce pollution	mitigation: legislation/enforcement	Stricter regulations and higher taxes on the use of highly polluting substances
reduce atmospheric emission	economic: taxes or subsidies	NOx tax
reduce impact shipping:pollution	economic: taxes or subsidies	Additional port, fairway and harbour taxes for "polluting" ships
Reduce pollution	mitigation: legislation/enforcement	Stricter regulations and higher taxes on the use of highly polluting substances
reduce impact waste water treatment:pollution	technical	Additional reduction of contaminants other than P and N with Water Treatment Plants
reduce effects pollution	remediation: cleaning	Cleaning pollution by products of offshore drilling operations, e.g. drilling muds and cuttings
reduce impact land based industry:litter	regulatory instruments	Restrictions on the use of plastics
	traceability/labelling	Improve the traceability, where feasible, of marine pollution
reduce effects pollution	management coordination: monitoring	Contingency plans for chemicals and oil spills in case of accidents
reduce pollution	mitigation: legislation/enforcement	Stricter standards for dumping
reduce pollution	infrastructure	Phasing out improper dumping sites (e.g. for dredged material, sewage sludge and vessels)

reduce pollution	infrastructure	Liquidation of illegal dumping sites
reduce pollution	spatial and temporal distribution controls:zoning	Spatial zoning dumping areas
reduce impact shipping:pollution	technical	Alternatives for anti-fouling paints
reduce litter	economic: taxes or subsidies	Subsidize the construction of new modern landfills
reduce litter	economic: taxes or subsidies	Subsidize the improvement of the solid waste management in the coastal zone
reduce impact non-renewable energy (oil & gas operations) : light pollution	technical	Using green light on offshore platforms
reduce impact renewable energy (operations) :collision hazard	management coordination: protocol	Put windmills to a stop during periods of bird migration
Restrictions on aggregates and dredging	mitigation: legislation/enforcement	Ban or further regulation of deepwater drilling
Restrictions on aggregates and dredging	spatial and temporal distribution controls:zoning	Spatio-temporal delineation of extraction zones (planning) to avoid particularly sensitive features (micro-silting)
Restrictions on aggregates and dredging	spatial and temporal distribution controls:zoning	Spatio-temporal mega instead of local sand nourishments in the coastal zone
reduce impact aggregates and dredging:disturbance	spatial and temporal distribution controls:zoning	Spatio-temporal restrictions, e.g. no nourishment in breeding season or near lactating seals, or spatial restrictions to nourishment in habitats
Restrictions on aggregates and dredging	spatial and temporal distribution controls:zoning	Spatio-temporal zoning of shell mining
Restrictions on aggregates and dredging	economic: taxes or subsidies	Aggregate taxes / levy (e.g. (Marine) Aggregate Levy Sustainability Fund (MALSF))
reduce impact aggregates and dredging: sea floor integrity	technical	Using deeper sandpits, decreasing the area of excavation
reduce impact aggregates and dredging: sea floor integrity	technical	Using sand for nourishment with comparable sediment characteristics as the natural situation

reduce impact aggregates and dredging	technical	Application of an environmental friendly sand extraction methodology or other mitigating measures for aggregate extraction
conservation ecosystem characteristic: habitat restoration	technical	Optimise shape burrow pits for ecological development
reduce impact aggregates and dredging: seafloor impact	technical	Strokenwinning mining the pit in strips the idea is that this will improve colonization.
Restrictions on aggregates and dredging	spatial and temporal distribution controls:zoning	Beach instead of underwater nourishment or underwater nourishment instead of beach nourishment
reduce impact aggregates and dredging: changes in siltation	technical	Limiting silt plumes by limiting silt overflow
reduce impact aggregates and dredging	management coordination: monitoring	Application of a feedback monitoring system on the effects of dredging activities, enabling one to intervene rapidly when dangerous levels are exceeded
restrictions on human activities	mitigation: licenses/permits	Marine Licence scheme
Restrictions on aggregates and dredging	spatial and temporal distribution controls:zoning	Archaeological Exclusion Zones
restrictions on human activities	spatial and temporal distribution controls:zoning	Designation of SACs, SPAs and MCZs
restrictions on human activities	mitigation: licenses/permits	Environmental impact assessment undertaken with each licence application
restrictions on human activities	mitigation: licenses/permits	Environmental Impact Assessment (EIA) as a basis for licences / permits for constructions in the marine environment (e.g. offshore wind farms Denmark)
restriction on telecommunications (construction)	spatial and temporal distribution controls:zoning	Spatio-temporal planning of cables to minimize environmental (e.g. avoid sensitive sites) and technical risk (e.g. avoid wrecks)
restriction on non-renewable Energy (oil & gas construction)	spatial and temporal distribution controls:zoning	Spatio-temporal planning of pipelines to minimize environmental (e.g. avoid sensitive sites) and technical risk (e.g. avoid wrecks)
restrictions on human	spatial and temporal distribution	Spatial application of Environmental Impact Zones/buffer zones around the project site

