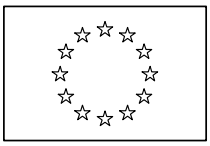

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COMMISSION STAFF WORKING PAPER

Relationship between the initial assessment of marine waters and the criteria for good environmental status

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1. INTRODUCTION

The Marine Strategy Framework Directive (MSFD)[1], often referred to as the Marine Directive, establishes a framework within which Member States must take the necessary measures to achieve or maintain good environmental status (GES) in the marine environment by the year 2020 at the latest. Member States are required to adopt marine strategies. These are plans of action which are to be delivered in several stages (Art. 5) and reviewed every six years. Marine strategies must apply an ecosystem-based approach to the management of human activities (see Art. 1(3)).

GES is defined in Art. 3(5) of the Marine Directive and it must be determined on the basis of the qualitative descriptors in Annex I of the Directive. Pursuant to Art.9(3), the Commission adopted on 1 September 2010 a Decision on criteria and methodological standards on good environmental status of marine waters[2], which is largely structured on the basis of the list of descriptors. The current document provides supplementary technical information on certain elements contained in the Commission Decision on GES criteria. To that end, it builds upon the relevant text from the Task Group reports by ICES/JRC[3] on the descriptors of GES, incorporating technical information from these documents and from comments made by Member States and stakeholders during 2010 which, although they could not be incorporated within the Commission Decision on GES criteria, could be useful for the implementation process. The main purpose of this document is to facilitate a better understanding of linkages between different articles and annexes under the Marine Directive. It aims to highlight a more explicit and integrated relationship between, on the one hand, the criteria and indicators laid down in the Commission Decision on GES criteria (which follow the structure of the list of descriptors of GES contained in Annex I to the Directive) and, on the other hand, the categories in Annex III of the Directive relating to the initial assessment of marine waters. Linkages are also provided to other relevant EU policies, such as the Water Framework Directive, to facilitate their integrated implementation where appropriate.

To that end, after an initial section on overarching matters (in particular the relationships between state, impacts and pressures), the main part of this document is organised on the basis of the structure of Annex III of the Directive, which contains indicative elements for the purpose of the initial assessment which is due in 2012 (Art. 8). Therefore, chapters 3 and 4 are structured according to the state characteristics of the marine environment (Annex III, Table 1 of the Directive) and pressures and impacts from human activities (Annex III, Table 2 of the Directive). It is recalled that both lists are expressly defined as indicative, allowing for additional elements based on regional, sub-regional or national characteristics and uses of the sea. For each section of characteristic or pressure and impact, the document addresses the linkage with the relevant criteria and indicators of the Commission Decision on GES criteria, facilitating an integrated understanding of the various components of the Directive (in particular, between the initial assessment and the determination of GES and targets.

A rational understanding of the linkages between the determination of GES (according to the descriptors of Annex I and the Commission Decision on GES criteria) and assessment (along the lines of Annex III) will also be needed for pragmatic and efficient monitoring programmes.

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1 Directive 2008/56/EC of the European parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

2 Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU), hereafter referred to as the Commission Decision on GES criteria.

3 A joint programme of work undertaken on behalf of the European Commission by the International Council for the Exploration of the Sea and the Joint Research Centre: http://www.ices.dk/projects/projects.asp#MSFD.

Monitoring needs to be related to both aspects. Art. 11 states that monitoring programmes need to be established on the basis of the initial assessment made pursuant to Art. 8(1) and also that they must allow for the "ongoing assessment of the environmental status of their marine waters". The latter must be made on the basis of the indicative lists of elements set out in Annex III and the list set out in Annex V of the Directive, and by reference to the environmental targets established pursuant to Art. 10. All these concurring drivers for monitoring are a further reason for an integrated approach.

Other elements for consideration in the initial assessment are described in chapter 5.

Chapter 6 looks forward on further issues relevant to implementation, including issues such as the relationship with climate change, the need for adaptive management, regional cooperation, the Common Implementation Strategy, the further implementation having regard to impacts and how identified research needs can be addressed.

The document contains a series of annexes. This includes an indicative timetable on the implementation of the Marine Directive (Annex 1) as well as various tables including on criteria, indicators and their linkages with the structure of the initial assessment described in Annex III to the Directive (see Annexes 2, 3, 4 and 5).

2. OVERARCHING MATTERS ON ASSESSMENT

2.1. Relationship between pressure, impact and state

A pressure can be described as a change, due to anthropogenic activities, in a physical, chemical or biological characteristic of the environment compared with background levels. A pressure, at particular levels of intensity, has the potential to have a direct or indirect impact on any part of the ecosystem. For example, the introduction in the natural environment of non-indigenous species as a consequence of human activities provides a pressure on the native biodiversity. When such species become abundant within habitats, they can alter the structure and functioning of the habitat and its native biodiversity and thus be considered to be causing an impact.

The degree of the impact depends upon various factors, such as the intensity and spatial and temporal distribution of the pressure and the sensitivity of each component of an ecosystem (e.g. a species or a habitat) to the pressure. Assessments of the state of ecosystem components are consequently informed by the impacts upon them which arise from each pressure. The cumulative impacts affecting the component, deriving from all the pressures, need to be assessed to determine whether the state of the component is in a condition compatible with GES.

Because of the comprehensiveness of the concept of GES, as described in Art.3(5), the descriptors in Annex I of the Directive, although generally with a focus on the desired state of the marine environment, already contain in practice a combination of state, impact and pressure elements. Therefore, this is also reflected in the Commission Decision on GES criteria, to the extent that it develops further the descriptors by laying down 26 criteria and 56 associated indicators to guide the assessment of progress towards GES. As a consequence, these criteria and indicators include a combination of state, impact and pressure elements.

In practice, there is a need to use pressure, impact and state indicators in combination to monitor and assess the state of the marine environment and to manage human activities having an impact upon it. **Annex 2** to this document provides a full list of the GES descriptors and their associated criteria and indicators, and includes an indication of whether they can be considered primarily as state, impact or pressure indicators. Some indicators have been designed in a manner which aims at capturing various aspects. For instance, some of them can be considered as both an impact and pressure indicator. For the indicator on effects of contaminants (8.2.2), the first part of the description relates to a pressure ('Occurrence, origin, extent of significant acute pollution events') but the latter part refers expressly to the impact (‘and their impact on biota physically affected by this pollution’). Similarly the indicators for criterion 9.1 on contaminants in seafood can be considered to reflect both the pressure ('level of contaminants') and the impact ('number of contaminants which have exceeded maximum regulatory levels' and 'frequency of regulatory levels being exceeded'). It is noted that, in this specific case, the impact considered by legislators relates primarily to human health.

Moreover, an impact indicator is ultimately intended to reflect whether there is an impacted state or not. Therefore, several indicators can be considered as both state and impact indicators, as they can serve both functions: most criteria and indicators under Descriptor 3 on commercial fish stocks tend to be used to assess impact on the fish stocks in relation to fishing pressure, whilst most criteria and indicators under Descriptor 6 on sea-floor integrity aim at addressing specific impacts, as described further in section 4.4 on physical loss and damage. In section 6.5 the relationships between the characteristics, pressures and impacts are further elaborated.

Sometimes there is insufficient scientific understanding so far of the relationships between pressures and impacts, and this can limit the ability to directly link a deterioration in the state of the ecosystem (or its components) to particular pressures. Indications of the need for further research on these relationships are given at relevant points in this document, including in the final section 6.6.

2.2. Relationship between the initial assessment, the determination of GES and environmental targets

For the initial assessment due in 2012, the Directive requires Member States to make an assessment (Art. 8), comprising:

(a) an analysis of the essential features and characteristics and current environmental status of their waters, based on the indicative list of elements set out in Table 1 of Annex III,

(b) an analysis of the predominant pressures and impacts, including human activity, on the environmental status of marine waters which is based on the indicative list of elements set out in Table 2 of Annex III, and

(c) an economic and social analysis of the use of the waters and the cost of degradation of the marine environment.

The initial assessment should take account of existing data where available.

By the same time (July 2012), Member States need to determine GES and establish environmental targets and associated indicators which will enable progress towards achieving GES to be assessed. The second periodic assessment in 2018 will therefore be an assessment of progress made since the 2012 initial assessment, having regard to the objective of taking measures to achieve or maintain GES by 2020 at the latest.

In determining GES and setting targets, it is important that the results of the initial assessment, which will be based on the indicative lists of characteristics (components of the marine ecosystems), pressures and impacts of Annex III of the Directive, are taken into account. All these simultaneous exercises, the initial assessment, the determination of GES and the setting of targets, should, wherever possible, be developed in an integrated manner so that subsequent assessments can build upon and be compared with the initial assessment while providing information on progress towards achieving GES. Therefore, chapters 3 and 4 of this document aim at identifying the criteria and indicators most relevant to the element(s) of Tables 1 and 2 in Annex III of the Directive (the indicative list of characteristics, pressures and impacts). This approach is summarised in **Annex 3** to this document.

The monitoring programmes, which are due in 2014, aim at providing data and information for an assessment of the environmental status, including progress towards GES. With the implementation of monitoring programmes, the gap between the available information from the initial assessment and the information needed with regard to future assessments should be further reduced.

For all these reasons it is advisable, as far as is possible, to base the initial assessment on the same ecosystem components and the same pressures (Annex III), and descriptors, criteria and indicators (Annex I, Decision) as will be used in subsequent assessments of whether GES has been achieved. As the initial assessment and the determination of GES, targets and indicators are being prepared in

parallel, full alignment may not be possible in the 2012 reports, as acknowledged in the Commission Decision on GES criteria[4].

This document aims to support an integrated understanding and further development of these various elements.

2.3. Implications of pressure, impact and state considerations on the determination of GES and environmental targets

As defined in the Directive (Art. 3(7)), an environmental target means a qualitative or quantitative statement on the desired condition of the different components of, and pressures and impacts on, marine waters. Targets and associated indicators may for instance specify the boundary (or threshold value) between an acceptable and an unacceptable condition (e.g. of a chemical level, population condition, habitat and community condition). They should be capable of guiding progress towards achieving GES, taking into account the indicative lists of pressures and impacts set out in Table 2 of Annex III of the Directive and also the continuing application of relevant existing environmental targets laid down at national, EU or international level in respect of the same waters.

Member States have the responsibility to determine the characteristics of GES and establish targets. In principle, targets should, where possible, be based on the characteristics of GES and therefore should be established having regard to the GES criteria and indicators in the Commission Decision on GES criteria. It is likely that a range of different types of targets will have to be established to capture collectively the state of ecosystem components (reflecting good environmental status of ecosystem components), impacts (reflecting the need to avoid or improve an undesirable state not equivalent to GES) and pressures (reflecting the need to reduce or stabilise them). Targets relating to pressures and impacts can provide a pragmatic focus on what is considered not to be a Good Environmental Status, and therefore facilitate the monitoring of progress towards achieving GES and the identification of appropriate programmes of measures. Particular attention is therefore likely to be needed on targets for reductions in the intensity and spatial extent of impacts on the marine environment in order to achieve or maintain GES. Targets on impacts should, where possible, be associated with relevant pressures and eventually to the programmes of measures related to specific human activities. The development of operational targets relating to concrete implementation measures to support their achievement, as described at point 2(c) of Annex IV to the Marine Directive, is likely to require the identification of associated indicators on drivers (human activities) and related pressures.

The development of targets and associated indicators must be carried out in the framework of the requirement for regional cooperation, keeping in mind the objective of coherence of frameworks within the different regions (Art. 5(2) and Art. 6) and coherence across the EU (Art. 12). For this reason, after the establishment by Member States of targets and associated indicators, the Commission will assess whether the elements notified constitute an appropriate framework to meet the requirements of the Directive. It will consider the coherence of frameworks within the different marine regions or sub-regions and across the EU. The Commission will also inform whether, in its opinion, the elements notified are consistent with this Directive and provide guidance on any modifications it considers necessary. This assessment and review process, due in 2013, allows for comparison between marine regions or sub-regions and therefore an opportunity to strengthen coherence at EU level in the implementation of the Marine Directive.

[4] Annex, Part A, points 8 and 9.

2.4. Methodological standards

The methodologies required for assessment and monitoring of the marine environment need to take into account and, where appropriate, be based upon those applicable under existing EU legislation and, where relevant, information, knowledge and approaches developed in the framework of Regional Sea Conventions.

A screening of available methodological standards has been undertaken by the Joint Research Centre (JRC) for DG Environment, with the aim of facilitating exchange of information among and within regions. JRC has prepared the Working Document "Review of Methodological Standards related to the Marine Strategy Framework Directive Criteria on Good Environmental Status" (JRC, 2011), based on the review of available standards in the following EU legislation and International Conventions:

(a) Water Framework Directive (WFD 2000/60/EC);

(b) Environmental Quality Standards Directive (EQS 2008/105/EC);

(c) Habitats Directive (92/43/EEC);

(d) Birds Directive (2009/147/EC);

(e) Common Fisheries Policy;

(f) Regional Sea Conventions covering European seas (OSPAR, HELCOM, BARCELONA, BUCHAREST).

It is noted that there are additional standards relevant to good environmental status not mentioned in the Working Document, such as those found in the EU animal health and food safety legislation, such as Regulation (EC) No 853/2004 laying down specific hygiene rules for food of animal origin[5].

Methodological standards are not defined in the Marine Directive. The Working Document by the JRC suggests that methodological standards are required for different purposes:

(a) assessing the status of the marine environment;

(b) setting environmental targets;

(c) executing monitoring.

International standard methodologies and guidelines exist, subject to adaptation where appropriate, for the assessment and monitoring of some indicators relevant for some descriptors of GES, such as in contaminants, eutrophication and litter. For other descriptors, such as biodiversity, non-indigenous species, food webs and sea-floor integrity, there is a general lack of technical guidelines and agreed methodologies adequate for the purposes of the Marine Directive.

Methodological standards that are already available and potentially relevant to the Directive are reported in the Working Document prepared by the Joint Research Centre and are therefore not addressed further in this document. The review is limited to methodologies which are available

[5] OJ L 139, 30.4.2004, p. 55. See more relevant information in section 4.3.3.

within European legislation and international conventions. The JRC Working Document does not place requirements on Member States on how the Directive should be implemented and methods included are not endorsed by the Commission as suitable as they stand for immediate application. However, they constitute the basis for further elaboration on methodological standards to be used for implementation of the Marine Directive, as mentioned in the Commission Decision on GES criteria.

3. STATE CHARACTERISTICS

3.1. Physical and chemical features

Table 1 in Annex III to the Marine Directive contains an indicative list of state characteristics related to the physical and chemical features of the marine environment (see Table 1 below).

Table 1: Characteristics with regard to physical and chemical features

Characteristics	
Physical and chemical features	- Topography and bathymetry of the seabed, - annual and seasonal temperature regime and ice cover, current velocity, upwelling, wave exposure, mixing characteristics, turbidity, residence time, - spatial and temporal distribution of salinity, - spatial and temporal distribution of nutrients (DIN, TN, DIP, TP, TOC) and oxygen, - pH, pCO_2 profiles or equivalent information used to measure marine acidification.

3.1.1. Identification of the relevant GES criteria and indicators

There are no criteria and indicators in the Commission Decision on GES criteria which address specifically, in isolation of their relation with particular ecosystem components or pressures and impacts on the ecosystem, the state of the general physical and chemical features listed in the first part of Annex III Table 1. The criterion 'nutrients level' (5.1) and associated indicators (5.1.1 nutrient concentrations and 5.1.2 nutrient ratios) reflect the state of nutrients but are closely related to nutrient enrichment and are therefore included in section 4.10 for the purpose of this document.

3.1.2 Linkages to other GES criteria and indicators

Whilst the spatial and temporal distribution of nutrients is mentioned in the section of Table 1 of Annex III as stated above, this issue is particularly relevant to nutrient enrichment and is therefore better addressed as a pressure (section 4.10). It is also noted that the situation with regard to chemicals is addressed later in Annex III to the Directive and therefore later in this document (section 4.8).

At the same time, all the physical and chemical parameters mentioned above are relevant for the description of the characteristics and the assessment of the condition of water column and seabed habitats, of habitats for species and of ecosystems as a whole. They are consequently of relevance to the ecosystem components detailed in sections 3.3, 3.4 and 3.5, and in particular to criterion 1.6 (habitat condition) and the associated indicator 1.6.3 (habitat condition). The physical characteristics of the seabed, such as the substrate type, structure and topography, and the characteristics of the overlying waters (e.g. temperature, salinity, currents, waves) are especially relevant in determining the character of biological communities. Additionally, understanding changes in many of these parameters, due to natural dynamics and climatic variation, is important in order to help interpret changes seen in monitoring data and to distinguish from changes in the ecosystem as a result of anthropogenic pressures.

In addition, there are several impact criteria and indicators, addressed later in this document, where an adequate understanding of physical and chemical characteristics is specifically relevant. Topography and bathymetry may be influenced by physical loss and damage (indicators 6.1.1 biogenic substrata and 6.1.2 extent of seabed affected; section 4.4), whilst hydrological changes (indicator 7.2.2 change in habitats; section 4.5) may influence the overall physical conditions in an area. Changes in water transparency and oxygen levels (indicators 5.2.2 and 5.3.2; section 4.10) may influence water and seabed characteristics.

3.2. Biological features and habitat types - overview

Following the structure in the Commission Decision on GES criteria and having regard to the information provided by the relevant ICES/JRC Task Group report on the interpretation and application of Descriptor 1 on biological diversity, the habitat types and biological features provided in Annex III Table 1 of the Directive are to be treated as follows:

(a) At the level of individual species;

(b) At the level of functional groups (of highly mobile species);

(c) At the level of habitat types;

(d) At the level of ecosystems.

GES criteria and indicators are associated to each of these levels, as detailed in sections 3.3 to 3.5, together with further guidance on the treatment of functional groups, predominant and special habitat types and habitats in particular areas.

It is noted that Table 1 of Annex III of the Directive does not contain a specific section for assessment at the scale of ecosystem. However, the contents of Table 1 are only indicative. The Commission Decision on GES criteria confirmed the need to undertake an assessment at ecosystem level. This is necessary to capture the purpose of Descriptor 1 in Annex I to the Directive, which addresses biodiversity incorporating the ecosystem level in its definition. Moreover, this broader assessment seems indispensable having regard to the ecosystem definition of GES in Art. 3(5) of the Directive. Therefore, this document is based on the understanding that assessments of environmental status should also include assessments at ecosystem level, although this may not be fully achievable for the initial assessment as the necessary assessment tools may need further development. One practical implication is that a number of criteria and indicators contained in the Commission Decision on GES criteria in relation to the functioning of ecosystems, including those relating to Descriptor 4 on food webs, will be addressed in this document in the section on ecosystem assessment, even if they refer to certain species or functional groups, because of their function in food webs. Of course, such species will anyway need careful consideration in the section on the assessment of species and functional groups.

The assessment of non-indigenous species, and in particular invasive non-indigenous species, can in principle be carried out in two separate sections: as a description of state in the section on biological features, or as a pressure and impact. For this reason, the item is mentioned twice in Annex III, both in Table 1 and in Table 2. Having said that, in the process of development of the Commission Decision on GES criteria, it became clear that the main interest for Member States is the pressure and impact perspective, as this relates to management measures (notably, the prevention of introductions of non-indigenous species). For this reason, this document addresses all elements relating to non-indigenous species in chapter 4. Similar approaches are adopted, for the purpose of this document, for nutrients and for hazardous substances, which can be partly considered in

relation to state characteristics (Table 1 of Annex III) but are more appropriately dealt with under pressures and impacts in the context of Table 2 of Annex III (*i.e*. chapter 4 of this document).

Finally, whilst Annex III Table 1 refers first to habitats and then to species, this document follows, for the purpose of identifying relevant criteria and indicators, the order laid down in the Commission Decision on GES criteria (from species to habitats and then to ecosystems), to the extent that an overview can only be achieved on the understanding of the various components. Common issues relevant to species, habitat and ecosystems are considered at section 3.6.

3.3. Biological features (species and functional groups)

Table 1 in Annex III to the Directive contains an indicative list of the state characteristics related to the biological features of the marine environment (see Table 2).

Table 2: Characteristics with regard to biological features

Characteristics	
Biological features	- information on the structure of fish populations, including the abundance, distribution and age/size structure of the populations - a description of the population dynamics, natural and actual range and status of species of marine mammals and reptiles occurring in the marine region or sub region - a description of the population dynamics, natural and actual range and status of species of seabirds occurring in the marine region or sub region - a description of the population dynamics, natural and actual range and status of other species occurring in the marine region or sub region which are the subject of EU legislation or international agreements - an inventory of the temporal occurrence, abundance and spatial distribution of non-indigenous, exotic species or, where relevant, genetically distinct forms of native species, which are present in the marine region or sub region.

(1) Individual species

At the level of individual species, the following are relevant:

(a) species listed under EU Directives and international agreements;

(a) commercially exploited species (in relation to Descriptor 3);

(b) genetically distinct forms of indigenous species;

(c) non-indigenous species, particularly those which are invasive (note that these are addressed further, as a pressure, in section 4.2);

(d) species which are assessed to represent or contribute to the assessment of functional groups (selection of such species should be based upon agreed criteria).

It is also noted that assessment of Descriptor 4 on food webs may include assessments of individual species. Where appropriate, the use of the same species as for Descriptor 1 on biodiversity and/or Descriptor 3 on commercial fish can maximise the use of data collected for assessments.

(2) Functional groups

At this level, following guidance from the relevant ICES/JRC Task Group report, and in the light of considerations by Regional Sea Conventions, the functional groups of highly mobile or widely dispersed species given in Table 3 are relevant.

Species group	Functional group
Birds	Intertidal benthic-feeding birds
	Inshore surface-feeding birds
	Inshore pelagic-feeding birds
	Inshore benthic-feeding birds
	Inshore herbivorous-feeding birds
	Offshore surface-feeding birds
	Offshore pelagic-feeding birds
	Ice-associated birds
Mammals	Toothed whales
	Baleen whales
	Seals
	Ice-associated mammals
Reptiles	Turtles
Fish	Diadromous fish
	Coastal fish
	Pelagic fish
	Pelagic elasmobranchs
	Demersal fish
	Demeral elasmobranchs
	Deep-sea fish
	Deep-sea elasmobranchs
	Ice-associated fish
Cephalopods	Coastal/shelf pelagic cephalopods
	Deep-sea pelagic cephalopods

Table 3: Functional groups of highly mobile and widely dispersed species of marine birds, mammals, reptiles, fish and cephalopods.

3.3.1 Identification of the relevant GES criteria and indicators

The criteria and indicators which are directly relevant for the assessment of the state of birds, mammals, reptiles, fish and cephalopods, plus listed species and those which have genetically distinct forms, are indicated in Table 4. The criteria and indicators provided in the Commission Decision on GES criteria for Descriptors 1 (biodiversity) and 3 (commercially exploited fish and shellfish) are particularly relevant for the assessment of the environmental state of these species groups. Several criteria and indicators for Descriptor 4 on food webs also concern species and functional groups and may therefore need also to be considered although, as mentioned earlier, their application is particularly relevant for assessment at the scale of ecosystems (section 3.5).

Consideration of the criteria and indicators in Table 4 is essential to identify the most appropriate ones to be used in the first and subsequent assessments, according to their ecological relevance to the region/subregion or specific area under analysis, taking into consideration the main risks for progressing towards GES and associated targets for each criterion. An assessment of the level of impacts from pressures (see section 3.3.2) is important to facilitate a prioritisation of future needs of the Directive.

Table 4: Relevant criteria and indicators with regard to biological features (individual species and functional groups)

	Component	Criteria	Indicators
At level of individual species	- Fish - Mammals - Reptiles - Seabirds - Other species of EU legislation and international agreements - Genetically distinct forms of native species	1.1 Species distribution	1.1.1 species distribution range 1.1.2 species distributional pattern 1.1.3 area covered by species
		1.2 Population size	1.2.1 population abundance
		1.3 Population condition	1.3.1 population demographics 1.3.2 population genetic structure
	- Commercially exploited fish and shellfish – additional criteria/indicators	3.2 Reproductive capacity of the stock	3.2.1 spawning stock biomass 3.2.2 biomass indices
		3.3 Population age and size distribution	3.3.1 proportion of large fish 3.3.2 mean max. length 3.3.3 fish length distribution 3.3.4 size at first sexual maturation
	- Non-indigenous species	Refer to section 4.2	
At level of functional groups	- Fish - Mammals - Reptiles - Seabirds - Cephalopods	1.6 Habitat condition	1.6.1 condition typical species 1.6.2 relative abundance 1.6.3 habitat condition

As mentioned above, non-indigenous species will be primarily handled, for the purpose of this document, in chapter 4 on pressures and impacts.

Commercially exploited fish and shellfish, to be dealt with under Descriptor 3, have specific criteria and associated indicators which provide for assessment of their state and also an indication of the level of impact on the stocks from fishing activities. The share of juvenile specimens in catches and landings (addressed by indicator 3.3.1 on the proportion of fish larger than the mean size of first sexual maturation) should be an important part of assessments on environmental status, given the results of recent research showing the importance of the presence of large specimens for the overall carrying capacity of ecosystems through mixing and fertilisation effects[6].

Assessments at the functional group level should aim at an overall assessment of the state of the group, taking account of the range of species typical for the group within the region or sub-region. The assessment is therefore similar to that for a community of species in water column and seabed habitats, in that it should consider the species composition and relative abundances of the component species, together with the condition of the habitat for the functional group; in some exceptional circumstances the criteria of habitat distribution and extent may also be relevant. Assessment at the functional group level may use representative species from the group (assessed at species level) to inform the overall assessment, provided suitable consideration is given to the overall state of the group (i.e. overall species composition and relative abundance).

[6] Weber, T.S. & C. Deutsch, 2010. Ocean nutrient ratios governed by plankton biogeography. Nature, **467**, 550-554.

3.3.2 Linkages to other GES criteria and indicators

The state of the biological features (such as species, functional groups), which are a central part of Annex III Table 1 and a main object of the biodiversity descriptors of Annex I to the Directive, may be impacted by a wide range of pressures, which are addressed in other parts in the initial assessment and are captured by various other descriptors in Annex I to the Directive.

Table 5: Further linkages to other criteria and indicators (dark cells (green) indicate where the indicators for impacts and pressures are known to be relevant in some areas, whilst light cells (orange) indicate the indicators that are potentially relevant)[7]

					Biological features at level of individual species or functional groups					
Descriptor	**Criteria**		**Indicators**		**Seabirds**	**Mammals**	**Reptiles**	**Fish**	**Cephalopods**	**Other species; genetically distinct forms**
D2	2.2	Environmental impact of invasive non-indigenous species	2.2.1	Ratio invasive non-indigenous species to native species	At level of functional group					
			2.2.2	Impact of non-indigenous species						
D3	3.1	Level of pressure of the fishing activity	3.1.1	Fishing mortality				Commercial species		Commercial species
			3.1.2	Ratio between catch & biomass				Commercial species		Commercial species
D6	6.1	Physical damage, having regard to substrate characteristics	6.1.1	Type, abundance, extent of biogenic substrate						For species associated with seabed habitats
			6.1.2	Extent of seabed affected by human activities						
	6.2	Condition of benthic community	6.2.1	Presence of sensitive and/or tolerant species.						
			6.2.2	Multi-metric indexes for benthic communities						
			6.2.3	Proportion of biomass/numbers in the macrobenthos						
			6.2.4	Benthic community size parameters						
D7	7.2	Impact of permanent hydrographical changes	7.2.1	Extent of habitats affected						
			7.2.2	Changes in habitats, in particular functions provided	For the habitat of the species, where appropriate					
D8	8.1	Concentration of contaminants	8.1.1	Concentration of contaminants						
	8.2	Effects of contaminants	8.2.1	Level of pollution effects						
			8.2.2	Occurrence, origin & extent of acute pollution & impact on biota						
D9	9.1	Levels, number and frequency of contaminants	9.1.1	Levels of contaminants, number exceeding regulatory levels				Commercial species		Commercial species
			9.1.2	Frequency of exceeding regulatory levels				Commercial species		Commercial species
D10	10.1	Characteristics of litter in the marine and coastal environment	10.1.1	Trends in litter on shores						
			10.1.2	Trends in litter in water column & on sea-floor						
			10.1.3	Trends in micro-particles						
	10.2	Impacts of litter on marine life	10.2.1	Trends in litter ingested						
D11	11.1	Distribution of loud, low & mid frequency impulsive sounds	11.1.1	Anthropogenic sound levels that entail significant impact						
	11.2	Continuous low frequency sound	11.2.1	Ambient noise levels						

To this end, Table 5 summarises the further linkages between the biological features to be considered in the initial assessment and the criteria and indicators laid down in the Commission Decision on GES criteria for other descriptors concerning pressures and associated adverse effects.

[7] In the table 'Other species' refers to species which are the subject of Community legislation or international agreements. 'Genetically distinct forms' are of native species (from Annex III Table 1 of the Directive).

This includes Descriptor 2 (non-indigenous species), 3 (commercial fish), 6 (sea-floor integrity), 7 (hydrographical changes), 8 and 9 (contaminants), 10 (litter) and 11 (energy, including noise). Most of these are relevant for the assessment of many biological features (as shown in the Table).

Having regard to the various potential linkages, it is clear that additional research will be required to provide an adequate understanding of cumulative impacts on ecosystem components. However, information is likely to already be available on the direct concerns of most relevance to the area and component under consideration, and the criteria and indicators related to such additional pressures should be identified by the initial assessment when addressing biological features.

3.4. Habitat types (and associated biological communities)

Table 1 of Annex III to the Directive contains an indicative list of the state characteristics related to the habitat types of the water column and seabed (see Table 6).

Table 6: Characteristics with regard to habitat types and associated biological communities

Characteristics	
Habitat types	- The predominant seabed and water column habitat type(s) with a description of the characteristic physical and chemical features, such as depth, water temperature regime, currents and other water movements, salinity, structure and substrata composition of the seabed, - identification and mapping of special habitat types, especially those recognized or identified under EU legislation (the Habitats Directive and the Birds Directive) or international conventions as being of special scientific or biodiversity interest, - habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference. This may include areas subject to intense or specific pressures or areas which merit a specific protection regime.
Biological features	- A description of the biological communities associated with the predominant seabed and water column habitats. This would include information on the phytoplankton and zooplankton communities, including the species and seasonal and geographical variability, - information on angiosperms, macro-algae and invertebrate bottom fauna, including species composition, biomass and annual/seasonal variability,

As indicated in the Commission Decision on GES criteria, the term habitat addresses both the abiotic characteristics and the associated biological community, treating both elements together in the sense of the term biotope. Consequently, the section on habitat types is treated here together with their associated biological features, as follows:

(a) Water column habitats are combined with phytoplankton and zooplankton communities;

(b) Seabed habitats are combined with angiosperms, macro-algae and invertebrate bottom fauna, and associated vertebrate fauna.

The other biological features (cephalopods, fish, reptiles, mammals and seabirds) are associated to differing degrees with water column and seabed habitats. As the majority of species within these

taxonomic groups are highly mobile and/or widely dispersed and can be associated with multiple habitat types during their life cycle, they are treated separately, within their functional groups (see section 3.3). Where individual species within these taxon groups are strongly associated with particular habitat types they should be treated as part of that habitat type; this is particularly relevant for certain fish species associated with seabed habitats. Linkages between the state of fish, mammals, reptiles and seabirds and the water column and seabed habitats in which they live can be treated more holistically under the ecosystem structure indicator (1.7.1) and, where appropriate, the food web indicator (4.3.1), and are therefore addressed under section 3.5 on assessment at ecosystem level.

Table 1 of Annex III to the Directive indicates three aspects relating to habitats. These are treated as follows:

(1) Predominant habitat types

To facilitate the consistency of assessments and the comparability of monitoring results a consistent set of predominant habitat types should be used across all regions and sub-regions (Table 7).

Table 7: Predominant habitat types

Ecological zone/realm	**Habitat type**
Seabed habitats	Littoral rock and biogenic reef Littoral sediment Shallow sublittoral rock and biogenic reef Shallow sublittoral coarse sediment[8] Shallow sublittoral sand Shallow sublittoral mud Shallow sublittoral mixed sediment Shelf sublittoral rock and biogenic reef Shelf sublittoral coarse sediment Shelf sublittoral sand Shelf sublittoral mud Shelf sublittoral mixed sediment Upper bathyal[9] rock and biogenic reef Upper bathyal sediment Lower bathyal[10] rock and biogenic reef Lower bathyal sediment Abyssal rock and biogenic reef Abyssal sediment

8 The sediment habitats can be subdivided into four classes (coarse, sand, mud, mixed) for the shallow and shelf zones. The shallow zone can be further divided into infralittoral and circalittoral zones. In some regions, the shelf may be referred to as 'offshore'. The littoral zone (Atlantic) is equivalent to the hydrolittoral zone (Baltic) and the medio-littoral zone (Mediterranean).

9 Refers to the Slope and Upper Bathyal zones of Howell (2010)

10 Refers to the Mid and Lower Bathyal zones of Howell (2010)

Ecological zone/realm	Habitat type
Water column habitats	Reduced salinity water[11] Variable salinity (estuarine) water Marine water: Coastal Shelf Oceanic
Ice habitats	Ice-associated habitats

Use of these types provides a direct link between the habitats assessed under Descriptor 1 and the substrate types to be assessed for Descriptor 6 (indicator 6.1.2, – different substrate types affected by physical damage) and to the European EUNIS[12] habitat classification scheme[13].

(2) Special habitat types

The category of special habitat types is directed, in particular, to those recognised or identified under several regulatory frameworks, such as EU legislation (the Habitats Directive and Birds Directive) or international conventions, as being of special scientific or biodiversity interest. These are often also referred to as 'Listed habitats'.

For the purposes of implementation of the Directive, a set of relevant 'Listed' (special) habitat types should be drawn up for each region/subregion, referring to the indicative list of policies given in Section 3.6.1.

As many of these listed types are at a finer level of definition than the predominant types, their assessment may contribute in whole or in part to the assessments required for the predominant habitat types.

(3) Habitats in particular areas

On this point, Annex III of the Directive refers to habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference. These can include, for instance:

(a) Areas subject to specific or multiple pressures and therefore likely to entail risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea;

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11 In the Baltic Sea and Black Sea, it may be appropriate to split this according to significant changes in the biology (i.e. 0.5-4.5‰; 4.5-18‰) or adopt a coastal/offshore approach similar to other regions. From 18-30‰ (in the Kattegat) is treated as variable salinity. The reduced and low salinity categories of the Task Group on biological diversity have been combined, due to overlap in salinity levels in the Baltic and Black Seas.

12 http://eunis.eea.europa.eu/habitats.jsp

13 For practical implementation of the Directive, the predominant habitat types can follow a modified EUNIS scheme, where biogenic reefs are associated with rock habitats (both have epibiota communities), coast and shelf habitats are separated (to reflect significant changes in human influences as well as ecological characteristics) and the deep sea follows the more refined zonal scheme of Howell, K.L., 2010. A benthic classification system to aid in the implementation of marine protected area networks in the deep/high seas of the NE Atlantic. Biological Conservation. 143, 1041-1056. Indicative maps of the predominant habitat types for some regions are provided by the EUSeaMap project (www.jncc.gov.uk/EUSeaMap); these provide indicative depth boundaries between the different zones, which vary according to the oceanographic characteristics of the different marine regions and are subject to further development.

(b) Areas already designated, or that may deserve designation, for various forms of spatial and management protection. This can include fishery-closed areas or areas subject to specific navigation rules because of their environmental characteristics (*e.g.* Particularly Sensitive Sea Areas) as well as marine protected areas. It is recalled that marine protected areas are also to be addressed in Art. 13(4) in which there is a need to establish a coherent and representative network that adequately covers the diversity of the constituent ecosystems. The Directive therefore provides the opportunity to complete current efforts to identify and designate marine protected areas for the Habitats and Birds Directives and for the Regional Sea Conventions and to fulfil the commitments under the Convention of Biological Diversity.

Such "habitats in particular areas" relate primarily to specific places rather than specific habitat types. It is noted that this part of the initial assessment is of direct relevance to certain important provisions in the Directive, such as the objective to restore, where practicable, marine ecosystems in areas where they have been adversely affected (Art. 1(2)a)). This implies that the initial assessment should, wherever necessary, operate at a scale adequate to identify and address the situation in areas which merit a particular reference in the sense of this heading of Annex III.

3.4.1. Identification of the relevant GES criteria and indicators

The criteria and indicators which are relevant for the assessment of the state of habitat types (predominant and special) are indicated in Table 8. The criteria and indicators laid down in the Commission Decision on GES criteria for Descriptor 1 (habitats) are directly relevant for the analysis of the current environmental status, as are most of those relating to Descriptor 6 on sea-floor integrity.

Consideration of the criteria and indicators in Table 8 is essential to identify the most appropriate ones to be used in the first and subsequent assessments, according to their ecological relevance to the region/subregion or specific area under analysis, taking into account the likelihood of achieving GES and associated targets for each criterion. The predominant and special habitat types need to be assessed at the level of the region or subregion according to the criteria in the Commission Decision on GES criteria.

Table 8: Relevant criteria and indicators with regard to habitat types and associated biological communities

	Component	**Criteria**	**Indicators**
At level of habitat types	- Predominant seabed and water column habitat types, including their biological communities (phytoplankton, zooplankton, angiosperms, macro-algae, bottom fauna)	1.4 Habitat distribution	1.4.1 habitat distributional range 1.4.2 habitat distributional pattern
		1.5 Habitat extent	1.5.1 habitat area 1.5.2 habitat volume
		1.6 Habitat condition	1.6.1 condition typical species 1.6.2 relative abundance 1.6.3 habitat condition
	- Special habitat types, especially those under EU legislation and international conventions	6.2 Condition of benthic community	6.1.1 biogenic substrata 6.2.1 presence sensitive species 6.2.2 multi-metric indexes 6.2.3 proportion biomass of individuals above size 6.2.4 size spectrum of benthic community

3.4.2. Linkages to other GES criteria and indicators

As a first comment, some of the criteria and indicators for Descriptor 6 (sea-floor integrity) are contained in section 3.4.1. Having said that, such criteria and indicators are largely related to the assessment of impacts, notably from physical damage and loss, and are therefore considered in more detail in section 4.4.

Table 9: Further linkages to other criteria and indicators (dark cells (green) indicate where the indicators for impacts and pressures are known to be relevant in some areas, whilst the orange light indicate the indicators that are potentially relevant)[14]

					Water column and seabed habitat types – predominant, special types		
Desc-riptors	**Criteria**		**Indicators**		**Phytoplankton**	**Zooplankton**	**Angiosperms, macro-algae & bottom fauna**
D2	2.2	Environmental impact on invasive non-indigenous species	2.2.1	Ratio between invasive non-indigenous species & native species.			
			2.2.2	Impact of non-indigenous species			
D5	5.1	Nutrient levels	5.1.1	Nutrient concentration			
			5.1.2	Nutrient ratios			
	5.2	Direct effects of nutrient enrichment	5.2.1	Chlorophyll concentration			
			5.2.2	Water transparency related to algae			
			5.2.3	Abundance of opportunistic macroalgae			
			5.2.4	Species shift in floristic composition			
	5.3	Indirect effects of nutrient enrichment	5.3.1	Abundance of perennial seaweed			
			5.3.2	Dissolved oxygen			
D6	6.1	Physical damage, having regard to substrate characteristics	6.1.1	Type, abundance, extent of biogenic substrate			
			6.1.2	Extent of seabed affected by human activities			
D7	7.1	Spatial characterisation of permanent alterations	7.1.1	Extent of area affected	Water column habitat		
	7.2	Impact of permanent hydrographical changes	7.2.1	Extent of habitats affected			
			7.2.2	Changes in habitats, in particular functions provided			
D8	8.1	Concentration of contaminants	8.1.1	Concentration of contaminants			
	8.2	Effects of contaminants	8.2.1	Level of pollution effects			
			8.2.2	Occurrence, origin & extent of acute pollution and impact on biota	Can be relevant but focus is likely to be on higher taxa (e.g. seabirds, mammals) and on seabed habitats		
D9	9.1	Levels, number and frequency of contaminants	9.1.1	Levels of contaminants, number exceeding regulatory levels			Commercially exploited species
			9.1.2	Frequency of exceeding regulatory levels			
D10	10.1	Characteristics of litter in the marine and coastal environment	10.1.1	Trends in litter on shores			
			10.1.2	Trends in litter in water column & on sea-floor			
	10.2	Impacts of marine litter on marine life					

The overall state of a habitat type should be assessed in relation to the cumulative impact (adverse effects) on it from all the pressures from human activities to which it is subject. As shown above in relation to species, Table 9 summarises the linkages between the habitat types to be considered in the initial assessment and criteria and indicators laid down in the Commission Decision on GES criteria for other descriptors concerning pressures and associated adverse effects. This includes Descriptor 2 (non-indigenous species), 5 (eutrophication), 6 (sea-floor integrity) to the extent not

[14] The indicator 10.2.1 Trends in litter ingested by marine animals unlikely to be relevant to benthic habitats, but the criterion 10.2 could be (with other indicators).

addressed already above, 7 (hydrographical changes), 8 and 9 (contaminants) and 10 (litter). Most of them are relevant for the assessment of many habitat types (as shown in the Table).

Information is likely to already be available on the direct concerns of most relevance to the area and component under consideration, and the criteria and indicators related to such additional pressures should be identified by the initial assessment when addressing habitats.

3.5. Ecosystems

3.5.1. Identification of the relevant GES criteria and indicators

As mentioned earlier, Table 1 of Annex III to the Directive does not indicate specifically an assessment at the level of ecosystems. However, the Commission Decision on GES criteria provides a criterion at this level under Descriptor 1, and Descriptor 4 on food-webs is most readily associated to this scale. In fact, the definition of GES, as laid down in Art.3(5), requires an assessment at ecosystem level. In this context, ecosystems can be considered as encompassing multiple predominant habitat types and functional groups of species. The relevant state criteria and indicators are given in Table 10.

Table 10: Relevant criteria and indicators with regard to ecosystem level assessments

	Component	**Criteria**	**Indicators**
At level of ecosystems	Ecosystems	1.7 Ecosystem structure	1.7.1 composition ecosystem
		4.1 Productivity of key species or trophic groups	4.1.1 performance key predator
		4.2 Proportion of species at the top of food webs	4.2.1 large fish
		4.3 Abundance/distribution of key trophic groups/species	4.3.1 abundance trends selected groups

Careful selection of species and habitats for assessment at these levels should assist in providing the necessary information to undertake assessments at the ecosystem level.

The Commission Decision on GES criteria indicates that the interactions between the structural components of the ecosystem are fundamental for assessing ecosystem processes and functions. The criteria and indicators for Descriptor 4 provide specific elements of this in relation to food-webs. While interactions between species in a food web are complex and constantly changing, important variations in species relative abundance in an ecosystem will affect interactions in several parts of a food web, and may have an adverse effect on the functioning of ecosystems.

3.5.2. Linkages to other GES criteria and indicators

Whilst many pressures may impact marine ecosystems, the pressure and impact indicators in the Commission Decision on GES criteria which seem to be of most relevance at this level are 2.2.2 (impact non-indigenous species), 3.1.1 (fishing mortality), 3.1.2 (ratio between catch and biomass index), 5.3.2 (dissolved oxygen), 6.1.2 (extent of seabed affected), 7.1.1 (extent of area affected by permanent alteration), 7.2.1 (spatial extent of habitats affected), 7.2.2 (change in habitats due to hydrographical changes), 8.1.1 (concentration of contaminants), 8.2.1 (level of pollution effects)

and 8.2.2 (acute pollution events). The assessment at the scale of ecosystems will therefore imply, having regard to the comprehensive definition of GES in Art. 3(5) of the Directive, an overall understanding of the state of the environment is needed, having regard to cumulative impacts from the whole range of pressures of human activities. Assessment at this scale should therefore be important for the long-term purposes of the Directive, as laid down in Art. 1, but will require the further development of adequate integrated assessment approaches.

3.6. Biological features and habitat types – general issues

3.6.1. Linkages to other policies and conventions

There are a number of relevant EU Directives and international conventions requiring specific protection of some elements of biodiversity. The main ones are shown in Table 11.