activities	controls:zoning	
restrictions on human activities	spatial and temporal distribution controls:zoning	Spatio-Temporal restrictions on pile driving
Restrictions on fishing	mitigation: legislation/enforcement	Scrapping program to eliminate surplus capacity in fishing fleets, decommissioning programs
Restrictions on fishing	mitigation: legislation/enforcement	Reduce fishing fleet capacity
reduce impact fishing: selective fishing	mitigation: legislation/enforcement	Discard ban on the most commercially important species, ban on high grading
reduce impact fishing: selective fishing	mitigation: legislation/enforcement	Implementation or modification of Min/Max landing sizes
Restrictions on fishing	spatial and temporal distribution controls:zoning	Spatial designation of national fishing zones
Restrictions on fishing	spatial and temporal distribution controls:zoning	Spatial zoning acces of ships based on engine size and power
Restrictions on fishing	spatial and temporal distribution controls:zoning	Spatial zoning acces based on fishing methods
Restrictions on fishing	spatial and temporal distribution controls:zoning	Temporal seasonal restrictions of fishing techniques
Restrictions on fishing	economic: taxes or subsidies	Commercial fishing fees
Restrictions on fishing	economic: taxes or subsidies	Get rid of tax free diesel for commercial fisherman
Restrictions on fishing	economic: taxes or subsidies	Subsidies to fisherman to not fish in recovering areas
Restrictions on fishing	technical	Introducing structures to make bottom trawling impossible
reduce impact fishing	technical	Limited use of certain fishing techniques (e.g. gillnets, trawls)
reduce impact fishing	economic: taxes or subsidies	Taxes or fees to discourage certain fishing techniques
reduce impact fishing: seafloor impact	mitigation: legislation/enforcement	Ban on beam trawling
reduce impact fishing: seafloor impact	technical	Electric pulse fishing
reduce impact fishing: seafloor impact	technical	SumWing fishing

reduce impact fishing	mitigation: legislation/enforcement	Mandatory use of new (more selective) fishing techniques
reduce impact fishing	economic: taxes or subsidies	Taxes or fees to discourage certain fishing techniques
reduce impact fishing: bycatch	economic: taxes or subsidies	Subsidies to encourage certain fishing techniques (e.g. limit bycatch)
reduce impact fishing: bycatch	technical	Measures to minimise seabird by-catch
reduce impact fishing: bycatch	technical	Net materials that increase sound reflectivity and hence could reduce the by-catch of non target species
Reduce impact human activities	technical	The increased use of pingers to deter marine mammals
reduce impact fishing: selective fishing	mitigation: legislation/enforcement	Restrictions on mesh-size fishing gear
restrictions on human activities	spatial and temporal distribution controls:zoning	Spatial restriction on cables/pipelines

Annex 10 Management measures (aim only see Annex 9) linked to each of the elements of the impact chain.