Table 11: Linkages to other policies and conventions

	Biological features at level of individual species or functional groups							Water column and seabed habitat types		
Marine Strategy Framework Directive	Seabirds	Mammals	Reptiles	Fish	Cephalopods	Other species; genetically distinct forms	Non-indigenous species	Phytoplankton	Zooplankton	Angiosperms, macro-algae & bottom fauna
Water Framework Directive								within 1 nm		within 1 nm
Habitats Directive		Selected species	Selected species	Selected species						Selected habitats & species
Birds Directive										
Common Fisheries Policy				Commercial	Commercial					Shellfish
Helsinki Convention	Selected species	Selected species		Selected species						Selected habitats & species
OSPAR Convention	Selected species	Selected species	Selected species	Selected species				Eutrophication		Selected habitats & species
Barcelona Convention	Selected species	Selected species	Selected species	Selected species				MEDpol monitoring programme		Selected habitats & species
Bucharest Convention	Selected species	Selected species		Selected species						Selected habitats & species
Bern Convention										
Bonn Convention & agreements	Selected species	Selected species								
Ramsar Convention										Selected habitats & species
CITES		Selected species	Selected species	Selected species						
International Convention for the Regulation of Whaling		Selected species								

3.6.2. Spatial and temporal distribution

The habitat types and biological features are distributed spatially according to their ecological preferences and thus vary considerably from place to place, depending on the physiographic, oceanographic and geographic conditions. In addition, marine ecosystems are dynamic and thus subject to constant natural changes (e.g. due to predator-prey relationships and species migrations) as well as fluctuations resulting from climatic variation. There can periodically be regime shifts in some ecosystems which result in significant changes in the balance of species in the ecosystem.

The temporal scale for aspects of the life cycle (e.g. reproduction, growth, mortality) also varies considerably between species, from hours up to decades, and can, in some cases, result in dramatic fluctuations in population size between years.

It is important to understand the nature and scale of such spatial and temporal dynamics, with monitoring of biodiversity consequently undertaken at a periodicity which is suitable to distinguish such natural dynamics from the identification of changes due to anthropogenic pressures.

The determination of GES, the setting of state-based targets and the assessment of the state of marine biodiversity needs to take account of such spatial and temporal patterns in biodiversity.

In view of spatial and temporal distribution patterns, a suitable set of ecological assessment areas, which can adequately reflect both the ecological scales exhibited by the biodiversity components in each region or subregion and the links to scales which are effective for management measures, may be particularly helpful to define. Regarding measures, it is recalled that Art. 1(2)(a) of the Directive requires to protect and preserve the marine environment, prevent its deterioration or, where practicable, restore marine ecosystems in areas where they have been adversely affected.

3.6.3. Monitoring needs

Monitoring should aim in principle at identifying proximity to GES, direction of change (and, if possible, the rate of change) and progress towards (or away from) GES. However, the availability of long-term and spatially well-distributed monitoring data sets for assessing biodiversity is limited to a few well studied species groups and habitat types. This in turn has limited the development of effective indicators to monitor biodiversity. There is therefore, generally, a need for improved monitoring programmes which provide sound spatial and temporal coverage linked to the main pressures and impacts, and to facilitate an understanding of the natural and climatic variation in biodiversity. Monitoring should focus, in particular, on the locations and types of human activities and their associated pressures on and risks to biological diversity, which can help to provide a predicted or modelled extent of the pressures and thus their potential impact on biodiversity components, on the basis of sampling and related analysis.

Wherever possible, existing monitoring programmes for other policies should be harnessed and integrated, together with any necessary gap filling, to produce more holistic and effective programmes. Developing links to programmes for monitoring of pressures (e.g. contaminants, fisheries) can also be beneficial.

Monitoring of commercially-exploited fish is generally more advanced than other aspects of biodiversity. Nevertheless, there are considerable differences between regions and subregions, which may compromise the quality of GES assessments. Data for shellfish are often lacking.

3.6.4. Further development of the criteria and indicators

The criteria and indicators listed in the Commission Decision on GES criteria generally need to be developed further, more specifically, in accordance to the particular species, habitats and ecosystems which will be monitored and in relation to the differing regional characteristics. The purpose could be to make them more operational, for instance by specifying the selection of representative ecosystem components (species, habitats) within marine regions or subregions that still allow the main concerns within functional groups and predominant habitat types to be addressed.

The Commission Decision on GES criteria also specifies a number of areas requiring further development, for instance in relation to sea-floor integrity, some of which relate to state characterisation and are therefore relevant to this section (other aspects are more relevant to impacts, as mentioned).

There is still significant lack of understanding to assess the ecosystem consequences of changes in food webs. Therefore, there is a need to develop further indicators that focus on the relationships within the food web (to address for instance energy flow processes, main predator-prey processes, trophic relationships -e.g. assessment approaches for group level assessment related to the Marine Trophic Index[15], having regard to its application in the context of the Convention on Biological Diversity - or the structure of the food web). The objective of any revised assessment tools should be to ensure that populations of selected food web components occur at levels that are within acceptable ranges that will secure their long-term viability. Therefore, ecosystem components should be selected carefully, avoiding the need for large numbers of species (for which abundance or biomass trends are required) to be used and aiming to secure coherence with the species selected for assessment at species and functional group level.

Indicators for ecosystem assessment are particularly in need of further development for both structural and functional aspects. This applies at all scales, including for addressing biodiversity at the scale of the ecosystem.

3.6.5. Research needs

- Habitat types and biological features

Mapping of seabed habitats: there is a lack of broad-scale mapping, which provides an important tool for assessment and planning, for some areas of Europe's seas, particularly central and eastern Mediterranean and the Black Sea. It is also important to have fine-scale maps to facilitate detailed assessments (e.g. specific impacts from pressures, selection of appropriate monitoring sites).

Mapping of pelagic habitats: development of coherent broad-scale pelagic habitat maps is needed to support the effective assessment of predominant water column habitats. They are also important to show hot spots for pelagic species such as feeding grounds, up-welling areas and spawning areas.

Development of EUNIS habitat classification: The current EUNIS classification for marine habitats requires further development to ensure it is of full practical use for application within the Directive. Modification of the current classification is needed, in particular for the Baltic Sea, and for southern parts of the north-east Atlantic. In general the offshore and deep-water areas require improved classification, and more specific linking between the community types and the physical/hydrological habitat characteristics (to improve modelling of habitat distribution).

Maps for species: development of EUNIS class 'aggregations' to provide habitat maps for the different life history stages of highly mobile species is needed. Increased knowledge of the use of habitats by species: some highly mobile species depend on different habitats throughout their life cycle; the need for differing habitats and the levels of protection needed requires further research.

- Biological features not specifically addressed in the Commission Decision on GES criteria

Even though they are not mentioned in the indicative list of Table 1 of Annex III, microbes and viruses, which play a key role in ecosystem functioning (energy transfer at the base of the food web), need further attention. Although research knowledge on microbes and viruses is available, there is a lack of common understanding of the implications for environmental assessment and management programmes. There is a need to develop research on issues such as the role of microbes and viruses in ecosystem functioning across a range of ecological zones, the potential

[15] Pauly, D. 2010. Five easy pieces, Island Press, chapter 2 and Pauly *et al*., 1998. Fishing down marine food webs. *Science*, 269(5352): 860-863.

influence of climate-induced warming on microbial function in marine ecosystems and the relationships between pressures and microbial function, particularly for sea-floor impacts, such as physical disturbance and organic loading.

- Ecosystem functioning

As indicated, this should include additional scientific knowledge on various processes relevant to food webs, such as energy flows, main predator-prey processes and trophic relationships. More broadly, there is a general need for an enhanced knowledge on ecosystem functioning, which is central to the concept of GES, including interactions between biodiversity components within ecosystems. This issue, and other research needs which require a combined understanding of state and pressures, having regard to impacts, are addressed in section 6.6 which takes stock of general research needs.

3.7. Other features

Table 1 of Annex III to the Directive contains an indicative list of the state characteristics related to other features of the marine environment (see Table 12).

Table 12: Characteristics with regard to other features

Characteristics	
Other features	- A description of the situation with regard to chemicals, including chemicals giving rise to concern, sediment contamination, hotspots, health issues and contamination of biota (especially biota meant for human consumption) - A description of any other features or characteristics typical of or specific to the marine region or sub region.

The description of chemical properties that should be assessed in Annex III is potentially broad. Like physical features laid down in the first part of Annex III Table 1, chemical conditions are mentioned in Art. 3 (5b) of the Directive because their understanding, and the way they support marine ecosystems, can be of direct relevance. However, it is clear that the primary purpose of the initial assessment in relation to chemicals is to assess the contaminants in the marine environment and contaminants in fish and other seafood for human consumption.

This is a case where both tables of Annex III are largely overlapping. Although it would be possible to address chemical state in isolation, the introduction of contaminants implies a pressure which can impact the marine environment. Therefore, it is preferred to address contaminants in section 4.8.

Other features or typical characteristics to be taken into account must be indicated in the initial assessment of the current environmental status. There are no specific criteria and indicators associated with this aspect. However, this broad concept allows for the initial assessment to address all relevant aspects for a comprehensive understanding of the environmental features.

4. PRESSURES AND IMPACTS

Table 2 of Annex III to the Marine Directive contains an indicative list of pressures and impacts on the marine environment, including some examples from human activities from various economic sectors (drivers). It is important to highlight that this list is merely indicative as other pressures may be particularly relevant for certain ecosystem components. Member States must address in their initial assessment the "predominant" pressures and impacts, further to Art. 8(1)b, which is likely to entail the identification of additional pressures and impacts. In addition, Annex III is, like all other elements in the Marine Directive, subject to the principle of adaptive management laid down in Art. 3(5), which implies in this case the need for updating the list of pressures and impacts, in view of improved technical and scientific understanding, experience in management and emerging activities and associated pressures. The relationship with underlying drivers, notably human activities and economic sectors, is addressed in section 5.1. This aspect is further addressed in section 6.2 on adaptive management. While the structure of this chapter follows largely the elements laid down in Table 2 of Annex III to the Directive, some adjustments have been introduced.

Firstly, it appears that the sections on physical damage (and loss) and of biological disturbance share the underlying concept that the pressures at stake can directly affect the structure and functioning of ecosystems. This document therefore groups them more closely together, beginning with biological disturbance and starting this with the most intense pressure on the marine environment.

Secondly, the section on "biological disturbance" in Annex III has been split to improve readability in this document, as it contains rather separate elements and two of them also have a specific descriptor in Annex I (Descriptor 2 on non-indigenous species and Descriptor 3 on commercial fish), and have therefore been addressed in detail as mentioned (unlike the reference to the introduction of microbial pathogens).

Thirdly, the category in Annex III called "other physical disturbance" has been split along its two elements, underwater noise and marine litter. The reason is that each of them is reflected by a separate descriptor in Annex I (Descriptor 10 on litter and Descriptor 11 on introduction of energy, including noise), which has led to detailed development in the context of the Commission Decision on criteria for GES. It is also noted that these two pressures can be categorised as pollution, in the sense of Art. 3(8) of the Directive, and appear to be closer to other elements on pollution than to earlier sections on physical damage or loss.

In contrast, in the case of pressures and impacts more directly related to pollution, the situation may differ to some extent. On the one hand, a direct causal link with ecosystem structure and functioning may sometimes be difficult to establish. On the other hand, as defined in Art. 3(8), pollution includes inputs to the marine environment which result or are likely to result in deleterious effects such as harm to living resources and marine ecosystems, including loss of biodiversity, hazards to human health, the hindering of marine activities including fishing, tourism and recreation and other legitimate uses of the sea, impairment of the quality for use of sea water and reduction of amenities or, in general, impairment of the sustainable use of marine goods and services. As such, for polluting substances, target setting and measures do not require to make a direct link to ecosystem quality.

4.1. Biological disturbance: extraction of species, including incidental non-target catches

Table 2 of Annex III to the Directive contains an indicative list of the pressures and impacts related to biological disturbance (see Table 13).

Table 13: Pressures, impacts and associated activities related to biological disturbance

Pressures and impacts	
Biological disturbance	- Introduction of microbial pathogens, - Introduction of non-indigenous species and translocations, - Selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing).

This section of Table 2 addresses a variety of pressures and impacts, which have in common the potential for direct biological disturbance impacts. Such impacts relate both to the extraction by human activities of species, whether targeted or not, and to the biological introductions (whether voluntary or not).

4.1.1. Identification of the relevant GES criteria and indicators

The expression "selective" in Table 2 of Annex III carries a certain ambiguity, as the rest of the sentence ("including incidental non-target catches") indicates that there is often a failure in selectivity. It is therefore not used further in this document. Regarding the extraction of targeted species, the criterion and the associated indicators, under Descriptor 3 on commercially exploited fish and shellfish, is about the level of pressure and associated indicators related to the impacts of fishing on the state of fish stocks:

3.1 Level of pressure of the fishing activity

Fishing mortality (3.1.1)

Ratio between catch and biomass index (3.1.2)

3.2 Reproductive capacity of the stock

Spawning Stock Biomass (SSB) (3.2.1)

Biomass indices (3.2.2)

3.3 Population age and size distribution

Proportion of fish larger than the mean size of first sexual maturation (3.3.1)

Mean maximum length across all species found in research vessel surveys (3.3.2)

95% percentile of the fish length distribution observed in research vessel surveys (3.3.3)

Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation (3.3.4)

4.1.2. Linkages to other GES criteria and indicators

The distinction between, on the one hand, the criteria and indicators directly relevant and, on the other hand, indirect linkages to other criteria and indicators, needs to be considered carefully in the

case of biological disturbance. This is because it requires an understanding of the resulting effects on biological features ("biological"), although it addresses by definition a form of impact ("disturbance").

Therefore, as a general rule, biological disturbance arising from the extraction of species (target and not-target), but also from the introduction of non-indigenous species and possibly of microbial pathogens is expected to have an effect on the state of all relevant biodiversity components (i.e. at the level of species, habitats and ecosystems), which are addressed in other parts of the initial assessment (see chapter 3) and relate to the criteria and indicators for Descriptors 1, 3, 4 and where appropriate 6 (see sections 3.3-3.6). Biological disturbance has also the potential to affect more broadly ecosystem functioning, through the effect on food web structure by changing their components.

Fishing can have very relevant implications on biodiversity, for both target species and non-target ecosystem components. Extraction of species through fishing can have significant direct and indirect effects on benthic communities and habitats, affecting their diversity, community structure and trophic interactions.

The effects of fishing are the most important pressure which directly affects target species, and indirectly affects other non-target components of food webs. The food web is a fully interconnected system, so pressures on one part of the system may have impacts elsewhere which are not easily predictable. For example, harvesting of sandeels, in areas where they are a key species in the food web, will remove food for birds, mammals and piscivorous fish, and release predation pressure on zooplankton. In addition, fishing is usually size-selective within species, so larger individuals generally suffer greater rates of mortality. Exploited populations and communities consequently tend to contain relatively fewer large fish and their mean size is reduced. This may in turn have an indirect impact on their prey populations as a result of size-dependent predation and changes in density-dependent growth. Finally, while the most obvious effects from fisheries tend to respond to management action, the components which they influence are also subject to climate variation and other natural effects making precise attribution of cause and effect difficult.

In particular, it is noted that, although non-target catches (by-catch, discards) are rightly mentioned as an important form of biological disturbance in Table 2 of Annex III, they will not always be directly addressed by the criterion 3.1 on the level of pressure of the fishing activity. Until specific criteria and indicators are developed to capture this form of impact, it can still be assessed by having regard to the state of the relevant biodiversity components (e.g. birds, mammals, turtles, non-targeted fish, benthic features), including food-web interactions.

Biological disturbance from fishing activities will often be associated with physical damage of the seabed (addressed in section 4.4 and related to the criteria and indicators on Descriptor 6 on sea-floor integrity), which can be severely affected by specific fishing techniques such as trawling and dredging.

4.1.3 Linkages to other policies and conventions

In relation to biological impacts from fisheries, there is an immediate link with the Common Fisheries Policy (CFP). One of the purposes of the CFP, currently being reformed, is to provide for fisheries technical measures in order to prevent or significantly reduce the impacts of fishing activities. This is particularly the case of endangered by-catch species (vulnerable marine ecosystems, marine mammals, turtles, etc.). Actions can be taken in the framework of EU regulations (which allow under certain circumstances for Member States to adopt fisheries

measures) and regional fisheries management organisations, in addition to initiatives at global scale (e.g. United Nations General Assembly, Food and Agriculture Organisation).

4.1.4. Spatial and temporal distribution

Extraction of species for seafood occurs in all regions and varies considerably, depending on the area and available species for consumption. Such fishing activities have been undertaken in traditional practices for centuries, but have increased significantly in recent decades in line with demands due to increases in human populations. This has additionally led to extension of fisheries to other areas (e.g. deep sea) and a broader range of species being targeted, as well as increases in the take of traditional fisheries. With improved technology the ability to capture fish and shellfish has increased in recent years, increasing the efficiency of fishing activities and intensifying the effects on targeted species and on by-catch and associated habitats.

It should be noted that control measures, in particular in the context of the CFP and the Community Fisheries Control Agency, combined with technological devices such as Vessel Monitoring Systems (VMS) being installed on an increasing number of fishing vessels, enable a better understanding of how fisheries activities are distributed in space and time. Combining this information with increased knowledge on ecosystem features, particularly vulnerable habitats and species, can provide a basis for reducing impacts, in line with the ecosystem-based approach to the management of human activities.

However, difficulties will remain in assessing the spatial distribution and degree of impact of some localised fisheries, particularly those in coastal areas which can be particularly sensitive, and by recreational fishing, which may sometimes target large specimens that are important in food webs.

4.1.5. Monitoring needs

Monitoring programmes have been established for most commercial fish and shellfish stocks through the Data Collection Framework (DCF[16]) under the CFP, and are focused on assessments of the available stocks for fishing, based on research vessel surveys or registration of catches and/or landings. However, there are considerable differences between (sub)regions in terms of data availability and issues remain pertaining to suitability of some existing data sources.

There is a particular need to address certain fish stocks, such as deep-sea stocks, for which there is very scarce information on fishing mortality rates and biomass indices. Furthermore, national plans for basic data collection should be reinforced, including for such cases, and should provide the data to the relevant scientific groups for their accurate assessment.

It is noted that the DCF also provides for collection of data relevant to some impacts of fisheries, for instance on non-target (by-catch) species. As the reformed CFP is expected to enhance the importance of ecosystem-based fisheries management and interactions with marine ecosystems, there could be scope for addressing other aspects of the impacts of fisheries on the environment.

4.1.6. Further development of the criteria and indicators

The criteria and indicators on biological disturbance from fisheries relate to the level of pressure from fishing activities, and in particular ensuring that fishing mortality is at a level equal to or lower

[16] Commission Decision of 18 December 2009 (2010/93/EU): Adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013 (notified under document C(2009) 10121).

than F_{MSY}, the level capable of producing Maximum Sustainable Yield (MSY). However, even this approach remains associated to the assessment of individual stocks. Therefore, one area for further development is how to integrate complex situations, such as mixed fisheries and cases where ecosystem interactions are important. As already mentioned in the Commission Decision on GES criteria, long-term management plans may result in exploiting some stocks more lightly than at F_{MSY} levels in order not to prejudice the exploitation at F_{MSY} of other species. It may be possible to integrate this concept in the further development of indicators. An issue for possible further development, based on additional scientific research involving fisheries and environmental experts, is whether there is scope for indicators different to MSY, to capture such broader implications. The report of the relevant ICES/JRC Task Group report also points to addressing the complexity of predator-prey interactions, which makes it difficult to achieve biomass targets (other than safeguard limits) simultaneously for inter-related stocks.

All these considerations suggest that, rather than the criteria and indicators, the concept that may need to be developed in the medium term with a broader perspective is the Descriptor 3 as such, which remains associated to individual stocks approaches and may not be adequate for capturing interactions between stocks and, more broadly, with the wider ecosystem. Having said that, Art.9 (3) requires to adopt criteria "on the basis" of Annex I, but does not prescribe to limit criteria to the specific terms in Annex I. The definition of GES, contained in Art.3 (5), provides an adequate basis for expanding any indicators to capture broader ecosystem considerations.

Concerning indirect impacts mentioned in Table 2 of Annex III, such as by-catch and discards, the Commission Decision on GES criteria does not contain specific criteria and indicators, allowing the matter to be considered in the context of criteria and indicators on Descriptor 1 (biodiversity), 4 (food-webs) and where appropriate 6 (sea-floor integrity). However, one question is whether additional criteria and indicators should be developed, specifically on by-catch and discards. This is relevant for the future revision of the Commission Decision on GES criteria, but seems already applicable for the purpose of the decisions to be taken by Member States for the purpose of Art.10 on environmental targets and associated indicators. Any such targets and indicators may be established keeping in mind the need to develop more selective gears that could help unwanted species to escape safely, which can be accompanied by other technical measures to phase out such biological impacts (such as extension of closed areas, threshold levels, move-on rules).

4.1.7. Research needs

A whole range of research needs to enhance ecosystemic considerations in the assessment of impacts from fisheries have been already mentioned in the section on the further development of the criteria and indicators, and therefore are not repeated here.

In general, research (and often associated monitoring initiatives) that provides additional reference levels or improved indicators for more species, is required. Fishery-independent methods for assessments, notably those based on surveys, can be useful for independent validation of abundance trends. In particular, shellfish emerge as one of the groups of species for which the data to determine GES are often lacking.

There is a particular need for additional research on certain fish stocks, such as deep-sea stocks, for which there is very scarce information on their fishing mortality rates and their biomass indices, as a condition to any meaningful ecosystem-based management for deep-sea areas. As all matters relating to biodiversity, it may sometimes be difficult to distinguish research needs as such from enhancing monitoring, as a basis for knowledge. National plans for basic data collection should be reinforced and should provide the data to the relevant scientific groups for their assessment.

4.2. Biological disturbance: introduction of non-indigenous species and translocations

Table 2 of Annex III to the Directive contains an indicative list of the pressures and impacts related with biological disturbance (see Table 14).

Table 14: Pressures, impacts and associated activities related to biological disturbance

Pressures and impacts	
Biological disturbance	- Introduction of non-indigenous species and translocations

4.2.1. Identification of the relevant GES criteria and indicators

The biological disturbance derived from introduction of non-indigenous species, and in particular those which become invasive, can be assessed using the criteria and indicators under Descriptor 2 on non-indigenous species:

2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species

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 of such species (2.1.1)

2.2 Environmental impact of invasive non indigenous species

Ration 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) (2.2.1)

Impacts of non-indigenous invasive species at the level of species, habitats and ecosystems where feasible (2.2.2)

Non-indigenous species can be understood to be species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Other terms sometimes used include alien, exotic, non-native or allochthonous species. Their presence in the given region is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges (e.g. due to dispersal by ocean currents) and natural dispersal due to climate change do not qualify a species as a non-indigenous species. However, secondary introductions of such species from the area(s) of their first arrival could occur without human involvement due to spread by natural means and would still be considered as non-indigenous species.

When non-indigenous species become established and have spread, are spreading or have demonstrated their potential to spread elsewhere, and have an adverse effect on biological diversity, ecosystem functioning, socio-economic values and/or human health in invaded areas they can be termed invasive non-indigenous species. In the process of preparation of the Commission Decision on GES criteria, it became apparent that the main concerns relate to such invasive non-indigenous

species. This is now reflected in several parts of the Commission Decision, which is coherent with the approach taken at global level (Convention on Biological Diversity) and with the EU decision to develop a dedicated legislative instrument on invasive alien species. There is however likely to be a gradation in characteristics of non-indigenous species, from those which are present in only modest numbers and have little effect on associated native communities through to those which are present in high densities and have significant effects on associated communities. In some cases, the combined presence of multiple non-indigenous species, even if each of them is in relatively low densities, may give rise through cumulative effects to a substantial change in natural community composition. It is noted that the consequences of the current levels of non-indigenous species will probably not be completely realized until several decades into the future[17].

Species of unknown origin which can not be ascribed as being native or non-indigenous are termed cryptogenic species. They also may demonstrate invasive characteristics and should in principle be included in assessments of non-indigenous species.

4.2.2. Linkages to other GES criteria and indicators

The considerations made in section 4.1.2 on the difficulty of the distinction between, on the one hand, the criteria and indicators directly relevant and, on the other hand, indirect linkages to other criteria and indicators, applies to all forms of biological disturbance. This includes in particular the case of introduction of non-indigenous species. It is expected to have an effect on the state of all relevant biodiversity components (i.e. at the level of species, habitats and ecosystems), which are addressed in other parts of the initial assessment (chapter 3) and relate to the criteria and indicators for Descriptors 1, 4 and 6 (see sections 3.3-3.6). Non-indigenous species may have an impact on some populations of commercial fish and shellfish, by interference or competition with exploitation or culture activities. This close relation with assessment of the state of ecosystem components also explains that non-indigenous species are addressed both in Table 1 of Annex III on environmental characteristics and in Table 2 of Annex III on pressures and impacts, both issues being in principle relevant and closely related. It is noted that, in fact, the inter-linkage is not only with assessment at the level of individual species, as the structure of Table 1 of Annex III might suggest. Biological disturbance has generally the potential to affect more broadly ecosystem functioning, through the effect on food web structure by changing their components. In fact, non-indigenous species, and in particular invasive non-indigenous species, may cause shifts in trophic nets and alteration of energy flow and organic material cycling. This may involve cascading effects causing large scale changes. This may be potentially quantified through the energy channelled through the food web by an invasive non-indigenous species, but changes in functional groups may be used as a proxy for this assessment. The magnitude of the impact may be ranked from no measurable effect to massive ecosystem-wide shifts in the food web structure and/or loss of the key functional groups within different trophic levels.

Apart from linkages, some differences need to be mentioned. Invasive non-indigenous species do not respond in the same way as a chemical pollution or eutrophication which may be diminished provided that appropriate measures are taken. Their impact is not mitigated, but rather potentially aggravated, by water circulation processes. Instead, the risk of new biological invasions can be most effectively reduced by precautionary measures (e.g. ballast water management), while control or eradication of existing invasive non-indigenous species is particularly challenging.

[17] Essl, F., Dullinger, S., Rabitsch, R., Hulme, P.E., Hülber, K., Jarošík, V., Kleinbauerc, I., Krausmanng, F., Kühnh, I., Nentwigi, W., Vilàj, M., Genovesik, P., Gherardi, F., Desprez-Loustau, M-L., Roques, A. & Pyšek, P. 2011. Socioeconomic legacy yields an invasion debt. www.pnas.org/cgi/doi/10.1073/pnas.1011728108

Non-indigenous species, particularly if invasive, may cause genetic change due to hybridization, decline in populations of native species, shifts in community structure, and changes in biotope diversity. While some of these impacts may be captured using the criteria and indicators specific to Descriptor 2 on non-indigenous species, as described in the previous section, other impacts may only be indirectly appreciated when assessing the state of ecosystem components on the basis of the criteria and indicators for Descriptors 1 (biodiversity), 4 (food-webs) and 6 (sea-floor integrity). Thus, it is possible to observe impacts and alterations of food webs by non-indigenous species, due to changes in predator-prey relationships, competition for space, food, light and nutrients, causing displacement or exclusion, alteration of communities and habitats, resulting in changes in energy flow. Other indirect effects include diseases and parasites. Some non-indigenous species may change substantially the physical-chemical structure of bottom sediments by biodeposition, particle trapping or by converting soft sediments into shell deposits or biogenic reefs, by physical interaction (e.g. digging or burrowing animals such as crustaceans) or due to bioturbation and nutrients release.

4.2.3. Linkages to other policies and conventions

Regarding non-indigenous species, the 1982 United Nations Convention on the Law of the Sea (UNCLOS), explicitly establishes a general requirement for Parties to take measures “to prevent, reduce and control pollution of the marine environment resulting from … the intentional or accidental introduction of species alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto” (Art. 196). Within this framework, a number of actions have been taken in various international organisations.

In October 2010, Parties to the Convention on Biological Diversity (CBD) approved the following invasive alien species' target under the CBD Strategic Plan 2011-2020: ‘By 2020, invasive alien species and pathways are identified and prioritised, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment’. They also adopted a dedicated Decision on invasive alien species, which were also considered through a range of other decisions (*e.g*. biofuels and agricultural biodiversity).

Additional international conventions such as the Convention on the Conservation of European Wildlife and Native Habitats (Bern Convention, 1979) recommend a European strategy on invasive alien species. Moreover, the Convention on Wetlands (Ramsar Convention, 1971) and the Bonn Convention on Migratory Species (1979) both have resolutions regarding non-indigenous species.

The main goal of the IMO International Convention on the Control and Management of Ships' Ballast Water and Sediments is to prevent, minimize and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments. The entry into force of the Ballast Water Management Convention would be one of the most important steps towards the reduction of unintentional spreading of non-indigenous species regionally and worldwide.

So far no comprehensive instrument exists at EU level to tackle non-indigenous species, although the European Commission is engaged in the development of a dedicated legislative instrument on invasive alien species. In the case of the marine environment, Descriptor 2 of Annex I to the Marine Directive specifies that "non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems". The Regulation for use of non-indigenous and locally absent species in aquaculture of 2007 establishes a framework governing aquaculture practices in relation to alien and locally absent species to assess and minimise the possible impact of these and any associated non-target species on aquatic habitats. The Habitats Directive (Art. 22) and Birds Directive contain an explicit invasive alien species prevention obligation. More broadly, the

Phytosanitary Directive, the legislation on animal health, the Regulation on wild species trade, and various environmental directives including the Water Framework Directive (WFD) (included as a 'potential anthropogenic impact' in Annex V) also address non-indigenous species.

4.2.4. Spatial and temporal distribution

The degradation gradient in relation to non-indigenous species is a function of their relative abundances and distribution ranges, which may vary from low abundances in one locality with no measurable adverse effects up to occurrence in high numbers in many localities, causing massive impact on native communities, habitats and ecosystem functioning. Non-indigenous species may expand their distribution and increase their abundance from a local source through processes which may not be controllable. The spatial extent, rate of spread and impacts on the environment will depend on biological traits of a non-indigenous species and environmental conditions within an invaded ecosystem.

Introduction of non-indigenous species is widespread, through vectors such as ships and boats and the transfer of aquatic species by human activities. However the issue is particularly marked in the Mediterranean Sea in association with transfers through the Suez Canal. There is a general acceptance that those areas with elevated numbers of non-indigenous species are at greater risk of exposure to future invasions.

The assessment of impacts of non-indigenous species should generally begin at the local scale, such as "hot spots" and "stepping stone areas" for non-indigenous species introductions (e.g. marinas, port areas, offshore structures, etc)[18] or in areas of special interest (marine protected areas, lagoons, etc). Depending on the taxonomic/functional group to which non-indigenous species belongs, the assessment can involve areas from confined benthic habitats to the entire water column. Local scale assessments can be further integrated into the next spatial level evaluations at a subregional (*e.g.* Gulf of Finland in the Baltic or Adriatic Sea in the Mediterranean) or a regional sea level.

The attributes of biological invasions are changing at different temporal scales (*e.g.* days/weeks for phytoplankton and years/decades for benthic communities and fish). The temporal scales addressed should vary depending on the taxonomic/functional group of an invasive on-indigenous species.

4.2.5. Monitoring needs

Monitoring can be focused on non-indigenous species as a pressure through the processes and pathways for their introduction and as an impact through assessing their distribution and abundance in the marine environment. Because eradication of non-indigenous species, once established, is usually extremely difficult, the greatest benefit is likely to come from effective monitoring of the pathways and vectors for their introduction, with associated measures to prevent further introductions.

Targeted monitoring programmes for non-indigenous species in the environment are generally rather limited, and often restricted to a few particular (invasive) species in localised areas. Some relevant data are collected as a result of incidental records of such species from ongoing biological monitoring for other purposes. Such monitoring offers the most effective means in the future of general monitoring of non-indigenous species, but should be complemented by more targeted monitoring in high-risk areas and for invasive non-indigenous species.

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[18] The areas surrounding aquaculture installations should only be considered as "hot spots" in the case of use of alien species. In that case, Regulation 708/2007 concerning the use of alien and locally absent species in aquaculture addresses the assessment and management of possible impacts.

Standard marine biological survey methods are recommended for monitoring of non-indigenous species, but these may have to be adapted to obtain the level of taxonomic identification required. Habitats exposed to a high risk of receiving non-indigenous species also should be taken into account, even if they are usually not being monitored on a regular basis. In reality, there are often many monitoring and recording systems in place for different purposes, and efforts should be made pursuant to the Marine Directive to collate and coordinate this information so that it can be used effectively for the GES assessment.

Understanding of non-indigenous species is increasing with time, particularly over the last two to three decades, with new introductions being recognised against a backdrop of knowledge on the native species in each region.

4.2.6. Further development of the criteria and indicators

For non-indigenous species there is a need to develop potentially useful indicators to ensure they are operationally applicable in different regions and in relation to the different predominant habitat types. For instance, the concept of "biopollution level" index takes into account the abundance and distribution range of non-indigenous species in relation to native biota in the invaded area and aggregates data on the magnitude of the impacts these species have at various levels, including native communities, habitats and ecosystem functioning, with the purpose of concluding the situation within a range of categories (from no bio-invasion impact, through intermediate levels, to massive impact) and they can be short-term or permanent.

4.2.7. Research needs

Further knowledge will be conditional upon enhanced taxonomic training (or access to taxonomic expertise) and increased effort to monitor poorly studied ecosystems. Priority research needs include risk assessment methodologies and the further development of methodology for environmental impacts assessment of invasive non-indigenous species. The identification of vectors, traits of introduced species to better understand why some species become invasive in some areas and further study of natural dispersal mechanisms of introduced species after arrival and establishment in a new area, are essential. There is a need to quantify uncertainty in relation to propagule pressure (number of individuals of non-indigenous species multiplied by the number of introduction attempts). As for other pressures, there is a need to understand the impacts and how the presence of these species relates to the evaluation of GES. This is closely related to the need to develop methods for quantifying the impact of non/indigenous species and assessing changes to the resilience and functioning of marine ecosystems.

4.3. Biological disturbance: introduction of microbial pathogens

Table 2 of Annex III to the Directive contains an indicative list of the pressures and impacts related with biological disturbance (see Table 15).

Table 15: Pressures, impacts and associated activities related to biological disturbance

Pressures and impacts	
Biological disturbance	- Introduction of microbial pathogens

4.3.1. Identification of the relevant GES criteria and indicators

Because no descriptor addresses expressly the issue of microbial pathogens, no information has been reported in the ICES/JRC Task Group reports and there are no criteria and indicators in the Commission Decision on GES criteria to specifically address this matter. As in the case of the descriptor of contaminants in seafood, the legislator has decided to include human health impacts in the Marine Directive, as a complement to other considerations related to ecosystem structure and function.

4.3.2. Linkages to other GES criteria and indicators

The expansion of aquaculture and the demand for fish have resulted in the large-scale movements of aquatic species and their pathogens, which can impact on the wild fish host populations. Ingestion of contaminated seafood can cause infection by pathogens or toxicity from toxins elaborated by micro-organisms or algae which in some cases can be of non-indigenous origin.

The criteria and indicators for other descriptors may be indirectly relevant to the biological disturbance created by the introduction of pathogens. The criteria and indicators established for Descriptor 9 on contaminants in seafood shares the underlying concern of legislators about impacts on human health, rather than on ecosystems as such. Impacts on human health need to be considered because they constitute a form of pollution, as defined in Art. 3(8). As with contaminants in seafood, a major issue for pathogens is the levels and number of pathogens and the frequency of regulatory levels being exceeded.

4.3.3. Linkages to other policies and conventions

Regarding pathogens, according to the Bathing Water Directive[19] Member States must ensure that monitoring of the parameters set out in Annex I (intestinal enterococci and *Escherichia coli*) and must take adequate measures to prevent, reduce or eliminate the causes of pollution. Pollution means, for this purpose, the presence of microbiological contamination or other organisms or waste affecting bathing water quality and presenting a risk to bathers' health. Notwithstanding measures to inform the general public, the Bathing Water Directive does not specify any particular type of measure to increase or even to deal with the quality of bathing waters. The same applies with Directive 2006/113/EC on the quality required for shellfish waters, which also laid down requirements for microbiological contamination. In general terms, the treatment of urban waste water appears to be amongst the most important factors influencing the quality of bathing waters

[19] Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC

and shellfish waters in relation to microbiological contamination. In this context, it is important to underline that point B.4 of the Annex of the Urban Waste Water Treatment Directive[20] establishes that, if the waters receiving the effluents of any waste water treatment plant have to comply with the conditions laid down by other EU legislation (*e.g*. bathing water), the functioning of the concerned plant will ensure the needed quality of the effluents.

Further, under the Water Framework Directive, protection of economically significant aquatic species (e.g. fish, shellfish) in relevant protected areas has to be ensured in the environmental objectives and the plans and programmes. From 2013, Directive 2006/113/EC on the quality required for shellfish waters will be repealed and its objectives and requirements will have to be incorporated in river basin management plans. The latter will also address diffuse sources relevant to microbial contamination, such as agriculture.

Microbiological status is also an important consideration in the context of EU food safety legislation and animal health. On the latter, Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals[21], in particular establishes a harmonised framework aiming at preventing the spread of aquatic animal diseases. It contains several provisions on surveillance/monitoring aimed at the early detection of both listed pathogens and possible emerging diseases. In addition, Annex III to Regulation (EC) No 853/2004 laying down specific hygiene rules for food of animal origin[22], for instance, contains mandatory methodological standards to be used by Member States in relation to matters such as live bivalve molluscs for human consumption (classification of production areas based on their microbiological status and information related to the presence of algae producing biotoxin).

4.3.4. Spatial and temporal distribution

Introduction of microbial pathogens tends to be associated with sewage discharge and therefore mostly focused on coastal areas. In areas frequented by tourists, the intensity can increase during the tourist season in areas where adequate sewage treatment is not in place.

4.3.5. Monitoring needs

In relation to pathogens, in the framework of the Bathing Water Directive, as regards coastal waters, Member States will monitor and classify bathing water quality of areas concerned, take appropriate management measures to improve the bathing water quality and provide information to the public on bathing water quality. Two bacteriological parameters have to be monitored by Member States: intestinal enterococci and *Escherichia coli*, for which different values are considered. When relevant, monitoring activities will also cover cyanobacteria. The assessment consists in identifying which values are found for individual bathing waters and therefore establishing their level of quality (ranging from excellent, good, sufficient and poor). By the end of the 2015 bathing season, which is also the date for adopting programmes of measures under the Marine Directive, Member States must ensure for the purpose of the Bathing Waters Directive that all bathing waters are at least of sufficient quality, and must have taken appropriate measures to increase the number of waters classified as good or excellent.

4.3.6. Further development of the criteria and indicators

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[20] Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

[21] OJ L 328, 24.11.2006, p. 14.

[22] OJ L 139, 30.4.2004, p. 55.

In the case of pathogens, no criteria and indicators have been developed, since the Commission Decision on GES criteria is mostly based on Annex I to the Directive, which does not mention them. However, there is a potential for assessing the opportunity of incorporating criteria and indicators in a future revision, while avoiding any unnecessary overlap with applicable legislation such as the Bathing Water Directive. In any case, Member States may wish to incorporate targets and associated indicators on pathogens for the purposes of Art. 10, having regard to their already existing obligations, so as to provide an overview of the state of the environment.

4.3.7. Research needs

Knowledge needed to properly implement the Bathing Water Directive is already largely developed and available. In any event, further development will be welcome if it covers analysis methods that are more reliable, easier to use and cheaper than those currently used. Availability of such methods would entail better and more frequent sampling, and the increase in the number of measurements could contribute to build up dosage-response models. In broader terms, linkages between human health (namely infectious diseases) and environmental/ecological processes (pollution, fish infections, etc.) are still in need of further development.

4.4. Physical loss and physical damage

Table 2 of Annex III to the Directive contains an indicative list of the pressures and impacts related to physical loss and physical damage (see Table 16).

Table 16: Pressures, impacts and associated activities with regard to physical loss and damage

Pressures and impacts	
Physical loss	- Smothering (*e.g.* by man-made structures, disposal of dredge spoil), - Sealing (*e.g.* by permanent constructions).
Physical damage	- Changes in siltation (*e.g.* by outfalls, increased run-off, dredging/disposal of dredge spoil), - Abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring), - Selective extraction (*e.g.* exploration and exploitation of living and non-living resources on seabed and subsoil).

For the purpose of this document, both elements are considered within this section because of the overall similarity of the underlying pressures. In a number of cases, the distinction remains relative, depending on intensity of pressures and of timescales, as shown by the fact that some of the examples of pressures are mentioned in both headings (disposal of dredge spoil).

However, both types of pressures differ in some important respects, primarily in terms of severity of effect. In the case of definitive loss, for instance as a consequence of construction of infrastructures sealing the seabed, it is the extent of the habitat which is affected, not its condition. Another possible difference, relevant to management response (as well as for data availability), is that many cases of physical loss are related to infrastructure development which are activities subject to a regulatory licence and, in general, an environmental impact assessment, whereas this may not always be the case for other activities leading to physical damage. For all these reasons, wherever

this is possible, both types of pressures (loss and damage) should be identified, quantified and reported separately.

4.4.1. Identification of the relevant GES criteria and indicators

If pressures from human activities, such as those mentioned in Table 16, have created such a severe impact as to result in physical damage and even physical loss, it is necessary to identify the extent of seabed and the particular habitats affected or lost. These changes should be assessed by applying the GES criteria and indicators specified in the Commission Decision on GES criteria under Descriptor 6 on sea-floor integrity:

6.1 Physical damage, having regard to substrate characteristics

Type, abundance, biomass and areal extent of relevant biogenic substrate (6.1.1)

Extent of the seabed significantly affected by human activities for the different substrate types (6.1.2)

6.2 Condition of benthic community

Presence of particularly sensitive and/or tolerant species (6.2.1)

Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species (6.2.2)

Proportion of biomass or number of individuals above some specified length/size (6.2.3)

Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community (6.2.4)

Some of the indicators mentioned above, particularly indicator 6.1.1 (biogenic substrate), and the indicators listed under criterion 6.2 on the condition of benthic community, can also be categorised as state indicators. Therefore, they are in principle directly relevant also to the description of state (see section 3.4.1). However, this state characterisation only becomes really meaningful once it is combined with a description of the impact, which is captured by other directly related indicators, such as the extent of seabed affected (pressure indicator 6.1.2) or the shifts in biological composition of communities addressed by several of the indicators above. For this reason, it is proposed to refer to these criteria and indicators as a whole in this section of the document, which relates to pressures and impacts. This is without prejudice to the need to use the relevant information also in the section of the initial assessment relating to state, in particular of seabed habitats, as explained further below.

In addressing physical loss and physical damage, the management objective should be that human pressures do not hinder the ecosystem components to retain their natural diversity, productivity and dynamic ecological processes. Many benthic areas seem to be in a situation where management action is needed to meet the objective of Art. 1(2)(a) of the Directive.

Assessment of physical loss or damage should start with the identification of those human activities considered likely to cause such effects and a categorisation of the types of pressure, including those listed in Table 16. Where possible, spatial maps of the distribution and intensity of the physical loss

and damage should be developed, categorized separately as they relate directly to the habitat extent (loss) and habitat condition (damage) criteria of Descriptor 1 on biological diversity.

This understanding of the pressures should then be related to the different seabed substrate types and hence to habitat types, in order to make an adequate assessment of the impacts[23]. Overlay of the two sets of data in a geographical information system is an effective way to assess the extent of substrate type/habitat type which may have been affected.

Substrate characteristics include physical properties of the seabed such as grain size, porosity, rugosity, solidity, topography and geometric organisation (e.g. three-dimensional aspects of the habitat). Substrate is a driver of patterns in diversity, function and integrity of benthic communities. Together with hydrological conditions, it is a main factor structuring benthic habitats. The different types of substrate should be considered separately (e.g. sediments such as gravels, sands and muds, hard substrates, and biogenic substrates), both because they contribute differently to ecosystem processes and habitat diversity and because they are often affected by different human activities and their pressures. This distinction into substate types is closely related to the predominant seabed habitat types described in section 3.4; treating their assessment together can significantly streamline the assessment, monitoring and management requirements for seabed aspects of the Directive.

Impacts of pressures on substrates are likely to be more readily assessed through an analysis of benthic community conditions in terms of species composition, size composition and life history traits. Benthic community composition is a priority issue for assessments: it captures information on the biological diversity, structure, and dynamics of communities and represents a fundamentally valued feature of ecosystem's potential to function well, to resist potential threats, and be resilient. The presence of species sensitive to pressures (here, physical disturbance), which are often fragile and/or long-lived, is a sign of a healthy community. The size composition of a community integrates information on community dynamics processes such as productivity, mortality rate, and life history strategies of the benthic species in the area, viewed in aggregate. Life history traits are a categorisation of the role of species within the benthic community; this analysis helps establish the balance of species in a community that represents a good state and hence inform how particular indicators are expressed. As community dynamics are often high, assessing state of a community at the level of functional groups (e.g. balance between filter feeders and deposit feeders) can often be a more effective way to assess community state when this is subject to constant changes in specific species composition.