Aim	Driver	Pressure	Component
nature conservation	all	all	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
conservation ecosystem characteristic: fish	Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling Waste Water Treatment Agriculture (Hydro) Power Station Operations	Nitrogen and Phosphorus enrichment Selective Extraction of Species Salinity regime change Barrier to species movement	Fish Deep sea Fish Pelagic Fish Benthic
conservation ecosystem characteristic: habitat	Coastal defense Aggregates Fishing - Benthic trawling Navigational Dredging Coastal Infrastructure (operations)	Abrasion Substrate_Loss	Habitats Bottom fauna and flora Fish Benthic Marine mammals Seabirds inshore Bathymetry/ topography
Conservation ecosystem characteristic: hydrographical conditions	Waste Water Treatment Coastal Infrastructure (operations) Non-renewable Energy (Nuclear) Operations Renewable Energy - operations (Hydro) Power Station Operations Desalination Aggregates	Salinity regime change Waterflow rate change	Habitats Plankton Bottom fauna and flora Fish Benthic Fish Pelagic Seabirds inshore Salinity Nutrients & Oxygen
Conservation ecosystem characteristic: marine mammals	Coastal defense Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling Military Navigational Dredging Non-renewable Energy (Nuclear) Construction Non-renewable Energy (oil & gas construction) Renewable Energy - construction Research Shipping Renewable Energy - operations	Disturbance Marine Litter Death or injury by collision Underwater noise Barrier to species movement Selective Extraction of Species	Marine mammals
Conservation ecosystem characteristic: water quality	Aggregates	Input of organic matter	Habitats

Aim	Driver	Pressure	Component
	Aquaculture	Nitrogen and Phosphorus enrichment	Plankton
	Coastal defense	changes in siltation	Bottom fauna and flora
	Navigational Dredging		Fish Benthic
	Waste Water Treatment		Fish Pelagic
	Agriculture		Seabirds inshore
			Nutrients & Oxygen
reduce litter	Shipping	Marine Litter	Bottom fauna and flora
	Fishing - Pelagic trawling		Fish Deep sea
	Fishing - Pelagic trawling		Fish Benthic
	Tourism/Recreation		Fish Pelagic
	Waste Water Treatment		Marine mammals
	Land-based Industry		Seabirds inshore
			Seabirds offshore
			Reptiles
reduce atmospheric emission	all	Introduction of other substances	all
		Emergence regime change	
		Thermal regime change	
		Salinity regime change	
		pH changes	
reduce introduction NIS	Aquaculture	Introduction of non-indigenous species	Habitats
	Land-based Industry		Bottom fauna and flora
			Fish Deep sea
			Fish Benthic
			Fish Pelagic
			Seabirds inshore
reduce pollution	Aquaculture	Input of organic matter	Habitats
	Shipping	Introduction_of_Non_synthetic_co	Bottom fauna and flora
	Land-based Industry	Introduction_of_Radionuclides	Fish Deep sea
	Waste Water Treatment	Introduction_of_Synthetic_compou	Fish Benthic
	Agriculture	Introduction of other substances	Fish Pelagic
	Non-renewable Energy (oil & gas operations)		Marine mammals
	Non-renewable Energy (Nuclear) Operations		Seabirds inshore
			Seabirds offshore
			Reptiles
reduce noise	Military	Underwater noise	Fish Deep sea
	Shipping		Fish Benthic
	(Hydro) Power Station Construction		Fish Pelagic
	Coastal Infrastructure (construction)		Marine mammals
	Non-renewable Energy (Nuclear) Construction		
	Non-renewable Energy (oil & gas construction)		
	Renewable Energy - construction		
	Research	Marine Litter	Bottom fauna and flora
reduce effects litter	Shipping		Fish Deep sea
	Fishing - Pelagic trawling		Fish Benthic
	Fishing - Pelagic trawling		Fish Pelagic