Within the various substrate types, biogenic substrates are identified as a priority in relation to assessment and monitoring of possible impacts on the seabed. The complexity and properties of the physical structure of such substrates, which tend to be the most sensitive to physical disturbance, strongly influence the associated flora and fauna, since they often provide a three-dimensional habitat for a wide variety of species and a range of functions (*e.g.* shelter from predators, contribution to the material exchange at the sediment-water interface, energy input via photosynthesis by submerged vegetation). Some types of biogenic substrates may be difficult to monitor directly but, as mentioned above, monitoring of their functions may be carried out, in a manner more sensitive to impacts, by assessing species composition, size composition and life history traits.

[23] Maps of substrate and habitat type have been developed (see, for example, www.jncc.gov.uk/EUSeaMap) by the European Commission for some regions/sub-regions and will contribute to the development of EU Marine Knowledge 2020 (COM(2010) 461).

When using the proposed criteria, both for benthic communities and for substrate features, consideration should be given to the many differences between coastal and deeper water benthic communities and substrates. Some of these differences are simply consequences of history: due to the greater ease of sampling much more is known on the coastal and near-shore sea-floor habitats and communities than of those of offshore and deep-sea. Some differences are ecological: though knowledge is less complete offshore and in the deep-sea, many studies suggest that the relevant space- and time-scale are often broader in these ecosystems than in coastal ecosystems. The ecosystem processes that are supported by the substrate features are also affected by depth. The functional significance of any substrate type is unlikely to be identical in coastal, shelf and deep-sea locations.

4.4.2. Linkages to other GES criteria and indicators

As mentioned, there is a close relationship with the assessment of habitats and their benthic communities, to be carried out for the state characteristics of the area (section 3.4). This is a fundamental premise for the understanding, and if possible the quantification, of the physical damage and/or the identification of the substrate loss, in terms of changes in benthic community structure and functionality. It is noted that the criteria on habitat extent (related to physical loss) and habitat condition (related to physical damage) are accompanied by different indicators and could be subject to different targets for the purpose of assessing progress towards good environmental status.

In addition to direct impacts on habitats, physical loss and damage also have the potential to affect indirectly the migration and other life cycle aspects of certain species. This may be relevant for the assessment of certain species, and specifically for fish stocks (*e.g.* spawning and nursery areas). In this respect, it is recalled that Annex III requires the assessment of habitats in areas which, by virtue of their characteristics, location or strategic importance, merit a particular reference.

Permanent alteration of the hydrographical conditions (*i.e.* changes in tidal regime, sediment transport, current or wave action) can trigger, or may be otherwise associated with, physical loss or damage of seabed habitats. Therefore, there is a linkage with the criteria and indicators described in section 4.5 and with Descriptor 7 on hydrographical changes.

The integrity of the benthic habitats and associated species will often require addressing cumulative impacts of pressures other than physical disturbance. This includes assessing areas impacted by hypoxia or even anoxia (present or past), which are addressed in the section on 4.10 on nutrient and organic matter enrichment (for instance by the presence of benthic communities associated with low oxygen conditions). Another issue related to physical disturbance of seabed is the contamination of sediments and biota by hazardous substances, addressed in section 4.8. Sediments may be repositories for many of the more toxic chemicals that are introduced into water bodies. Contaminated sediments represent a hazard to aquatic life through direct toxicity as well as through bioaccumulation in the food web.

4.4.3. Linkages to other policies and conventions

Linkages to the most relevant EU Directives and international Conventions requiring specific protection of some seabed habitat types are already listed in Section 3.6.1 and therefore are not repeated in this section. Several sectoral instruments, at international and EU level, also address specific forms of physical damage (e.g. regulation of fishing with bottom gears in Regional Fisheries Management Organisations and EU fisheries legislation, Code of Conduct for Responsible Fisheries, control of dumping in the framework of the London Convention). Before implementing new plans or projects, the making of an Environmental Impact Assessment is compulsory for a range of human activities. If such works are part of a strategic plan, a Strategic Environmental

Impact Assessment is often required[24]. It is an obligation under the Espoo Convention[25] and the EU Directive on environmental impact assessment to notify and consult neighbouring countries on projects under consideration that are likely to have adverse environmental impact across national boundaries.

4.4.4 Spatial and temporal distribution

Physical losses and damages have a patchy distribution because they relate to specific activities, developments and infrastructure which occur in the marine environment in relation to particular needs. This includes placement of structures and permanent constructions, whether in the sea or developments on land having a direct impact (*e.g*. coastal defence and related activities, land claim, ports and related dredging works, infrastructure for exploitation of resources such as oil and gas, including platforms and pipelines, offshore wind farms, outfalls, submarine cables). Other forms of physical damage or loss, depending on the vulnerability and resilience of the habitat types affected, arise due to extractive activities, whether of biological (e.g. fisheries, including trawling with fishing gear) or non-biological resources (e.g. sand and gravel extraction, dredging, disposal of dredge spoil), or other activities (e.g. anchoring, boating, artificial reefs and islands).

There is typically a greater concentration of such pressures in the intertidal and coastal subtidal zones compared with offshore and in deep water. The total effect on marine habitats depends on the distribution and extent of each habitat type in relation to the pressure. Accumulation of smaller effects or from repeated activities and associated losses needs to be considered in conjunction with impacts from other pressures.

An adequate spatial and temporal understanding of physical damage and loss is required to determine the proportion of habitats impacted by human activities. This should be particularly useful for a combined assessment approach, as described in paragraph 6 of part A of the Commission Decision on GES criteria, and therefore for an integrated understanding of overall progress towards GES in the context of ecosystem-based approach to the management to human activities having an impact on the marine environment. Spatial identification of such impacts is also indispensable to take management action necessary to prevent the deterioration of the marine environment and, where practicable, restore marine ecosystems in areas where they have been adversely affected (Art. 1(2)b), which is likely to require taking targeted actions in specific areas under risk or threat.

4.4.5. Monitoring needs

Monitoring is needed in relation to a range of activities which cause physical damage to the seabed, such as trawling, sand and gravel extraction and dredging, as well as boating, anchoring and other potentially damaging activities, to provide data on the severity, and spatial and temporal nature, of the damage (and where appropriate, habitat loss).

For activities subject to a licence (including, but not only, infrastructure developments), monitoring needs should be linked, for efficiency purposes, to the information and data produced during the planning and licensing stage and its follow-up.

An assessment of the possible impact as part of the Environmental Impact Assessment (EIA) often needs to be made prior to the implementation of the activity, and is often preceded by a Strategic Environment Assessment (SEA) at a broader scale. When the proposed activity is licensed and

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[24] EIA Directive 85/337/EEC, SEA Directive 2001/42/EC

[25] Convention on Environmental impact Assessment in a Transboundary Context

implemented, this should be accompanied by the obligation to monitor the impacts. The collected data and the results of the monitoring, i.e. the extent of the impact, should be fed back to the regulator so that it can contribute to the monitoring and assessment needs for the Directive, i.e. assessment of cumulative impact on a habitat type in the region or subregion, and to the revalidation of the used models. The use of models can be a useful tool for the assessment of the extent of the influence, which is usually beyond the actual footprint of the infrastructure, provided that models are accompanied by an adequate validation with observed data.

It is noted that the implementation of the Marine Directive also provides an opportunity to reassess the adequacy of the existing EIA and SEA frameworks to capture all the relevant impacts on the marine environment from a range of human activities and, if appropriate, to introduce adjustments, for instance in the context of the programme of measures.

4.4.6. Further development of the criteria and indicators

As already reported in section 3.6 for biological features and habitat types, the criteria and indicators listed in the Commission Decision on GES criteria generally need to be developed further, in accordance to the particular species, and habitat, and in relation to the seabed types and the differing regional characteristics. They need to be make more operational for their most appropriate use.

4.4.7. Research needs

As already mentioned in Section 3.6.3, mapping of seabed habitats is a fundamental tool for assessment, planning and management, and there is a lack of broad-scale mapping, especially in some areas of European seas. For detailed assessments, particularly in relation to specific impacts from pressures and human activities, it is necessary to have fine-scale maps to facilitate the establishment of monitoring stations, to enable interpretation of the results and completion of the assessment of the status of the area. For areas considered to be under most pressure from human activities a continued survey to prepare high quality habitat maps should be encouraged.

Understanding of ecological processes of the sea-floor and particularly direct impacts of most human pressures on the sea-floor still needs to be further developed. More has to be learned about the dynamics of how those processes interact, the natural factors that influence these dynamics and how the ecosystem interactions convey the direct effects of human pressures into indirect impacts on ecosystem components and their interactions. In general, non-destructive and non-extractive methods of investigation should be given priority, particularly in fragile deep-sea ecosystems, in coherence with the application of the precautionary approach in relation to exploitation.

4.5. Interference with hydrological processes

Table 2 of Annex III to the Directive contains an indicative list of the pressure and impacts related with hydrological processes (Table 17).

Table 17: Pressures, impacts and associated activities with regard to hydrological processes

Pressures and impacts	
Interference with hydrological processes	- Significant changes in thermal regime (e.g. by outfalls from power stations), - Significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction).

4.5.1. Identification of the relevant GES criteria and indicators

The identified pressures and impacts related to changed hydrographical conditions through interference with hydrological processes are directly linked to human activities such as building of infrastructures and dumping. These kinds of activities have a mainly local and patchy distribution, but nevertheless have the potential to have adverse effects on the marine ecosystem, particularly in combination or when undertaken in confined areas. The following GES criteria and indicators related to Descriptor 7 on permanent alteration of hydrographical conditions are relevant:

7.1 Spatial characterisation of permanent alterations

Extent of area affected by permanent alterations (7.1.1)

7.2 Impact of permanent hydrographical changes

Spatial extent of habitats affected by the permanent alteration (7.2.1)

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 (7.2.2).

Interference with hydrological processes is considered to encompass changes in the thermal or salinity regimes, changes in the tidal regime, sediment and freshwater transport, current or wave action and changes in turbidity. These can cause an alteration in the hydrographical conditions. All these changes may lead to modifications of the physical and chemicals characteristics of the marine waters and consequent affects on marine ecosystems. These types of changes are normally triggered by building activities, such as extension of the coast, building of artificial islands or other infrastructural works in the marine environment (such as outfalls from power stations, bridges to islands, offshore installations). The reference to the example outfalls from power stations suggests that the Directive addresses pressures from industrial and other activities on land which may affect the marine environment, in this case hydrological processes in marine waters. This is coherent with the treatment of chemicals, nutrient enrichment or marine litter.

Typically, any permanent installation on the seabed or alteration of the shoreline (e.g. flow control modifications, ports, marinas) will lead to some changes in water flows. The degree of change and the period over which such change occurs varies considerably, depending on the type of modification. Assessment of the degree of change can be related to both the water column and the sea-floor, and consequently to their biological communities including migratory species. To determine GES, one needs to take account of the scale of the changes (spatial, temporal) and the severity of change in relation to the ecosystem component and the cumulative effects from all permanent alterations together with impacts from other pressures.

4.5.2. Linkages to other GES criteria and indicators

Changes in hydrological processes can affect water column and seabed habitats and are therefore relevant to Descriptors 1 and 6. The indicator 7.2.1 on habitats affected by permanent alterations is similar to indicator 6.1.2 on sea-floor integrity (and may often be associated with the same human activity), although the former indicator can additionally include water column habitats. The possible changes in habitats are assessed by the habitat indicators, as defined in criteria 1.4 (habitat distribution), 1.5 (habitat extent), 1.6 (habitat condition) and 1.7 (ecosystem structure). The indicator 7.2.1 (spatial extent of habitats effected) also has a linkage to the Descriptor 4 on food webs, especially indicator 4.3.1 on abundance trends of functionally important selected groups/species. Changes in hydrographical conditions also have the potential to affect the migration and other life cycle aspects of certain species. This may be relevant for criteria and indicators related to species, and specifically for fish stocks (e.g. spawning and nursery areas). In this respect, it is recalled that Annex III requires the assessment of habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference.

4.5.3. Linkages to other policies and conventions

Use of Environmental Impact Assessment and Strategic Environmental Impact Assessment processes is important to enable existing and new proposals to be considered in the light of their cumulative impacts on any particular ecosystem component (i.e. considering the total level of impacts on a component and assessing the potential additional impact of any new proposals in the light of the definition of GES and associated targets) (see section 4.4.3). For coastal waters, the WFD[26] sets hydro-morphological objectives that need to be addressed through measures in the context of River Basin Management Plans.

The impact of permanent hydrological changes may have an effect on a wider area. Possible external effects on protected areas under the obligations of the Habitat Directive, or on certain areas of importance to fisheries management (*e.g.* spawning, nursery), should be carefully assessed when projects are being developed.

4.5.4. Spatial and temporal distribution

Permanent changes in hydrographical conditions can be triggered by an infrastructural work which can have a limited spatial scale. The effect, however, may be spread to a much larger geographical and temporal scale. This applies in particular when such individual activities are undertaken in the framework of an overall strategy likely to entail cumulative impacts, for example coastal defence structures. The overall effect of these hydrographical changes on marine habitats depends on the scale of the affected area in relation to the overall distribution and extent of these habitats within the region/sub-region and on the resilience of affected species and communities when considered from this cumulative perspective.

4.5.5. Monitoring needs

The monitoring needs are linked to the planned activity of the infra-structural work. An assessment of the possible impact as part of the EIA needs to be made prior to the implementation of the activity.

As mentioned in section 4.4.5, the use of models might be a useful tool to make the assessment of the extent of the influence which is usually beyond the direct footprint of the infrastructure followed by appropriate monitoring against predicted impacts if the proposal goes ahead.

[26] Directive 2000/60/EC

4.5.6. Further development of the criteria and indicators

These indicators need in general to be made operational at the level of the GES assessment scales, particularly to account for cumulative affects of hydrological changes together with other impacts and for use in conjunction with other impact indicators for the assessment of specific water column and seabed habitat types.

4.5.7. Research needs

The main concern with regard to research needs is to better understand the linkage between hydrological changes and marine ecosystem functioning. This is an area which is particularly reliant on developing an adequate understanding of cumulative impacts. It is also noted that the licensing authority that approves the EIA is likely to require additional knowledge and may have research needs when making the assessment of the impact of a proposed or foreseen activity. A better, consolidated understanding of the knowledge needs of authorities involved in licensing infrastructure projects would be useful to better approach the research requirement associated to such pressures.

4.6. Other physical disturbance: introduction of energy, including underwater noise

Table 2 of Annex to the Directive contains an indicative list of the pressure and impacts related to other physical disturbances (see Table 18). The repositioning of certain elements of Table 2 of Annex III in this document allows the treatment of a closer range of pressures which can be considered as pollution in the sense of Art. 3(8) of the Directive, as the latter encompasses the introduction of energy (including underwater noise), litter and substances (whether hazardous substances or nutrients). All these elements are further related for the purpose of the objective laid down in Art. 1(2)(b) of the Directive, which is to prevent and reduce inputs in the marine environment, with a view to phasing out pollution as defined in Art. 3(8), so as to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea (Art. 1(1)(b)).

Table 18: Pressures, impacts and associated activities with regard to other physical disturbances (energy)

Pressures and impacts	
Other physical disturbance	- Underwater noise (e.g. from shipping, underwater acoustic equipment)

At the current stage of the Marine Directive implementation, the development of targets and indicators of underwater noise has been identified as a first priority. Criteria and indicators related to other forms of energy might be developed later.

Noise input occurs at many scales of both space and time. Anthropogenic sounds may be of short duration (e.g. impulsive sounds, such as from seismic surveys and piling for wind farms and platforms, as well as explosions) or be long-lasting (e.g. continuous sounds, such as dredging, shipping and energy installations). Lower frequency sounds may travel very far through the water. Different species are sensitive to different frequency levels. Species that are exposed to noise may be adversely affected over a short time-scale (acute effect) or a long time-scale (permanent or chronic effects). Adverse effects may range from subtle (e.g. temporary harm to hearing, behavioural effects) to obvious (e.g. death in the worst case).

Natural phenomena (e.g. lightning, rain and waves) generate sound at various frequencies. In addition, different marine activities, such as shipping, sonar and seismic surveys, piling and dredging, generate sound, although the amount of energy involved is less well known. The Marine Board provided in 2008[27] an overview of noise levels and frequencies of anthropogenic and naturally occurring sound sources in the marine environment.

4.6.1. Identification of the relevant GES criteria and indicators

The criteria and indicators below focus on the pressure from noise that affects relatively large areas. The first indicator focuses on loud impulsive sounds that are known to cause behavioural alterations in marine species. Most commercial activities giving rise to high sound levels are executed under regulated conditions subject to a licence. This creates the opportunity for coordinating coherent requirements for registering the occurrence of such loud impulsive sounds and if necessary introducing management measures.

The following pressure criteria and indicators are relevant:

11.1 Distribution in time and place of loud, low and mid frequency impulsive sounds

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 level that are likely to entail significant impact on marine animals, measured as Sound Exposure Level (in dB re 1µPa^2.s) or as peak sound pressure level (in dB re 1µPa$_{peak}$) at one meter, measured over the frequency band 10 Hz to 10 kHz (11.1.1).

The second indicator addresses pervasive sounds from shipping and other sources in the ocean that are believed to reduce the ability of marine species to use sound for communication and other purposes.

11.2 Continuous low frequency sound

Trends in the ambient noise level within the 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 a statistical representative sets of observation stations and/or with the use of models if appropriate (11.2.1).

4.6.2. Linkages to other GES criteria and indicators

Indicator 11.1.1 on loud impulsive sounds is influenced by different human activities such as piling, oil and gas exploration and exploitation, dredging and shipping. It can have an impact on the state of certain species, especially mammal and fish species and could therefore be reflected in the assessment of their state, which needs to capture cumulative impacts, including from noise (see section 3.3).

4.6.3. Linkages to other policies and conventions

There are no direct linkages with the main policies addressed in other parts of this document, although several Regional Sea Conventions carry out an inventory of human activities capable of generating underwater noise, such as offshore energy. The issue of underwater noise is also being

[27] Marine Board (2008). The effects of anthropogenic sound on marine mammals. Position Paper 13.

addressed in a range of international fora, such as the International Maritime Organisation, the International Convention for the Regulation of Whaling and several agreements in the framework of the Convention on Migratory Species.

4.6.4. Spatial and temporal distribution

Information on the spatial and temporal distribution of noise is essential for effective assessment of Descriptor 11. High energy levels of noise are related to physical activities such as drilling for offshore oil and gas, piling for wind farms, seismic surveys and explosions, which are often subject to licensing. The distribution of the influenced area in place and time for different species makes it possible to assess the actual stress or pressure on the ecosystem.

An understanding of the distribution in space of the average ambient noise offers the possibility to make an assessment of the distribution of noisy and less noisy areas over the regions and sub-regions. Noise-density maps of the marine environment could be developed by the use of models. It is noted that several EU agencies collect, for safety or control purposes, the spatial features of several human activities which generate underwater noise (e.g. SeaSafeNet by the European Maritime Safety Agency EMSA, and VMS information held by the Community Fisheries Control Agency for fishing vessels).

4.6.5. Monitoring needs

The monitoring of the two indicators by Member States should enable aggregation of information at the level of marine regions or sub-regions. Further, it is necessary to ensure comparability of assessment approaches and methods within and between marine regions or subregions, particularly as affected species of cetacean and fish can be very wide-ranging. For this purpose, the development of technical specifications and standardized methods is required.

4.6.6. Further development of the criteria and indicators

The impact of noise, both loud and ambient noise, on biodiversity is far from being well understood. Different species (cetaceans, fish) react to different frequencies and noise levels. Reaction can range from behavioural changes via chronic stress to physiological effects (damage). It is currently difficult to make an assessment of the reaction of a certain species to differing levels and types of noise, and so to provide assessments in terms of their environmental state. Additional knowledge will continue to be gathered and applied on the impacts of noise on biodiversity to support the development of suitable impact indicators, probably for different species. To support the further development of this descriptor and allow for adequate management measures based on impacts on biodiversity, additional scientific and technical progress is therefore required. Proposals for monitoring schemes for ambient noise level from a representative set of observation stations need to be developed. The development and use of forecasting and transport models could contribute tremendously to the practical and economic feasibility of collecting information on the distribution of underwater noise. Additional criteria and indicators may be necessary to capture the various forms of underwater noise from smaller ships, including recreational boats, which may have cumulative adverse effects. Criteria and indicators may need to be developed for the introduction of other forms of energy.

4.6.7. Research needs

Further research is needed on the impact of underwater noise on the ecosystem. There are initiatives at international, European and national level, as well as by stakeholders. Also other forms of energy input, such as thermal energy (e.g. discharges of warm water from industrial installations),

electromagnetic fields (e.g. electricity cables from international grids and offshore wind-farms) and light (e.g. from offshore activities), could impact components of marine ecosystems. The potential impact of these forms needs to be studied further.

4.7. Other physical disturbance: marine litter

Table 2 of Annex III to the Directive contains an indicative list of the pressure and impacts related to other physical disturbances (see Table 19).

Table 19: Pressures, impacts and associated activities with regard to other physical disturbances (litter)

Pressures and impacts	
Other physical disturbance	- marine litter

In the Directive special attention is paid to the pressure of litter in all its forms. The impacts from litter on ecosystem components are not well known, but there are cases which show clearly the potential impact of these pressures. There is an emerging international awareness of the impacts of this pressure, which ranks now this issue as a global problem of major interest. The focus of the identified indicators is on the assessment of the pressure. Further research will be required on the impacts at various levels.

4.7.1. Identification of the relevant GES criteria and indicators

The qualitative description for determining good environmental status is Descriptor 10, by which properties and quantities of marine litter do not cause harm to the coastal and marine environment. Marine litter can be any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. It consists of items that have been made or used by people and deliberately discarded or unintentionally lost into the sea and on beaches, including such materials transported into the marine environment from land by rivers, draining or sewage systems or winds. For example, marine litter consists of plastics, wood, metals, glass, rubber, clothing or paper. Harm can consist of social (reduction in aesthetic value and public safety), economic (e.g. cost to tourism, damage to vessels, fishing gear and facilities, losses to fishery operations, cleaning costs) and environmental aspects (mortality or sub-lethal effects on plants and animals through entanglements, captures and entanglement from ghost nets, physical damage and ingestion including uptake of micro-particles (mainly micro-plastics) and the release of associated chemicals, facilitating the invasion of non-indigenous species, altering benthic community structure).

The relevant criteria and indicators are:

10.1 Characteristics of litter in the marine and coastal environment

Trends in the amount of litter washed ashore and/or deposited on coastlines, including analyses of its composition, spatial distribution and, where possible, source (10.1.1);

Trends in the amount of litter floating at the surface, in the water column and deposited on the sea-floor, including analyses of the composition, spatial distribution and where possible, source (10.1.2);

Trends in the amount, distribution and composition of micro-particles (in particular micro-plastics) (10.1.3).

10.2 Impacts of litter on marine life

Trends in the amount and composition of litter ingested by marine animals. (e.g. stomach analysis) (10.2.1).

4.7.2. Linkages to other GES criteria and indicators

There is no direct linkage between the pressure indicators and other GES indicators. However, shipping, as a potential source of litter, is also related to the indicators for non-indigenous species (i.e. through ballast water) and to the creation of continuous underwater noise. This might become relevant when developing measures which could be beneficial in reducing more than one pressure. Marine litter may have an impact on biodiversity and so link with indicators for Descriptor 1, in which effects on species such as birds, mammals and turtles are documented, as a consequence of abandoned nets (ghost fishing). Accumulations of litter have the potential to affect seabed habitats in some localised areas. The pathway of (micro-)plastics may play a role in the further spreading of non-indigenous species (Descriptor 2).

4.7.3. Linkages to other policies and conventions

There are a number of conventions and treaties which make reference to marine litter.

The UN Convention on the Law of the Sea (UNCLOS), the UN environmental programme (UNEP)/Global Programme of Action (GPA), The International Maritime Organisation (IMO)/ The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V on prevention of garbage dumping, the London Convention 1972 on the prevention of marine pollution by dumping of wastes, the Basel Convention on the control of transboundary movements of wastes, the Food and Agriculture Organisation code of conduct for responsible fisheries and the EC Directive on Port Reception Facilities[28] are all relevant, but have no indicators established at present to monitor this issue.

The different Regional Sea Conventions around Europe have developed guidance on assessment of the occurrence of marine litter on beaches. OSPAR has also developed an Ecological Quality Objective as an indicator for the amount of litter in the marine ecosystem.

4.7.4. Spatial and temporal distribution

It is necessary to assess the composition of litter and identify the activity to which it is linked including, where possible, its origin. This includes discharges and leakages from land, including both point and diffuse sources of litter, such as municipal landfills, untreated sewage discharges, coastal industries and coastal tourism. In addition to land-based sources, other sources of marine litter include offshore activities, shipping vessels (including waste and lost cargo), fishing vessels (including lost or abandoned fishing gear), aquaculture and litter from boating.

Evaluations of sources alone will not be sufficient to measure harm and so long-term monitoring in the marine environment will be required. Thus, even if sources become increasingly better identified, the distribution of litter in the marine environment is highly variable due to temporal variations caused by meteorological and hydrodynamic events (*e.g.* strong currents in certain

[28] Directive 2000/59/EC and amendment 2002/84/EC

shallow waters), including seasonal fluctuations and are important issues when evaluating effects as these factors will influence the distribution and abundance of litter. Such variability needs to be taken into consideration for monitoring schemes. Aerial survey may help to assess the distribution of litter and can also work as an early warning in the event of aggregations of litter, although techniques may need further development to be fully operational. Litter levels vary considerably also due to differing input levels across the regions.

4.7.5. Monitoring needs

Long-term monitoring programmes are required to assess trends and distribution patterns in the amounts of litter and to monitor the benefits of implemented measures. Highly affected areas should be monitored locally. Temporal scales should take into account seasonal variations.

The Marine Directive is an opportunity for standardized monitoring and assessment methods over Europe. Combined surveys with other descriptors, such as for biodiversity, or related to certain uses, such as shipping, have potential to be more cost effective. Monitoring the quantities and distribution of litter in the different areas of the marine environment (coastline, water column, seabed) will give a basis for actual and potential assessment of socio-economic and ecological impacts of litter. Impacts on species, distribution and concentrations of micro-particles and chemical burdens monitor the direct harm to the marine ecosystem.

4.7.6. Further development of the criteria and indicators

Further development is required with regard to standardized methods for monitoring litter which floats, in the water column and on the sea-floor. The method should deliver statistically representative data for the region in a cost effective and practicable manner.

The use of certain species as a monitor for plastics in the environment needs to be extended to more regions in the EU. The Fulmar, a seabird which occurs in the North Atlantic, north of Brittany in France, is being used as an Ecological Quality Objective by OSPAR. The indicator on trends in the amount and composition of litter ingested by marine animals (10.2.1), while reflecting the amount of litter at sea, can also be related to impact considerations. However, in relation to impacts, it would benefit from more specific formulation, with reference to numbers of animals dying or affected due to litter, for it to act fully to support the criterion and allow monitoring of the impact of ingested litter on marine life.

For other areas, other relevant species need to be identified and the method tested. The introduction of regional differences in methods and selected species might be appropriate after an assessment of the potential to compare data from different methods and regions.

4.7.7. Research needs

Although some activities are already being undertaken in the framework of Regional Sea Conventions, there is still a need for further development of several indicators, notably those relating to impacts of litter. Also the degradation processes of litter in general and plastics in particular require more research. To increase the knowledge of the risks associated with certain types of chemicals clinging to small particles and micro-plastics (including plastics, synthetic materials and fabrics) further research is needed. Research can be useful on the factors influencing the distribution and densities of litter at sea (human factors, hydrodynamics, geomorphology etc.), the normalisation of methods and the determination of thresholds, as well as for the assessment of socio-economic impacts.

4.8. Contamination by hazardous substances and other chemicals

Annex III to the Directive refers to chemicals in two separate places (see Table 20). They are first listed in Table 1 of Annex III, among other features, with a focus on chemicals giving rise to concerns. Then, Table 2 of Annex III, which contains an indicative list of pressures and impacts, refers to contamination by hazardous substances. It would therefore be possible to approach the initial assessment from the two angles, starting by a description of chemicals present in the marine environment, and then address separately the introduction of substances by human activities. For some chemicals, it is possible that assessment of concentrations in the environment is the most feasible approach, whereas for others it is possible and preferable to address their introduction at source (loads, etc). This may require a case-by-case approach, taking into account practicable monitoring strategies and information available from a range of sources (e.g. licensing of industrial activities, information on riverine inputs gathered in the implementation of the WFD and within the Regional Sea Conventions). In any case, the range of chemicals to be considered is likely to be common to both tables. To the extent that one of the purposes of the Directive is to prevent and reduce inputs in the marine environment, with a view to phasing out pollution (see Art. 1(2)(b)), this document focuses on the pressure side and therefore addresses here all issues relating to contaminants.

Table 20: References to hazardous substances and other chemicals in Annex III to the Directive.

Chemical characteristics, including chemicals giving rise to concern.

Characteristics	
Other features	- A description of the situation with regard to chemicals, including chemicals giving rise to concern, sediment contamination, hotspots, health issues and contaminants of biota (especially biota meant for human consumption),

Pressures, impacts and associated activities with regard to contamination by hazardous substances

Pressures and impacts	
Contamination by hazardous substances	- Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC which are relevant for the marine environment such as pesticides, anti-foulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances), - Introduction of non-synthetic substances and compounds (e.g. heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation, atmospheric deposition, riverine inputs), - Introduction of radio-nuclides.

Contaminants include both hazardous substances and other chemicals. According to the Water Framework Directive, hazardous substances are substances (i.e. chemical elements and compounds) or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern in the marine environment.

The selection of relevant chemical contaminants and related issues should be made for each assessment region by Member States, where possible within the frameworks of Regional Seas Conventions. Convergence between the marine regions and sub-regions should aim at ensuring an equal level of environmental protection and coherence of frameworks within the different regions and sub-regions.

It is noted that the introduction of radio-nuclides is included as a pressure to be described in the Directive for the purpose of the initial assessment. In their assessments, Member States should determine whether there are impacts on the marine environment from radio-nuclides so that the necessary actions can be taken via the appropriate mechanisms. It should however be recalled that, as indicated in the recitals of Directive, Art. 30 and 31 of the Euratom Treaty regulate discharges and emissions resulting from the use of radio-active material and the Directive should therefore not address them.

In the case of contaminants in seafood, in order to protect public health, it is essential to keep consumer intake of contaminants in food at levels which are toxicologically acceptable. Member States need to monitor and assess the possible presence of substances for which maximum levels are established at European level for products meant for human consumption. Other relevant standards (as mentioned in Annex I to the Directive) may include national and international (e.g. WHO/FAO) standards and recommendations set for fish and other seafood that are not in contradiction with the EU legislation.

4.8.1. Identification of the relevant GES criteria and indicators

All contaminant types and pollution effects need to be considered. The relevant criteria and indicators are defined in the Commission Decision on GES criteria, and include a combination of state, impact and pressure elements:

8.1. Concentration of contaminants

Concentration of the contaminants, 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 (8.1.1).

8.2. Effects of contaminants

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 (8.2.1).

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 (8.2.2).

9.1 Levels, numbers and frequency of contaminants

Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels (9.1.1)

Frequency of regulatory levels being exceeded (9.1.2)

Contaminant concentrations in marine species may give rise to concern not only for human consumption, but also to marine species.

4.8.2. Linkages to other GES criteria and indicators

Indicators on marine litter are related with contaminants indicators as litter may release, cumulate or transport contaminants, or due to the interaction between pollutants and litter. Chemical pollution may affect biodiversity (e.g. species and habitat condition), the integrity of food webs and sea-floor ecosystems.

Ultimately, there is a need to increase scientific understanding of how the pressure (introduction of contaminants) impacts marine ecosystems. At the same time, it is also recalled that the Directive requires, in line with international commitments at global and regional level, to prevent and reduce inputs in the marine environment with a view to phasing out pollution. In this sense, pollution as defined in Art.3 (8) does not only include harm to living resources and marine ecosystems but also other deleterious effects.

4.8.3. Linkages with other policies and conventions

There are linkages to other conventions (mainly Regional Sea Conventions) and policies where reference is made to contaminants.

Relevant provisions of Directive 2000/60/EC (Water Framework Directive) in territorial and/or coastal waters have to be taken into consideration to ensure proper coordination of the implementation of the two legal frameworks, having also regard for the information and knowledge gathered and approaches developed in Regional Sea Conventions. Directive 2008/105 lays down the associated Environmental Quality Standards (EQS) for priority substances and certain other pollutants as provided for in Art.16 of Directive 2000/60. Besides these, there is EU legislation (e.g. REACH regulation 1907/2006) and international conventions (e.g. the London Convention (1972/1996)) which deal with the sources of specific contaminant types.

The objectives of both OSPAR and HELCOM with regard to hazardous substances are to continuously reduce discharges, emissions and losses of hazardous substances, with complete cessation by 2020, the ultimate aim being the achievement of concentrations in the marine environment near background values for naturally occurring elements and substances and close to zero for man-made synthetic substances. The objectives of the monitoring activities implemented as part of MEDPOL (UNEP-MAP) are to present periodic assessments of the state of the environment in hot spots and coastal areas, to determine temporal trends of some selected contaminants in order to assess the effectiveness of actions and policy measures, and to enhance the control of pollution by means of compliance with national/international regulatory limits. In the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP), each country is obliged to undertake ecological monitoring in marine stations. As mentioned, convergence between marine regions and sub-regions should aim at ensuring an equal level of environmental protection.

European regulatory levels for contaminants in seafood are set on the basis of scientific advice provided for by the European Food Safety Authority (EFSA) taking into account their toxicity as well as their potential prevalence in the food chain. Relevant EU legislation includes Commission Regulations (EC) 1881/2006 and 333/2007 setting methodological standards when determining levels of contaminants in fish and seafood for human consumption. As mentioned, there are other relevant national and international (WHO, FAO) standards and recommendations set for fish and other seafood.

4.8.4. Spatial and temporal distribution

The coverage in monitoring of open sea and deep sea environments is generally less dense than in the coastal environment. This partly reflects the vicinity of the coastal environments to land-based direct sources and therefore the spatial distribution of many contaminants. At the same time, data from the open sea environment is needed in order to assess the oceans and seas as final contaminant sinks and as receiving waters from atmospheric input and offshore emissions, and to capture the extent to which they are affected by contaminants.

Contaminants can arise from numerous anthropogenic sources such as land-based industrial activity, discharge, municipalities, pesticide use, veterinary products used in aquaculture, shipping lines, petrogenic sources or, where relevant, nuclear accidents and discharges. Knowledge about the spatial and temporal distribution of these sources is of great value. It should be noted, however, that natural oceanographic and geological factors, including geothermal activity, can sometimes be responsible for elevated levels of some chemicals in fish and seafood.

Regarding temporal distribution, it is necessary to maintain some national and regional programmes in order to produce statistically-valuable data. In this sense, the potential to detect statistically-significant trends in concentration levels will increase as the length of time-series data sets increases. There could therefore be scope to take advantage of existing time-series data, for example data already collected in response to other national or international policies, and to maintain these time-series data sets for use in a Marine Directive context.

4.8.5. Monitoring needs

Not all marine regions are covered to an equal spatial extent by national or regional monitoring programmes on contaminants and their introduction into the marine environment. Efforts should aim at improving this situation to provide a more even spatial coverage within regions and across the EU. This may necessitate further monitoring away from the coast to adequately assess levels of contaminants across larger sea areas than has been done in the past. A close cooperation with EU

neighbouring countries in marine monitoring and pollutant load monitoring is crucial for sound assessments, as most European marine regions are shared with non-EU countries.

The combination of conventional and newer, effect-based, methodologies, with the assessment of environmental concentrations of contaminants, can provide a useful and comprehensive approach. As the occurrence of adverse effects at various levels of organisation (organism, population, community, and ecosystem) needs to be avoided, monitoring schemes should also indicate the approaching of critical values as early warning.

Convergence of monitoring and assessment methods over Europe is required, having regard to the objective of coherence of frameworks within the different marine regions or sub-regions and across the EU. Monitoring programmes should include the assessment of quantities of contaminants entering the marine environment via rivers, from direct point-sources and via the atmosphere. The assessment should also address concentrations of contaminants in the different environmental matrices, i.e. water, sediment, and the tissues of biota. Monitoring programmes should also include the quantification of biological effects of contaminants at different levels of biological organisation, allowing for the assessment against threshold levels of response that are indicative of significant harm to the organisms concerned, and should in principle include passive sampling and biological effect techniques. Long-term monitoring programmes are required in order to assess trends and distribution patterns and the influence of potential measures. Programmes monitoring contaminants in marine environment in general do not use regulatory levels set for public health, but make use of criteria such as environment quality standards, environmental assessment criteria or other approaches.

Programmes monitoring human exposure on the other hand do use regulatory levels set for public health. A number of contaminants in the marine environment giving rise to concern from a public health point of view, which often also reflects general environmental concerns, have been selected. Regulatory levels have been laid down for lead, cadmium, mercury, polycyclic aromatic hydrocarbons, dioxins and dioxin-like PCBs and also radio-nuclides. Other substances of concern are arsenic, non-dioxin like PCBs, phthalates, organochlorine pesticides, organotin compounds, brominated flame retardants and polyfluorinated compounds. To the extent that the primary objective of such schemes is human health, an intake assessment taking into account the importance in the human diet of the species showing exceeding levels could also be considered.

These programmes however too often lack the necessary data to link the samples and results to specific (sub)-regions (i.e. traceability from source) and this condition should be improved by strengthened monitoring of the introduction of substances to the marine environment. Their sampling procedures are mainly designed to assess human exposure: sampling includes all sizes of fish sold for human consumption rather then focusing on a standardised sample which offer greater possibilities to compare degrees of contamination in the marine environment. Since such programmes sample fish from different sizes and ages, higher levels can not automatically be interpreted as a negative status or evolution of the environmental status.

4.8.6. Further development of the criteria and indicators

The integration of the results of chemical monitoring programmes and combination of data from chemical and biological-effects monitoring, is an active area of technical development in the EU context and within the Regional Sea Conventions. Current experience indicates that integration of chemical monitoring programmes is facilitated by coherent and consistent sets of environmental target levels (EQSs, EACs, etc). A limited number of biological effects techniques are currently validated, quality controlled and have assessment criteria, and are therefore available for use. Further development work is necessary, through the EU, Regional Sea Conventions or Member

States, to expand the range of target levels to include a greater number of contaminants and biological effects.

The current approach for monitoring fish and other seafood for compliance with levels set for public health protection is very different from monitoring of biota for environmental purposes. Existing monitoring programmes for fish and seafood for public health reasons generally focus on estimating consumer exposure rather than assessing environmental status; consequently the monitoring should link better to the source in the marine environment of the contaminated seafood.

The indicator related to acute pollution events has not been addressed in the technical reports by JRC and ICES before and needs further development.

4.8.7. Research needs

Ongoing research is vital for a better understanding of the underlying fundamental principles and for the further development of monitoring approaches as indicated in the previous section. Setting targets for GES implies an improved understanding of the processes affecting contaminant cycling and availability, the responses of marine organisms to contaminants, knowledge of the marine food-webs and the identification of sources. Effective implementation of the Directive to improve marine environmental quality will be greatly dependent on improvements in knowledge in key areas. In addition, as for many other issues, the availability of appropriate monitoring and assessment tools will often be a prerequisite to adequate knowledge.

There is a lack of a well-defined established simple quantitative link between levels of contaminants in marine environment (sediment, water) and levels in biota and seafood, clearly demonstrating a general research need on transfer of contaminants from the marine environment to species. In general, it would be useful to identify possible relations between contaminant levels in sediment, and tissues of fish and other seafood. Further, similar research should be extended to better defining the links between the contaminant loads and concentrations in the environment to be able to identify important sources of contamination and ultimately also improve their management.

4.9. Systematic and/or intentional release of substances

Table 2 of Annex III to the Directive contains an indicative list of the pressures and impacts related to the systematic and/or intentional release of substances (Table 21).

Table 21: Pressures, impacts and associated activities related to systematic releases of substances

Pressures and impacts	
Systematic and/or intentional release of substances	- Introduction of other substances, whether solid, liquid or gas, in marine waters, resulting from their systematic and/or intentional release into the marine environment, as permitted in accordance with other EU legislation and/or international conventions.

4.9.1. Identification of the relevant GES criteria and indicators

In the framework of Descriptor 8 on the *concentration of contaminants*, the relevant criteria and indicators are, like for section 4.8:

8.1. Concentration of contaminants

Concentration of the contaminants mentioned above, measured in the relevant matrix (such as biota, sediment and water) in a way that ensures comparability with assessments under Directive 2000/60/EC (8.1.1)

8.2. Effects of contaminants

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 (8.2.1).

Offshore petroleum exploration and exploitation activities are sources of chemical contamination through systematic releases, particularly from produced water (accidental oil spills are addressed in section 4.8). Contaminants and heavy metals discharged in produced water and related pollution effects should be considered. Most offshore activities within the EU take place in the North East Atlantic, particularly in the North Sea, although such activities are developing in other European seas.

The selection of relevant chemical contaminants (indicators) should be done by Member States, where possible harmonized within their frameworks of Regional Sea Conventions, while aiming at coherence at EU level wherever common problems exist, to ensure an equal level of environmental protection.

Carbon dioxide storage in sub-seabed geological formations, such as abandoned oil and gas wells, is an emerging offshore activity, permitted subject to certain conditions by EU legislation and some Regional Sea Conventions; it is understood that this activity was also targeted by legislators under this part of Annex III.

4.9.2. Linkages to other GES criteria and indicators

There are indirect links to other indicators. The closest link is with indicators of Descriptor 9 on seafood as contaminant concentrations in marine species may give rise to concern not only for human consumption, but also to broader aspects of ecosystem quality. Finally, produced water may affect indirectly other indicators, mainly on biodiversity (Descriptor 1).

4.9.3. Linkages to other policies and conventions

Relevant provisions of Directive 2000/60/EC (Water Framework Directive) in territorial and/or coastal waters have to be taken into consideration to ensure proper coordination of the implementation of the two legal frameworks, having also regard to the information and knowledge gathered and approaches developed in Regional Sea Conventions, as mentioned in section 4.8.3.

4.9.4. Spatial and temporal distribution

Discharge of produced water is relevant for those regions where offshore petroleum activity exists. The spatial distribution of the pressures follows largely the presence of industrial locations, which is driven by the presence of hydrocarbons in some parts of the subsoil. The consideration of potential impacts needs to take into account, on the one hand, that releases will be affected by a range of hydrological processes and, on the other hand, the possible cumulative effect of discharges.

4.9.5. Monitoring needs

Currently not all Regional Seas are covered to an equal spatial extent by national or regional monitoring programmes. Monitoring programmes should include the assessment of concentrations

of contaminants in environmental matrices, i.e. water and wild fish species. Long-term monitoring programmes are required to assess trends and distribution patterns and the influence of potential measures.

4.9.6. Further development of the criteria and indicators

Current experience indicates that integration is greatly facilitated by coherent and consistent sets of environmental target levels (EQSs, EACs, etc). Several conventions have proven to have useful methodology for reporting. Marine monitoring science continues to develop, and the implementation strategy for the Directive should allow for programmes and procedures to evolve with time so as to maintain and improve the level of protection for marine ecosystems.

4.9.7. Research needs

Research needs on hazardous chemicals do not differ particularly depending on the source of activity, and are therefore already addressed in section 4.8.7. It is certain that a range of specific research needs are already developed in relation to emerging activities addressed by section 4.8, such as carbon dioxide storage in sub-seabed geological formations, and this will include addressing potential environmental concerns at all stages of the process.

4.10. Nutrient and organic matter enrichment

As in the case of chemicals, Annex III to the Directive refers in two separate parts to nutrients and their effects (see Table 22). The presence of nutrients is first listed in Table 1 of Annex III, among the chemical characteristics. Then, Table 2 of Annex III, which contains an indicative list of pressures and impacts, refers to nutrient and organic matter enrichment. It is indeed possible to approach the initial assessment from the two angles, starting by a description of nutrients present in the marine environment (assessment of state), and then address separately nutrient enrichment (loads, etc) and its impacts. In any case, to the extent that one of the purposes of the Directive is to prevent and reduce inputs in the marine environment, with a view to phasing out pollution (see Art. 1(2)(b)), this document focuses on the pressure side and therefore addresses under this section all issues relating to nutrients, including the effects of enrichment.

Nutrients naturally present in the sea include nitrogen (N) and phosphorus (P) compounds, as well as compounds of silicon (Si).

Table 22: References to nutrients and their effects in Annex III to the Directive

Chemical characteristics

Characteristics	
Physical and chemical features	- Spatial and temporal distribution of nutrients

Pressures, impacts and associated activities related to contamination by hazardous substances

Pressures and impacts	
Nutrient and organic matter enrichment	- Inputs of fertilizers and other nitrogen and phosphorus-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition), - inputs of organic matter (e.g. sewers, mariculture, riverine inputs).