Aim	Driver	Pressure	Component
	Tourism/Recreation		Marine mammals
	Waste Water Treatment		Seabirds inshore
	Land-based Industry		Seabirds offshore
			Reptiles
reduce effects NIS	Aquaculture	Introduction of non-indigenous species	Habitats
	Shipping		Bottom fauna and flora
	Tourism/Recreation		Fish Deep sea
	Coastal Infrastructure (operations)		Fish Benthic
	Non-renewable Energy (oil & gas operations)		Fish Pelagic
	Renewable Energy - construction		Seabirds inshore
reduce effects pollution	Aquaculture	Input of organic matter	Habitats
	Shipping	Introduction_of_Non_synthetic_co	Bottom fauna and flora
	Land-based Industry	Introduction_of_Synthetic_compou	Fish Deep sea
	Waste Water Treatment	Introduction of other substances	Fish Benthic
	Agriculture		Fish Pelagic
	Non-renewable Energy (oil & gas operations)		Marine mammals
			Seabirds inshore
			Seabirds offshore
			Reptiles
reduce impact human activities	all	all	all
reduce impact aggregates and dredging	Aggregates	Disturbance	Habitats
	Navigational Dredging	Input of organic matter	Plankton
	Coastal defense	Smothering	Bottom fauna and flora
		Abrasion	Fish Benthic
		Underwater noise	Marine mammals
		Introduction_of_Non_synthetic_co	Seabirds inshore
		Selective Extraction of Non-living material	Bathymetry/ topography
		changes in siltation	Seabirds offshore
reduce impact aggregates and dredging: changes in siltation	Aggregates	changes in siltation	Habitats
	Navigational Dredging		Plankton
	Coastal defense		Bottom fauna and flora
			Seabirds inshore
			Seabirds offshore
reduce impact aggregates and dredging: sea floor integrity	Coastal defense	Substrate_Loss	Habitats
	Aggregates	Abrasion	Bottom fauna and flora
	Navigational Dredging	Selective Extraction of Non-living material	Fish Benthic
			Seabirds inshore
			Seabirds offshore
			Bathymetry/ topography
reduce impact aggregates and dredging:disturbance	Aggregates	Disturbance	Marine mammals
	Navigational Dredging		Seabirds inshore
	Coastal defense		Seabirds offshore
reduce impact agriculture	Agriculture	Input of organic matter	Plankton
		Nitrogen and Phosphorus enrichment	Bottom fauna and flora
		Introduction_of_Synthetic_compou	Fish Deep sea

Aim	Driver	Pressure	Component
			Fish Benthic Fish Pelagic Nutrients & Oxygen Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact agriculture:eutrophication	Agriculture	Nitrogen and Phosphorus enrichment	Plankton Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Nutrients & Oxygen
reduce impact agriculture:pollution	Agriculture	Input of organic matter Introduction_of_Synthetic_compou	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
Reduce impact aquaculture	Aquaculture	Introduction of non-indigenous species Input of organic matter Introduction of microbial pathogens Nitrogen and Phosphorus enrichment Introduction_of_Synthetic_compou	Habitats Plankton Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles Nutrients & Oxygen
reduce impact aquaculture:introduction NIS	Aquaculture	Introduction of non-indigenous species	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Seabirds inshore Seabirds offshore
reduce impact fishing	Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling	Abrasion Death or injury by collision Selective Extraction of Species Substrate_Loss Marine Litter	Habitats Bottom fauna and flora Fish Deep sea Fish Pelagic Fish Benthic

Aim	Driver	Pressure	Component
			Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact fishing: bycatch	Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling	Death or injury by collision Selective Extraction of Species	Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact fishing: seafloor impact	Fishing - Benthic trawling	Abrasion Substrate_Loss	Habitats Bottom fauna and flora Fish Benthic Seabirds inshore Seabirds offshore
reduce impact fishing: selective fishing	Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling	Selective Extraction of Species	Fish Deep sea Fish Benthic Fish Pelagic
reduce impact fishing:litter	Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling	Marine Litter	Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact land based industry:eutrophication	Land-based Industry	Nitrogen and Phosphorus enrichment	Plankton Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Nutrients & Oxygen
reduce impact land based industry:litter	Land-based Industry	Marine Litter	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact non-renewable energy (oil & gas operations) : light pollution	Non-renewable Energy (oil & gas operations)	Barrier to species movement	Seabirds inshore Seabirds offshore
reduce impact non-renewable energy (oil & gas operations) : pollution	Non-renewable Energy (oil & gas operations)	Input of organic matter Introduction_of_Non_synthetic_co Introduction of other substances	Habitats Bottom fauna and flora Fish Benthic