4.10.1. Identification of the relevant GES criteria and indicators

The relevant criteria and indicators in marine waters are:

5.1. Nutrients levels

Nutrients concentration in the water column (5.1.1)

Nutrient ratios (silica, nitrogen and phosphorus), where appropriate (5.1.2)

5.2. Direct effects of nutrient enrichment

Chlorophyll concentration in the water column (5.2.1)

Water transparency related to increase in suspended algae, where relevant (5.2.2)

Abundance of opportunistic macro-algae (5.2.3)

Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities (5.2.4)

5.3. Indirect effects of nutrient enrichment

Abundance of perennial seaweeds and sea grasses (e.g. fucoids, eelgrass and Neptune grass) adversely impacted by decrease in water transparency (5.3.1)

Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned (5.3.2)

4.10.2. Linkages with other GES criteria and indicators

There are links to indicators related with biodiversity, mainly with benthic species and phytoplankton communities, and to marine food webs (see sections 3.4 and 3.5). The relation with marine food web indicators is mainly related with the abundance of key trophic groups. In the case of biodiversity there is a link with indicators related with species distribution, population size and habitat condition.

As indicated in section 4.4.2 on physical disturbance, benthic habitats and associated species may be subject to cumulative impacts from physical damage and eutrophication effects. Decreasing oxygen supply of bottom water and/or the upper sediment may result in significant changes to the benthic communities and can lead to mass mortality of species in the communities. Important indicators for oxygen concentration include abundance of species sensitive or tolerant to the oxygen level and the spatial distribution of oxygen/hydrogen sulphide concentrations.

4.10.3. Linkages to other polices and conventions

There is a body of relevant EU legislation, ranging from directives such as the Urban Waste Water Treatment Directive (UWWTD) and the Nitrates Directive to the more comprehensive Water Framework Directive (WFD). As a result of the WFD, EU Member States have delineated coastal water bodies. In most cases, the ”one nautical mile from baseline” in relation to biological impacts may only be a limited portion of the possible effect of more extensive eutrophic plumes (in the case of chemicals the baseline is at most 12 miles from baseline). Under the Nitrates Directive, MS have to identify eutrophic waters or waters at risk of becoming eutrophic, including estuaries, coastal and marine waters. Land draining into such waters must be designated as a vulnerable zone for which action programmes must be established. It should be noted that WFD, the Nitrates Directive and the Marine Directive are complementary directives, having the same overall objectives to reach good status. In addition, eutrophication issues have been for many years a significant part of the programmes of most Regional Sea Conventions. Finally, issues such as concentration of dissolved oxygen are expected to be of growing importance in a context of climate change.

4.10.4. Spatial and temporal distribution

Eutrophication has a varying spatial and temporal distribution, although some factors are expected to have a direct impact. As to the temporal distribution, concentrations of the main nutrients vary seasonally, as a result of natural processes in the sea and there will be variations between winter and summer, related to biological yearly cycles. Spatially, there will often be a difference between coastal and open water (especially when a sea is not semi-enclosed). Knowledge about the spatial and temporal distribution of the main sources of nutrient enrichment will be of great value.

Due to the large extent of some eutrophic zones, the sampling effort at sea necessary to assess with confidence algal biomass will often increase, compared to the existing needs for coastal waters under the WFD. More spatial samples for better geographical representation are expected to be needed for the purposes of the Marine Directive. Therefore, systematic use of additional tools such as remote sensing of surface chlorophyll, ferry boxes, and smart buoys can be particularly useful. In addition, meaningful assessments are likely to take into account areas smaller than a marine region or sub-region, having regard to oceanographic characteristics. Such areas may not however be identical to the assessment areas required for other assessments, such as biodiversity, until they are aggregated at the level of the region or sub-region.

4.10.5. Monitoring needs

Monitoring programmes should in principle aim at an understanding of a range of issues to be used for management purposes, including the concentration of nutrients, their effects and, where these occur, the nutrient load inputs to the marine environment (from riverine inputs, point sources on land and at sea and atmospheric loads). An adequate monitoring of loads is in principle essential for marine regions and sub-regions where eutrophication occurs leading to adverse effects such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

The spatial coverage of monitoring programmes in the marine environment to comply with the Directive may be divided into the coastal strip where the WFD and Nitrates Directive are already in force and a more extended marine area. In the former, the combination of surveillance, operational and investigative monitoring put in place by Member States for WFD and Nitrates Directive compliance should provide the fundamental basis for Marine Directive purposes with respect to eutrophication (even though marine areas may be affected from other human activities offshore and by atmospheric deposition). In the design of monitoring programmes for open marine waters, the different characterisations of the EU regional seas must be taken into consideration. Sampling must consider temporally appropriate data sets for each marine region or subregion, which may favour in some cases seasonal data sets (e.g. focusing on the productive period and/or winter nutrients) and in other cases an annual cycle, which may be more adequate for marine areas with less well defined seasonality. Frequent sampling will be required for problematic areas and those at risk. In addition, in order to detect acute effects, which often pose serious threats to the ecosystem, monitoring and modelling should where appropriate be temporally adjusted to rapidly developing events, such as the sudden and sharp peaks of oxygen depletion in bottom waters or harmful algal blooms.

The monitoring of open waters at stations well offshore requires the use of methodologies of ocean observation systems, including satellite remote sensing. The measured data may provide ocean boundary conditions for the WFD coastal area, and help establish the cause of violation of quality thresholds for some indicators.

A long-term monitoring and research infrastructure is needed, including marine/oceanic observation capabilities that include continuous plankton recorders and long-term fixed stations of data collection for model validation.

4.10.6. Further development of the criteria and indicators

Modelling may provide a new insight into long-range effects that are difficult to measure by field sampling techniques. Enclosed sea areas, like the Baltic Sea where eutrophication is affecting significant proportions of the region, require a regional approach. Delineation of areas and the related GES targets are based on evaluation of long-term development and ongoing modelling work of the expected impacts of nutrient loading reductions, e.g. as defined in the Baltic Sea Action Plan. There is a need for further harmonisation of the assessment processes within and between regions.

4.10.7. Research needs

There are research needs to fill gaps in understanding for a number of topics.

A better understanding of nutrient supply and enrichment processes requires particular attention to the estimation of nutrient loads, the measurement of natural background nutrient enrichment, and the contribution of transboundary supply of nutrients. It is noted that some hydrological drivers of environmental status, in relation to nutrient enrichment, may change their state periodically due to a

range of natural processes, some of them of a very broad temporal or spatial scale (for example the state of the North Atlantic Oscillation or the intensity of up-welling off the Iberian coast). These changes may cause large but natural changes in many features (physical, chemical and biological) of the ecosystems, resulting in more than one natural stable state for a healthy marine ecosystem. This is a field where research needs to be combined with enhanced monitoring effects, with a view to determine if the change in the physical and chemical conditions of the environment, if observed, is due to natural or anthropogenic reasons.

Concerning eutrophication symptoms, it is important to understand the mechanisms of eutrophication and to predict the alternative outcomes on ecosystem state. Research questions should focus on primary production and algal biomass regulation (e.g. nutrient regulation for algal biomass production, selection of dominant species, nutrient competition and needs, impact of top-down control), on harmful algal blooms, on factors that govern occurrence and extension of hypoxic sediment surface (e.g. distinguishing natural from human drivers) and on resilience and recovery of marine ecosystems (e.g. identification of critical nutrient loading thresholds beyond which the whole ecosystem may be changing). This is an area where climate change considerations should be integrated, for instance the impacts on availability and transformation of nutrients and organic matter from land to the sea.

There is generally a need for better integration of the different policies, rather than their separate delivery: river basin management plans under the WFD, measures in action programmes to reduce nutrient loads from agriculture under the Nitrates Directive, measures agreed under international conventions such as HELCOM and OSPAR.

5. FURTHER CONSIDERATIONS FOR THE INITIAL ASSESSMENT

5.1. Drivers - economic sectors

The Marine Directive does not contain a table with an indicative list of economic sectors and human activities using marine waters or which may have an impact on the marine environment. However, there are reasons to consider that the initial assessment would benefit from an explicit description of such economic sectors and human activities.

Some references in Art. 8 and Annex III on the initial assessment suggest the need to describe human activities.

On the one hand, the analysis of impacts and pressures, including the application of Table 2 of Annex III, cannot be carried out in the absence of a comprehensive knowledge and characterisation of the human activities creating such pressures. As a consequence of the legislative process, this table already contains some examples, expressed directly or indirectly, of some human activities. These are however very few, and are primarily designed to explain the type of pressure or impact, so the references do not reflect at all a comprehensive understanding of relevant human activities. In addition, while Annex III is explicitly described as indicative, Member States will have to carry out an analysis of "the predominant pressures and impacts, including human activity" (Art. 8(1)b). This would call in principle for comprehensive description of such activities within the initial assessment.

On the other hand, Member States must also carry out "an economic and social analysis of the use" of waters.

A first conclusion is that human activities, whether because of their pressures and impacts on marine waters, or because they actually use such marine waters, need to be analysed thoroughly in the initial assessment.

An indicative list of human activities is provided in **Annex 4**, based on guidance from the MSFD Working Group on Economic and Social Analysis[29], assessments and publications by Regional Sea Conventions, and the draft outline of the UN Regular process for global reporting and assessment of the state of the marine environment, including socio-economic aspects[30]. The annex also indicates the pressures, according to Table 2 of Annex III to the Directive, which each activity may generate. The extent of the pressure that the human activities generate depends very much on the frequency and the intensity of the activity in each area. Therefore, the relevance of the pressures to particular activities in Annex 4 should be considered as indicative only, and adapted as appropriate to suit regional and local situations.

A second point is that, in fact, the sectors using the seas may be to a large extent the same sectors having impacts on them, although the relation between both aspects may not always be direct or linear. Thus, some human activities have impacts on the sea although they do not even use marine waters (e.g. land-based pressures and even atmospheric deposition). Other human activities, by contrast, draw substantial benefits from clean seas and need to be understood also from the use side, and not only from the pressure side (e.g. tourism, recreation, aquaculture).

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29 MSFD Working Group on Economic and Social Analysis (2010) Economic and social analysis for the initial assessment of the Marine Strategy Framework Directive: a guidance document.

30 See http://www.un.org/Depts/los/global_reporting/global_reporting.htm, including Annex VI to the Recommendations of the UN General Assembly Ad Hoc Working Group of the Whole of 27-28 June 2011.

The initial assessment might benefit from containing a stand-alone section describing all the economic sectors related to marine waters. In addition, this is likely to be needed to feed into regional assessments of the Regional Sea Conventions and the UN Regular process for global reporting and assessment of the state of the marine environment. For the Commission, what really matters for the implementation of the Directive is that reporting on economic sectors is made consistently, and that all aspects relating to economic sectors are addressed (economic and social assessment of uses and pressures).

Finally, the assessment of human activities should integrate, to the extent possible, a spatial (and temporal) description of uses and possible pressures. Spatial information is often already available, although primarily for specific purposes, such as licensing and control schemes (e.g. Vessel Monitoring Systems). In such cases, it is likely to be available to several sectoral authorities and, in some cases, European Agencies (e.g. European Maritime Safety Agency and SafeSeaNet, Community Fisheries Control Agency).

Spatial information of human activities will be essential for a combined assessment described in the Commission Decision on GES criteria[31] and for facilitating the development of specific tools to support an ecosystem-based approach to the management of human activities, required to achieve good environmental status. Such tools include for instance spatial protection measures and measures in the list in Annex VI to the Directive, notably spatial and temporal distribution controls, such as maritime spatial planning.

5.2. Cost of degradation

The Directive states that, as part of the initial assessment, an economic and social analysis of the use of Member States' waters and of the cost of degradation of the marine environment needs to be undertaken (Art. 8(1)c). Substantial work has been carried out to develop a common understanding of this requirement by the Working Group on Economic and Social Assessment (WG ESA) under the framework of the Common Implementation Strategy (see section 6.4). The WG ESA has as its main focus to promote information sharing on the development of initial assessments (both at national and regional scales). It will initiate discussions concerning approaches and methods for socio-economic assessment under Art. 13 and 14 (including cost-benefit, cost-effectiveness assessment, impact assessment, disproportionate costs) and identify priorities for research.

To facilitate the work, WG ESA prepared in 2010 a Guidance Document focusing on the economic and social analyses required for the initial assessment for the Directive. The Guidance Document describes different approaches which can be used to perform an economic and social analysis of the use of marine waters. The focus is on two main approaches, namely the ecosystem services approach and the marine water account approach. The ecosystem services approach identifies the ecosystem services of the marine area as a starting point. The marine waters account approach identifies the economic sectors using the marine waters as a starting point. These approaches are not necessarily mutually exclusive. The issue is complex and the common activity so far has reached the conclusion that, at least for the first assessment due in 2012, several approaches could be envisaged. Whichever approach is chosen, it is important to combine the information on human activities with information on pressures and impacts. Furthermore, the Guidance Document describes how to perform 'business as usual' scenarios, and three different approaches to estimate costs of degradation (the ecosystem services approach, the thematic approach and the cost-based approach).

[31] See Annex, part A, point 6.

This activity has been useful as an initial phase because it has developed more strongly the concept of ecosystem services within the implementation of the Marine Directive. There is, however, a need to fully integrate this concept with the initial assessment under Art. 8(1)(a, b) and with the reduction in impacts from pressures that will be needed to achieve GES and associated targets. In addition, it should build further linkages between the assessments and broader processes under development, such as the UN regular process, which are likely to take further the concept of ecosystem services. Building on the results of The Economics of Ecosystems and Biodiversity study[32] and other processes, there is a need to further develop tools for the integration of economic aspects of biodiversity and ecosystem services into the assessment.

5.3. The initial assessment as a basis for GES

The Marine Directive states, in Art. 9, that Member States will determine a set of characteristics for good environmental status by reference to the initial assessment. Likewise, targets and associated indicators need to be established "on the basis of the initial assessment" (Art. 10). Later, the Marine Directive specifies that, again "on the basis of the initial assessment", Member States shall establish monitoring programmes for the "ongoing assessment of the environmental status" on the basis of the indicative lists of elements set out in Annex III, and by reference to the environmental targets (Art. 11). In fact, the initial assessment is even referenced as a further basis for the programmes of measures (Art. 13(1)(2)).

All this indicates that the initial assessment should constitute the basis upon which GES characteristics, targets, monitoring and measures are established in order to bridge the gap between the current state of the marine waters and the state which meets GES. There is a need to create a specific link in the initial assessment between the current situation and the long-term vision of GES, with a view to addressing the gap through the development of marine strategies and the introduction of management measures. This requires that each Member State identifies, to the best possible extent, in a given section of its initial assessment, how the current environmental state of its waters relates to GES. This comparative assessment should have regard to a series of elements. The first set of elements is contained in the Directive, and includes the definition of GES (Art. 3(5) and Annex I of the directive containing the descriptors). The second element is the criteria and indicators contained in the Commission Decision on GES criteria, while taking into account that certain limitations have been explicitly acknowledged for the initial period[33]. A third element is the objectives to be established by Member States under Art.9 and 10 of the Directive, i.e. the determination of GES and the set of environmental targets and associated indicators.

Having said that, Annex III is not structured in a manner which facilitates this comparative function for the purpose of GES assessment, especially because the categories are not directly aligned with the descriptors of GES under Annex I of the Directive. It is this structural discrepancy which this document has aimed to address, by supporting a more integrated approach to the various deliverables under the Directive. Ultimately, a decision will be needed on where to synthesize, within the initial assessment, the comparative assessment between the current status and GES. Common approaches may be decided by Member States within their respective marine regions, and if possible across regions, on the best way to deliver this important policy message. The information reported to the Commission should contain both the assessment of the current status and the determination of the desired status (GES) in a way which allows a direct relationship between the two to be made (such as by using the same components of the ecosystem and pressure types).

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[32] See http://www.teebweb.org/LinkClick.aspx?fileticket=bYhDohL_TuM%3d&tabid=924&mid=1813

[33] Annex, part A, point 9.

The determination of the current status is also particularly important for the purpose of assessing the cost of degradation, as this should link directly to an assessment of the gap between the current state of marine waters (as derived from the initial assessment) and the desired state (as determined by the characteristics of GES and associated environmental targets). It may be helpful to take into account ongoing or planned measures from other policies that will contribute to closing this gap, as well as any anticipated expansion of human activities. This is often referred to as a 'business as usual' scenario.

It is also noted that, ultimately, good environmental status is defined by Art. 3(5), including aspects relating to ecosystem structure and functioning, and that the set of descriptors in Annex I of the Directive may not fully reflect all aspects of this definition. There may be a need to develop an additional overall understanding of where the status of the marine environment stands in relation to GES. A useful approach could be to address elements of ecosystem structure and functioning through the development of specific metrics and indicators, some of which will anyway be needed in relation to criterion 1.7 (ecosystem structure) and for the assessment of food webs (Descriptor 4). It is acknowledged that effective methodologies for an overall understanding of the status of the marine environment may not yet be adequately developed for the initial assessment. At the same time, the initial assessment does need to cover the main cumulative and synergetic effects (Art 8(1)(b)(ii)), which implies developing an integrated understanding not only of impacts as such but of the resulting state of the environment.

6. LOOKING FORWARD

6.1. Assessing GES in a dynamic ecosystem and relationship with climate change

Good environmental status means the state 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 (Art. 3(5)). Further, Descriptor 1 on biodiversity points to the need for biodiversity to be in line with prevailing physiographic and climatic conditions.

The state of the marine environment has changed significantly during the last centuries as a result of a combination of natural processes and the impacts of pressures from human activities. There are for instance large-scale fluctuations linked to atmospheric processes, such as the North Atlantic Oscillation, which occur at very broad temporal scales (cycles of up to 150 years). In some cases, the ecological consequences of human activities on habitats or species (e.g. great whales) may take very long periods to manifest themselves. Also at a smaller scale, it will be important to make enhanced efforts, combining targeted monitoring and research, to distinguish natural variations from human related changes. This is necessary to identify better which pressures require management response and what are the most appropriate levels for targets with a view to achieving GES. In addition, climate change has further altered the state of the marine environment and is expected to do so even more in the next decades. Conditions in the past, when the adverse effects of human-induced pressures were significantly lower, can be used as a guide to a condition of the marine ecosystem where pressures are removed or reduced to levels allowing ecosystems to function fully, and hence to the characteristics of GES. However, these characteristics need to be designed in a dynamic manner to accommodate ongoing and future ecosystem changes and climate variation, in a context compatible with sustainable use. The focus for GES should therefore be towards the future, anticipating the need for reductions in pressures to a level compatible with GES and accommodating dynamic variations in ecosystems from natural processes and climate change.

Climate change influences different components of ecosystems, notably species distribution and composition/abundance in a community. Climate-related pressures, such as atmospheric air/water gaseous exchange rates, and also pH, temperature, salinity, water flow (tidal and ocean currents), sea level and wave exposure, may change in space and time. The gradual change in pH driven by the storage of carbon dioxide in the sea from anthropogenic activities, known as ocean acidification, is expected to have significant adverse effects on a range of marine ecosystems, habitats and species. The determination of GES may therefore need to be adapted over time to take account of ongoing changes caused by climatic variations. In developing their respective marine strategies, Member States need to specify, where appropriate, any evidence of climate change impacts, and incorporate such changes into the way they determine the characteristics of GES and set their environmental (state) targets. It is also important to state the assumptions upon which targets for specific components are based, i.e. in relation to other parts of the ecosystem which may change in the future due to natural variation and climatic processes or due to changes in pressures upon them.

Approaching the challenge of climate change and oceans will require improved scientific research to enhance understanding of the processes and adapted monitoring, including possibly early

warning to allow for response. Some research has also been launched in relation to likely shifts in species distribution as a result of climate change[34].

On response, it is acknowledged that most impacts of climate change on marine ecosystems (and in particular acidification) will be difficult to tackle through targeted management measures, since the overall mitigation strategies to reduce emissions are being adopted at global scale. Having said that, the main contribution from the management side to this major societal challenge is to support actions required for an effective adaptation strategy to climate change in relation to seas and coasts. The Commission has already highlighted this concern in the White Paper on adaptation to climate change[35] and in particular it's accompanying Commission Staff Working Paper on water, coasts and marine issues[36]. It is continuing its activities on climate change adaptation in coastal regions and maritime sectors, in the context of the overall EU Adaptation Strategy planned for 2013. In this perspective, it is clear that strengthening of the resilience of marine ecosystems and biodiversity must be the basis for a successful adaptation strategy to climate change for the seas. Ultimately, climate change concerns therefore reinforce the need to tackle, through various management measures, the whole range of pressures and impacts on marine ecosystems which are the subject matter of the Marine Directive.

6.2. Cyclical process of assessment and adaptive management

The Marine Directive is based on a cyclical process in which all the relevant steps are reviewed and updated every six years. This gives provision for the determination of GES to be adapted over time to take into account the dynamic nature of marine ecosystems and their natural variability, as well as the availability of further scientific knowledge and understanding. This additionally considers the fact that pressures and impacts on the marine environment may vary with the evolution of different patterns of human activity and the impacts of climate change. This approach is moreover coherent with the developments in Regional Sea Conventions and in the United Nations Regular Process for global reporting and assessment of the state of the marine environment, including socio-economic aspects.

In view of scientific and technical progress, and of management experience at national, regional, EU and global level, the structure and contents of the regular assessment under the Marine Directive (Art. 8 combined with Art. 17) can be adapted, in coherence with the overarching concept of adaptive management. It is recalled that Art. 24(1) allows for technical adaptation of the contents of Annex III. This provision explicitly refers to the need to take into account the periods for the review and updating of marine strategies laid down in Art. 17(2). This can be understood as meaning that adjustment should be made sufficiently in advance of future assessments to allow Member States to take them on board.

6.3. Regional cooperation and Regional Sea Conventions

Member States are subject to the obligation of regional cooperation as laid down in Art. 5 and 6 of the Directive, and in particular to the requirement to ensure that the different elements of the marine strategies are coherent and coordinated across the marine region or subregion concerned. To that end, they must use, where practical and appropriate, existing regional institutional cooperation

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34 See for instance project www.aquamaps.org.

35 White Paper "Adapting to climate change: Towards a European framework for action", COM(2009)147 final, 1.4.2009, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:EN:PDF

36 Commission Staff Working Paper "Climate Change and Water, Coasts and Marine Issues", SEC(2009) 386, , 1.4.2009, accompanying the White Paper "Adapting to climate change: Towards a European framework for action", http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2009:0386:FIN:EN:PDF

structures, including those under Regional Sea Conventions. Member States concerned must endeavour to follow a common approach for their initial assessment, determination of GES, targets, indicators, monitoring and measures.