Aim	Driver	Pressure	Component
			Fish Deep sea Fish Pelagic Seabirds inshore Seabirds offshore
reduce impact renewable energy (operations) :collision hazard	Renewable Energy - operations	Death or injury by collision	Seabirds inshore Seabirds offshore
reduce impact renewable energy (construction): noise	Renewable Energy - construction	Underwater noise	Fish Deep sea Fish Benthic Fish Pelagic Marine mammals
reduce impact renewable energy (operations)	Renewable Energy - operations	Death or injury by collision Waterflow rate change Emergence regime change Electromagnetic change Thermal regime change	Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Habitats
reduce impact renewable energy (operations): noise	Renewable Energy - operations	Underwater noise	Fish Deep sea Fish Pelagic Fish Benthic Marine mammals
reduce impact renewable energy (operations): thermal pollution	Non-renewable Energy (Nuclear) Operations Renewable Energy - operations	Thermal regime change	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Temperature Nutrients & Oxygen
reduce impact shipping	Shipping	Introduction of non-indigenous species Marine Litter Underwater noise Introduction of other substances Introduction_of_Non_synthetic_co Introduction_of_Synthetic_compou Emergence regime change Thermal regime change Salinity regime change pH changes Abrasion	all
reduce impact shipping: introduction NIS	Shipping	Introduction of non-indigenous species	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Seabirds inshore

Aim	Driver	Pressure	Component
			Seabirds offshore
reduce impact shipping:pollution	Shipping	Input of organic matter Introduction_of_Non_synthetic_co Introduction_of_Synthetic_compou	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact shipping: emission	Shipping	Introduction of other substances Emergence regime change Thermal regime change Salinity regime change pH changes	all
reduce impact shipping:noise	Shipping	Underwater noise Disturbance	Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore
reduce impact shipping-litter	Shipping	Marine Litter	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
Reduce impact tourism/ recreation	Tourism/Recreation	Disturbance Marine Litter	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
reduce impact tourism/recreation: litter	Tourism/Recreation	Marine Litter	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles

Aim	Driver	Pressure	Component
reduce impact waste water treatment	Waste Water Treatment	Introduction_of_Synthetic_compou Nitrogen and Phosphorus enrichment Marine Litter Input of organic matter	Habitats Plankton Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles Nutrients & Oxygen Chemicals
reduce impact waste water treatment: eutrophication	Waste Water Treatment	Nitrogen and Phosphorus enrichment	Plankton Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Nutrients & Oxygen
reduce impact waste water treatment:pollution	Waste Water Treatment	Introduction_of_Synthetic_compou Marine Litter Input of organic matter	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
restriction on non-renewable Energy (oil & gas construction)	Non-renewable Energy (oil & gas construction)	Smothering Abrasion Underwater noise changes in siltation	Habitats Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore
Restrictions on on non-renewable Energy (oil & gas operation)			
restriction on telecommunications (construction)	Telecommunications operation	Electromagnetic change Thermal regime change	Fish Deep sea Fish Benthic Fish Pelagic Marine mammals
restriction on telecommunications (operation)	Telecommunications construction	Smothering Abrasion Underwater noise changes in siltation	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore

Aim	Driver	Pressure	Component
restrictions on construction	(Hydro) Power Station Construction Coastal Infrastructure (construction) Non-renewable Energy (Nuclear) Construction Non-renewable Energy (oil & gas construction) Renewable Energy - construction Telecommunications construction	Disturbance Underwater noise Introduction of other substances Barrier to species movement Abrasion Substrate_Loss	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore
restrictions on human activities	all	all	all
restrictions on tourism/recreation		Disturbance Marine Litter	Bottom fauna and flora Fish Deep sea Fish Benthic Fish Pelagic Marine mammals Seabirds inshore Seabirds offshore Reptiles
restrictions on aggregates and dredging	Aggregates Navigational Dredging Coastal defense	Disturbance Smothering Abrasion Substrate_Loss changes in siltation Underwater noise Selective Extraction of Non-living material	Habitats Bottom fauna and flora Fish Benthic Marine mammals Seabirds inshore Seabirds offshore Bathymetry/ topography
restrictions on fishing	Fishing - Benthic trawling Fishing - Fixed Nets incl. potting and creeling Fishing - Pelagic trawling	Abrasion Death or injury by collision Selective Extraction of Species Substrate_Loss	Habitats Bottom fauna and flora Fish Benthic Seabirds inshore Seabirds offshore Fish Deep sea Fish Pelagic

Annex 11a Measures for the high-threat chains for descriptor 4 (Foodweb) per pressure-sector combination

The table below gives an overview of the measures (aim) for the high-threat chains for descriptor 4 per pressure-sector combination. To limit the output only those measures with a relatively narrow focus on the specific impact chains (i.e. an average SC score < 10) were selected.

The table can be read as following:
Pressure
  Sector
    Measures (aim)

Abrasion
Aggregates
conservation ecosystem characteristic: habitat
reduce impact aggregates and dredging
reduce impact aggregates and dredging: sea floor integrity
restrictions on aggregates and dredging
Fishing - Benthic trawling
conservation ecosystem characteristic: habitat
reduce impact fishing
reduce impact fishing: seafloor impact
restrictions on fishing
Navigational Dredging
conservation ecosystem characteristic: habitat
reduce impact aggregates and dredging
reduce impact aggregates and dredging: sea floor integrity
restrictions on aggregates and dredging
Shipping
conservation ecosystem characteristic: habitat
reduce impact shipping
Tourism/Recreation
conservation ecosystem characteristic: habitat
restrictions on tourism/recreation
Changes_in_siltation
Aggregates
reduce impact aggregates and dredging
reduce impact aggregates and dredging: changes in siltation
restrictions on aggregates and dredging
Agriculture
reduce impact agriculture
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Death_or_injury_by_collision
Shipping
reduce impact shipping
Input_of_organic_matter
Agriculture
reduce impact agriculture
reduce impact agriculture:pollution
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Tourism/Recreation
restrictions on tourism/recreation
Waste Water Treatment
reduce impact waste water treatment
reduce impact waste water treatment:pollution
Introduction_of_microbial_pathogens
Shipping
reduce impact shipping

Introduction_of_non_indigenous_s
Aquaculture
reduce effects NIS
Reduce impact aquaculture
reduce impact aquaculture:introduction NIS
reduce introduction NIS
Fishing - Benthic trawling
reduce effects NIS
reduce impact fishing
reduce introduction NIS
restrictions on fishing
Fishing - Pelagic trawling
reduce effects NIS
reduce impact fishing
reduce introduction NIS
restrictions on fishing
Military
reduce effects NIS
reduce introduction NIS
Research
reduce effects NIS
reduce introduction NIS
Shipping
reduce effects NIS
reduce impact shipping
reduce impact shipping: introduction NIS
reduce introduction NIS
Introduction_of_Non_synthetic_compounds
Agriculture
reduce impact agriculture
reduce impact agriculture:pollution
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Fishing - Pelagic trawling
reduce impact fishing
restrictions on fishing
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)
Non-renewable Energy (oil & gas operations)
reduce impact non-renewable energy (oil & gas operations) : pollution
restriction on on non-renewable Energy (oil & gas operation)
Shipping
reduce impact shipping
reduce impact shipping: emission
reduce impact shipping:pollution
Waste Water Treatment
reduce impact waste water treatment
reduce impact waste water treatment:pollution
Introduction_of_Synthetic_compounds
Agriculture
reduce impact agriculture
reduce impact agriculture:pollution
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Fishing - Fixed Nets incl. potting and creeling
reduce impact fishing
restrictions on fishing
Fishing - Pelagic trawling
reduce impact fishing
restrictions on fishing
Non-renewable Energy (oil & gas construction)

restriction on non-renewable Energy (oil & gas construction)
Shipping
reduce impact shipping
reduce impact shipping: emission
reduce impact shipping:pollution
Waste Water Treatment
reduce impact waste water treatment
reduce impact waste water treatment:pollution
Marine_Litter
Aquaculture
reduce effects litter
Reduce impact aquaculture
reduce litter
Fishing - Benthic trawling
reduce effects litter
reduce impact fishing
reduce impact fishing:litter
reduce litter
restrictions on fishing
Fishing - Fixed Nets incl. potting and creeling
reduce effects litter
reduce impact fishing
reduce impact fishing:litter
reduce litter
restrictions on fishing
Fishing - Pelagic trawling
reduce effects litter
reduce impact fishing
reduce impact fishing:litter
reduce litter
restrictions on fishing
Shipping
reduce effects litter
reduce impact shipping
reduce impact shipping-litter
reduce litter
Tourism/Recreation
reduce effects litter
Reduce impact tourism/ recreation
reduce impact tourism/recreation: litter
reduce litter
restrictions on tourism/recreation
Nitrogen_and_Phosphorus_enrich
Agriculture
reduce impact agriculture
Aquaculture
Reduce impact aquaculture
Land-based Industry
reduce impact land based industry:eutrophication
Tourism/Recreation
restrictions on tourism/recreation
Selective_Extraction_of_Non_livi
Aggregates
reduce impact aggregates and dredging
reduce impact aggregates and dredging: sea floor integrity
restrictions on aggregates and dredging
Selective_extraction_of_species
Aquaculture
conservation ecosystem characteristic: fish
Reduce impact aquaculture
Fishing - Benthic trawling
conservation ecosystem characteristic: fish
reduce impact fishing
reduce impact fishing: bycatch
reduce impact fishing: selective fishing
restrictions on fishing
Fishing - Fixed Nets incl. potting and creeling
conservation ecosystem characteristic: fish

reduce impact fishing
reduce impact fishing: bycatch
reduce impact fishing: selective fishing
restrictions on fishing
Fishing - Pelagic trawling
conservation ecosystem characteristic: fish
reduce impact fishing
reduce impact fishing: bycatch
reduce impact fishing: selective fishing
restrictions on fishing
Research
conservation ecosystem characteristic: fish
Smothering
Aggregates
reduce impact aggregates and dredging
restrictions on aggregates and dredging
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Navigational Dredging
reduce impact aggregates and dredging
restrictions on aggregates and dredging
Substrate_Loss
Aquaculture
conservation ecosystem characteristic: habitat
Reduce impact aquaculture
Coastal Infrastructure (construction)
conservation ecosystem characteristic: habitat
Fishing - Benthic trawling
conservation ecosystem characteristic: habitat
reduce impact fishing
reduce impact fishing: seafloor impact
restrictions on fishing
Non-renewable Energy (oil & gas construction)
conservation ecosystem characteristic: habitat
restriction on non-renewable Energy (oil & gas construction)
Telecommunications construction
conservation ecosystem characteristic: habitat
restriction on telecommunications (construction)
Tourism/Recreation
conservation ecosystem characteristic: habitat
restrictions on tourism/recreation
Thermal_regime_changes
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)
Underwater_noise
Military
reduce noise
Water_flow_rate_changes
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)

Annex 11b Measures for the high-threat chains for descriptor 6 (Sea floor integrity) per pressure-sector combination

The table below gives an overview of the measures (aim) for the high-threat chains for descriptor 6 Sea floor integrity per pressure-sector combination. To limit the output only those measures with a relatively narrow focus on the specific impact chains (i.e. an average SC score < 10) were selected.

The table can be read as following:
Pressure
  Sector
    Measures (aim)

Abrasion
Aggregates
conservation ecosystem characteristic: habitat
reduce impact aggregates and dredging
reduce impact aggregates and dredging: sea floor integrity
restrictions on aggregates and dredging
Fishing - Benthic trawling
conservation ecosystem characteristic: habitat
reduce impact fishing
reduce impact fishing: seafloor impact
restrictions on fishing
Navigational Dredging
conservation ecosystem characteristic: habitat
reduce impact aggregates and dredging
reduce impact aggregates and dredging: sea floor integrity
restrictions on aggregates and dredging
Shipping
conservation ecosystem characteristic: habitat
reduce impact shipping
Tourism/Recreation
conservation ecosystem characteristic: habitat
restrictions on tourism/recreation
Changes_in_siltation
Aggregates
reduce impact aggregates and dredging
reduce impact aggregates and dredging: changes in siltation
restrictions on aggregates and dredging
Agriculture
reduce impact agriculture
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Input_of_organic_matter
Agriculture
reduce impact agriculture
reduce impact agriculture:pollution
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Tourism/Recreation
restrictions on tourism/recreation
Waste Water Treatment
reduce impact waste water treatment
reduce impact waste water treatment:pollution
Introduction_of_microbial_pathogens
Shipping
reduce impact shipping
Introduction_of_non_indigenous_s
Aquaculture
reduce effects NIS

Reduce impact aquaculture
reduce impact aquaculture:introduction NIS
reduce introduction NIS
Fishing - Benthic trawling
reduce effects NIS
reduce impact fishing
reduce introduction NIS
restrictions on fishing
Military
reduce effects NIS
reduce introduction NIS
Research
reduce effects NIS
reduce introduction NIS
Shipping
reduce effects NIS
reduce impact shipping
reduce impact shipping: introduction NIS
reduce introduction NIS
Introduction_of_Non_synthetic_compounds
Agriculture
reduce impact agriculture
reduce impact agriculture:pollution
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)
Shipping
reduce impact shipping
reduce impact shipping: emission
reduce impact shipping:pollution
Waste Water Treatment
reduce impact waste water treatment
reduce impact waste water treatment:pollution
Introduction_of_Synthetic_compounds
Agriculture
reduce impact agriculture
reduce impact agriculture:pollution
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)
Shipping
reduce impact shipping
reduce impact shipping: emission
reduce impact shipping:pollution
Waste Water Treatment
reduce impact waste water treatment
reduce impact waste water treatment:pollution
Marine_Litter
Aquaculture
reduce effects litter
Reduce impact aquaculture
reduce litter
Fishing - Benthic trawling
reduce effects litter
reduce impact fishing
reduce impact fishing:litter
reduce litter
restrictions on fishing
Shipping
reduce effects litter
reduce impact shipping
reduce impact shipping-litter

reduce litter
Tourism/Recreation
reduce effects litter
Reduce impact tourism/ recreation
reduce impact tourism/recreation: litter
reduce litter
restrictions on tourism/recreation
Nitrogen_and_Phosphorus_enrich
Agriculture
reduce impact agriculture
Aquaculture
Reduce impact aquaculture
Land-based Industry
reduce impact land based industry:eutrophication
Tourism/Recreation
restrictions on tourism/recreation
Selective_Extraction_of_Non_livi
Aggregates
reduce impact aggregates and dredging
reduce impact aggregates and dredging: sea floor integrity
restrictions on aggregates and dredging
Selective_extraction_of_species
Fishing - Benthic trawling
reduce impact fishing
reduce impact fishing: bycatch
restrictions on fishing
Smothering
Aggregates
reduce impact aggregates and dredging
restrictions on aggregates and dredging
Aquaculture
Reduce impact aquaculture
Fishing - Benthic trawling
reduce impact fishing
restrictions on fishing
Navigational Dredging
reduce impact aggregates and dredging
restrictions on aggregates and dredging
Substrate_Loss
Aquaculture
conservation ecosystem characteristic: habitat
Reduce impact aquaculture
Coastal Infrastructure (construction)
conservation ecosystem characteristic: habitat
Fishing - Benthic trawling
conservation ecosystem characteristic: habitat
reduce impact fishing
reduce impact fishing: seafloor impact
restrictions on fishing
Non-renewable Energy (oil & gas construction)
conservation ecosystem characteristic: habitat
restriction on non-renewable Energy (oil & gas construction)
Telecommunications construction
conservation ecosystem characteristic: habitat
restriction on telecommunications (construction)
Tourism/Recreation
conservation ecosystem characteristic: habitat
restrictions on tourism/recreation
Thermal_regime_changes
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)
Water_flow_rate_changes
Non-renewable Energy (oil & gas construction)
restriction on non-renewable Energy (oil & gas construction)

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