Although Regional Sea Conventions have been established much before the entry into force of the Marine Directive and show substantial institutional differences (e.g. on the number of EU Member States among Contracting Parties), most of them have largely agreed to revise their policy objective and structure having regard to the Directive. In some cases, they have explicitly agreed to facilitate regional cooperation for the implementation of the Directive by the Member States concerned. A number of non-EU countries have actively supported this evolution, which allows making operational the ecosystem-based approach to the management of human activities, involving a cycle of actions, in coherence with the Directive (i.e. establishment of objectives, targets and indicators, updated monitoring, measures, and regular review).

The conference of the parties of the Barcelona Convention in January 2007 reaffirmed its commitment to ensuring a viable future for the Mediterranean, by promoting the implementation of the ecosystem approach as a key tool for achieving the obligations under the Barcelona Convention and its Protocols. The ministerial meeting of November 2009 agreed to strengthen cooperation and seek synergies with initiatives pursuing similar environmental objectives, including the Marine Directive.

The Black Sea Commission at its ministerial meeting in April 2009 adopted the Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea, including to further enhance the application of the ecosystem approach to the environmental management of the Black Sea.

The Helsinki Commission at its Ministerial Meeting in May 2010 decided to further develop the role of HELCOM as the main driving force of the implementation of the ecosystem approach to the management of human activities in the Baltic Sea marine area and to establish, for those HELCOM Contracting States being also EU Member States, the role of HELCOM as the coordinating platform for the regional implementation of the Marine Directive in the Baltic Sea. This includes striving for harmonised national marine strategies for achieving good environmental status according to the HELCOM Baltic Sea Action Plan, agreed at the Ministerial Meeting of November 2007, and the Marine Directive.

The OSPAR Ministerial Meeting in September 2010 adopted the North-East Atlantic Environment Strategy for 2010-2020, adapting OSPAR activities and structure to the needs for regional cooperation in implementation of the Directive. The Strategy has as its overarching objective the implementation of the ecosystem approach. An important element of the Strategy is the coordinated implementation of the Directive following a road map for doing so. A dedicated group has been set up to implement the road map.

In addition to all these activities, Member States and Regional Sea Conventions show an increasing interest in stimulating the exchange of knowledge and experience, for instance by inviting Member States or representatives of other marine regions to their activities. The European Union is a contracting party to three of the Regional Sea Conventions around Europe and can therefore share documents being elaborated with its Member States, thereby supporting further this useful cross-fertilisation process.

The cooperation across marine regions to enhance coherence and consistency, required by the Marine Directive, is further needed to take forward the broader coordination called for by the United Nations Regular Process on reporting and assessment of the marine environment. It is noted

that one of the regional workshops that need to be established in the first implementation cycle includes the North Atlantic, the Baltic, the Mediterranean and the Black Sea, which are precisely the four regions listed in Art. 4 of the Directive (although it is understood that the geographic scope of the North Atlantic, for the purpose of the UN process, is much larger then the North-East Atlantic marine region under the Marine Directive).

Coherence and consistency are not only needed between the Marine Directive and Conventions, but also with other relevant EU legislation.

6.4. The Common Implementation Strategy

The implementation of the Marine Directive requires activity at national, sub-regional/regional and EU level.

The development of a marine strategy by Member States, according to Art.5 of the Directive, will require developing a great deal of new knowledge and expertise. Each Member State has the responsibility, in the framework of regional cooperation in shared marine regions or sub-regions, to develop its marine strategy. Knowledge within one Member State or in one (sub) region might be of relevance in another Member State or (sub)region. Transfer of knowledge and experience from one region to another, outside the Convention area, should be facilitated through common activities at EU level.

The Commission will assess the coherence of Member States' approaches within the different marine regions or sub-regions and across the EU. To facilitate coherence, the Commission and the Member States have agreed to set up an informal process, the Common Implementation Strategy, which allows for the exchange of best practices and experiences between Member States and marine regions under different policy programmes, including regional conventions and policies under other relevant EU legislation. An informal organizational structure and its related work plan have been put in place for that purpose. The main purpose of the Common Implementation Strategy is to develop common understanding and joint approaches to ensure coherence and consistency throughout the EU. Its work programme and structure is adopted and regularly updated by the Marine Directors, who oversee twice a year the progressive delivery of the Directive.

Under the Marine Directors, a Marine Strategy Coordination Group (MSCG), open to stakeholders, has been established to coordinate the different working groups and activities under the Common Implementation Strategy. It evaluates the outcome of the different working groups and prepares documents and reports for the Marine Directors' meetings. The MSCG can also meet in the form of a joint workshop of direct interest to the activities of the various working groups.

In the initial period (2009-2011), Marine Directors agreed to set up three Working Groups: on Good Environmental Status (WG GES), Information exchange (WG DIKE) and Socio-economic analysis (WG ESA). The number and mandates of working groups is not permanent and is expected to be gradually adapted to better respond to the needs required for the various stages of implementation of the Directive.

6.5. Combined assessment - linking state characteristics to pressures through impacts

The Commission Decision on GES criteria indicates[37] that "*A **combined assessment** of the scale, distribution and intensity of the pressures and the extent, vulnerability and resilience of the different ecosystem components including where possible their mapping, allows the identification of areas*

[37] Annex, part A, point 6.

where marine ecosystems have or may have been adversely affected. It is also a useful basis to assess the scale of the actual or potential impacts on marine ecosystems." This indicates that there are three aspects of assessment that need to be combined: pressure, impact and state, and also that impact plays an articulating role between pressure and state. These relationships are of relevance to the initial assessment in assessing the pressures and their impacts (Art. 8(1b)) and in assessing the environmental status (Art. 8(1a)) which needs to take into account the cumulative impacts.

Such a concept can be elaborated further by highlighting more concretely the relationships between each state, impact and pressure indicator contained in the Commission Decision on GES criteria. In addition, this relationship can be presented in a manner coherent with the structure of Annex III of the Directive:

(a) 'Pressure indicators' focus on the consequence of human activities which can cause adverse effects on the environment. These indicators can be listed following the structure of Table 2 of Annex III (pressures and impacts).

(b) As a general concept, 'impact indicators' require a measure of (impacted) state. At the same time, their purpose remains the identification of the adverse effects of a particular pressure. This implies that, in many cases, impact indicators provide an important role for understanding the relationship between pressures and state. They can therefore be presented as being at crossing points, linking pressure and state indicators.

(c) As to pure 'state indicators', they do not address directly specific pressures, but may still reflect cumulative impacts, which derive from multiple pressures. There is a potential for several impacts to have a cumulative influence on particular ecosystem components (and hence be associated with a number of the impact and then pressure indicators). State indicators can be listed following largely the structure of Table 1 of Annex III (characteristics).

Therefore, the contents of the two tables in Annex III of the Directive, and the full list of criteria and indicators in the Commission Decision on GES criteria, can be further linked through an integrative table (**Annex 5**)[38] that provides a way of relating multiple pressures to the different state characteristics (ecosystem components). The table highlights the connecting role between pressure and state indicators that can be played by impact indicators. In this approach, impact indicators are placed at the centre of the table, at the cross-road between pressures and impacts, where there are potentially relevant links between a pressure and a component (i.e. when the component is likely to be exposed to, and sensitive to, the pressure). For example, in the table the impact indicator relating to litter (10.2.1) sits in the column for the pressure 'Physical disturbance – marine litter' and in the rows relating to biological features, as litter is known to affect, for example, species of bird and reptile.

The relevance of specific impact criteria and indicators to particular ecosystem components will depend on the scale, distribution and intensity of the pressure and the extent of exposure and sensitivity of the different ecosystem components to that pressure in a particular region (e.g. whether a particular seabed habitat is both exposed to and sensitive to physical disturbance). Therefore, the impact indicators, as shown in the central part of the table, only reflect an indication

[38] The left column (blue), reflects Table 1 of Annex III, and is put together with another column (turqoise) containing the associated state criteria and indicators. The top row (pink) follows Table 2 of Annex III and it is accompanied by another row (yellow) containing the associated pressure criteria and indicators. The impact criteria and indicators are shown in the orange cells.

of the possible associations between the pressures and components, but will depend on the characteristics of the two latter elements in any particular region, subregion, subdivision or any other relevant scale for assessment.

The pressure-state framework provided in Annex 5 can facilitate the identification of operational indicators and the prioritisation of efforts in implementing the Directive, through the following process:

(a) An assessment of each pressure in Table 2 of Annex III, according to the relevant pressure criteria and indicators and in terms of its spatial and temporal distribution and intensity, can be derived from the aggregation of the pressure resulting from relevant human activities (e.g. the total level of physical disturbance is derived from that caused by dredging, extraction and trawling activities);

(b) From this cumulative pressure, an assessment of the level of impact on the marine ecosystem can be determined, including which particular components of the ecosystem are affected by the impact;

(c) An assessment of each pressure in Table 2, as describe above (a, b), will give an understanding of the nature, distribution and intensity of impacts in a particular area, and thus inform the assessment of ecosystem components;

(d) An assessment of the state of an ecosystem component in Table 1 of Annex III, according to the relevant state criteria and indicators, can take account of the assessment of each pressure and its impacts. The assessment of state, consequently needs to take account of the cumulative impacts upon it arising from the multiple pressures to which it is exposed;

(e) Furthermore this state assessment should identify which impacts, and hence pressures, are of most concern in relation to achieving or maintaining GES in relation to the particular component;

(f) This, in turn, should inform the identification of suitable operational indicators (e.g. further specifying the Decision indicators to a particular component, pressure and region) and facilitate the setting of appropriate targets relating to the reductions in impacts that might be needed to achieve GES;

(g) The process described above may also lead to the identification of interactions between pressures and components for which the Commission Decision on GES criteria has not identified particular indicators, but which may be necessary to adequately monitor and assess particular pressures and/or components. This can be relevant for the purpose of the future revision of the Commission Decision on GES criteria[39], in accordance with adaptive management.

As indicated in the Commission Decision on GES criteria, such a combined assessment approach which takes into account risk-based considerations, also supports the selection of the most appropriate indicators related to the criteria for assessment of progress towards good environmental status. This is because it allows assessment efforts (and then management response) to be concentrated where impacts are most likely to occur, having regard to the combination of the specific pressures and ecosystem components.

[39] See recital 4 of the Commission Decision on GES criteria.

6.6. Research needs in line with the implementation cycle

This document has already recalled some of the research needs identified in the reports by the ICES/JRC Task Groups in relation to the different descriptors of GES, and some needs for further development highlighted in the Commission Decision on GES criteria.

A first conclusion is that enhanced knowledge needs appear in a broad range of areas. At the same time, a few overarching issues still emerge as common themes for research needs.

In view of the relationship between pressures, impacts and state, as described in more detail in this document (see section 6.5), it becomes even clearer that there is still an insufficient understanding of the relationships between pressures from human activities and their adverse effects on marine ecosystems, including biological diversity. Whilst these interactions are known at present for a selection of pressure/state interactions in relation to some ecosystem components in some regions, there remains much still to be fully understood. This should therefore be a central element of research to support an ecosystem-based approach to the management of human activities having an impact on the marine environment, as required by Art.1 (3) of the Directive.

Therefore, it is necessary to develop scientific knowledge to establish a relation between the intensity of the existing pressures and the degree of impact on ecosystem components, so as to facilitate the prediction of the likely scale of impact on different ecosystem components and the evaluation of the effectiveness of response by management. This must be combined with improved understanding of the sensitivity of habitats and species to the various types of pressure.

In other terms, having regard to the table in Annex 5, important research needs exist not only on each specific issue (i.e. an interaction represented by an individual cell in the table), but also to develop an adequate understanding of cumulative aspects (of pressures, and then of impacts on state components) (i.e. on the columns and rows of the table) and causal relationships from drivers, to pressures, to impacts and to state.

This must be accompanied by enhanced understanding of the natural and climatic variations, in order to facilitate distinction from anthropogenic-induced variation (i.e. impacts from human pressures). This improved knowledge is needed to support the interpretation of monitoring results as well as the setting of appropriate qualitative and quantitative aspects of GES.

In addition to this broader need, additional knowledge is required for an improved understanding of ecosystem functioning, in view of the definition of GES in Art.3 (5). Even if impacts are identified, it is necessary to understand to what extent they can affect ecosystem functioning. This can be fundamental for considering the extent of possible impacts on ecosystem services, and therefore the cost of degradation to such services. These considerations can be fundamental for the further implementation of the Directive, such as the programme of measures due in 2015, and for the update of marine strategies every six years in accordance with Art. 17.

There is a wide range of issues requiring research for the purpose of improving the understanding of ecosystem structure and its functions in relation to the definition of GES and hence links to targets and management measures. These include interactions between biodiversity components within ecosystems, nutrient and chemical cycling and their modulation by the biological systems, feedback mechanisms induced by hypoxia, understanding the relationship between habitat complexity and benthic community metrics (such as abundance, diversity, productivity), in addition to issues already mentioned above such as ecosystem responses under cumulative pressures.

Research is particularly necessary to explore ways to counteract generalised overexploitation of marine ecosystems. This research would aim to restore marine ecosystems to healthy state, within the internationally fixed deadlines. Such research should not only encompass ecological and biological parameters, but should also combine these with social and economic analyses to cover the full range of criteria underlying the necessary management decisions. An issue deserving particular consideration is the coherence and representativeness of networks of marine protected areas and their contribution to achieving the purposes of the Marine Directive.

One basic conclusion is that the entry into force and implementation of the Marine Directive requires a new approach to research so as to (1) support the combined assessment of state and pressures, having regard to impacts (from a cumulative perspective), (2) allow an understanding of risks to ecosystem structure and function and (3) ensure that knowledge is provided in time in view of the various deliverables within the recurrent six-year cycles.

It is positive that a number of important institutions related to the knowledge of the marine environment and its uses are gradually increasing their interest and involvement on matters directly related to the Marine Directive.

In addition, it is noted that, in many areas, the dividing line between research and monitoring needs will not be clear cut. This is because some individual components are not well known (e.g. deep sea species) and because impacts are not always sufficiently understood, and in such cases research needs to start by the gathering of adequate data, including through efficient monitoring. Another link between research and monitoring is that, for most criteria and indicators, scientific advice can provide a better insight on their relative cost and complexity to implement. Scientific advice can be useful to have regard to the strengths and weaknesses of criteria and indicators and to summarise the conditions that affect the performance of related monitoring.

For the latter, the active involvement of the European Environment Agency will be crucial. The raw data obtained through monitoring constitute the building blocks for assessment. They should therefore be compatible, reproducible and quality assured on a pan-European scale. Sampling and sample processing should follow internationally agreed procedures, independent of subsequent data analysis. It is also noted that the recent Communication on marine knowledge[40], in the framework of the Integrated Maritime Policy, aims to provide better access to data with a view to enhance the understanding of Europe's seas and oceans and already identifies the importance to carry out all the necessary efforts in coordination with the implementation of the Marine Directive.

In view of the magnitude of the challenge and the opportunity created by the Marine Directive, a concerted approach at various levels (national, regional and EU level, having also regard to global processes) is now needed to address these research needs in an efficient manner, considering that most of these needs will require substantial and continuous research efforts at all such levels during the next years.

As mentioned in the Commission Decision on GES criteria, the development of an improved scientific knowledge needs to be developed, in particular through the EU Marine and Maritime Research Strategy[41] coordinated by DG Research in the framework of the Europe 2020 strategy[42]. The EU research programme FP7 and the upcoming Horizon 2020 provide opportunities to initiate relevant marine research in line with the considerations above. The importance of the Marine

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40 Communication *'Marine Knowledge 2020'*, COM(2010)461 final.

41 Communication '*A European Strategy for Marine and Maritime Research. A coherent European Research Area framework in support of a sustainable use of oceans and seas'*, COM(2008) 534 final.

42 Communication '*Europe 2020 A strategy for smart, sustainable and inclusive growth'*, COM(2010) 2020 final.

Directive and the objective of reaching GES are becoming actively integrated in the calls "Oceans of Tomorrow". A number of marine projects are focusing on the implementation of the Marine Directive, such as MEECE[43], Knowseas[44] and ODEMM[45]. The Marine Directive should also play an important role in several European Research Areas, such as Bonus[46] or Seas-Era[47]. In addition, the Joint Programming Initiative on healthy and productive seas and oceans[48] has included the Marine Directive as one of the priority areas for concerted research.

As mentioned, although research programmes are focussing on the medium- and long-term, the implementation of the Marine Directive is a continuous effort, cyclic of nature, which will continue to demand new knowledge and insight, to be provided to support different deliverables by Member States and the Commission that will be due at different points in time within the six-year cycle.

For instance, enhanced knowledge to develop updated monitoring programmes is already needed by 2013 (taking one year margin ahead of the regulatory deadline). Scientific and technical solutions would be useful by 2014 to support programmes of measures, including approaches for eco-innovation and better resource efficiency by operators of economic sectors affecting the marine environment. Having regard to the long policy cycle of research, it would be possible and useful to identify more accurately research needs for a range of deliverables due in the medium term (if appropriate linking research to the main elements of the timetable of deliveries contained in Annex 1 to this document), such as the revision of criteria, indicators and methodological standards (scientific input by 2015), the update of assessment and targets in marine strategies (scientific input by 2017) and similarly thereafter. This would allow the optimal period for launching relevant research projects, having regard to the time needed for the project cycles, to be better anticipated.

Marine research is already starting to develop a perspective for the longer term having regard to the implementation of the Marine Directive. A major challenge is therefore to develop further a relationship between the existing and forthcoming knowledge needs for the Marine Directive and the strategic objectives of marine research policy, where appropriate through a permanent framework for science policy interface in line with the Marine and Maritime Research Strategy.

43 MEECE 'Marine Ecosystem Evolution in Changing Environment': http://www.meece.eu/default.html

44 Knowseas 'The Knowledge-based Sustainable Management for Europe's Seas': http://www.knowseas.com/

45 ODEMM 'Options for Delivering Ecosystem-Based Marine Management': http://www.liv.ac.uk/odemm/

46 BONUS science programme in the Baltic: http://www.bonusportal.org/about_bonus

47 SEAS-era 'Towards integrated marine research strategy and programmes http://www.seas-era.eu/np4/homepage.html

48 www.jpi-oceans.eu. See Commission recommendation on the research joint programming initiative 'Healthy and Productive Seas and Oceans'. OJ C 276 of 21.09.2011, p.1.

Background documents

Scientific Support to the European Commission on the Marine Strategy Framework Directive – **Management Group Report**. Author(s): A.C. Cardoso, S. Cochrane, H. Doerner, J.G. Ferreira, F. Galgani, C. Hagebro, G. Hanke, N. Hoepffner, P.D. Keizer, R. Law, S. Olenin, G. J. Piet, J. Rice, S.I. Rogers, F. Swartenbroux, M. Tasker, W. van de Bund. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 1 Report Biological diversity**. Author(s): S.K.J. Cochrane, D.W. Connor, P. Nilsson, I. Mitchell, J. Reker, J. Franco, V. Valavanis, S. Moncheva, J. Ekebom, K. Nygaard, R. Serrão Santos, I. Naberhaus, T. Packeiser, W. van de Bund & A.C. Cardoso. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 2 Report Non-indigenous species**. Author(s): S. Olenin, F. Alemany, A. C. Cardoso, S. Gollasch, P. Goulletquer, M. Lehtiniemi, T. McCollin, D. Minchin, L. Miossec, A. Occhipinti Ambrogi, H. Ojaveer, K. Rose Jensen, M. Stankiewicz, I. Wallentinus & B. Aleksandrov ICES/JRC 2010

Marine Strategy Framework Directive – Task **Group 3 Report Commercially exploited fish and shellfish**. Author(s): G. J. Piet, A. J. Albella, E. Aro, H. Farrugio, J. Lleonart, C. Lordan, B. Mesnil, G. Petrakis, C. Pusch, G. Radu & H.-J. Rätz. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 4 Report Food webs**. Author(s): S. Rogers, M. Casini, P. Cury, M. Heath, X. Irigoien, H. Kuosa, M. Scheidat, H. Skov, K. Stergiou, V. Trenkel, J. Wikner & O. Yunev. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 5 Report Eutrophication**. Author(s): J.G. Ferreira, J.H. Andersen, A. Borja, S.B. Bricker, J. Camp, M. Cardoso da Silva, E. Garcés, A.S. Heiskanen, C. Humborg, L. Ignatiades, C. Lancelot, A. Menesguen, P. Tett, N. Hoepffner & U. Claussen. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 6 Report Sea-floor integrity**. Author(s): J. Rice, C. Arvanitidis, A. Borja, C. Frid , J. Hiddink , J. Krause, P. Lorance, S. Á. Ragnarsson, M. Sköld & B. Trabucco. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 8 Report Contaminants and pollution effects**. Author(s): R. Law, G. Hanke, M. Angelidis, J. Batty, A. Bignert, J. Dachs, I. Davies, Y. Denga, A. Duffek, B. Herut, K. Hylland, P. Lepom, P. Leonards, J. Mehtonen, H. Piha, P. Roose, J. Tronczynski, V. Velikova & D. Vethaak. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 9 Report Contaminants in fish and other seafood**. Author(s): F. Swartenbroux, B. Albajedo, M. Angelidis, M. Aulne, V. Bartkevics, V. Besada, A. Bignert, A. Bitterhof, A. Hallikainen, R. Hoogenboom, L. Jorhem, M. Jud, R. Law, D. Licht Cederberg, E. McGovern, R. Miniero, R. Schneider, V. Velikova, F. Verstraete, L. Vinas & S. Vlad. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 10 Report Marine litter**. Author(s): F. Galgani, D. Fleet, J. Van Franeker, S. Katsanevakis, T.Maes, J. Mouat, L. Oosterbaan, I. Poitou, G. Hanke, R. Thompson, E. Amato, A. Birkun & C. Janssen. ICES/JRC 2010

Marine Strategy Framework Directive – **Task Group 11 Underwater noise and other forms of energy**. Author(s): M.L. Tasker, M. Amundin, M. Andre, A. Hawkins, W. Lang, T. Merck, A. Scholik-Schlomer, J. Teilmann, F. Thomsen, S. Werner & M. Zakharia. ICES/JRC 2010

All the above documents are available at: www.ices.dk/projects/projects.asp#MSFD

Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. Author(s): Piha Henna, Zampoukas Nikolaos. JRC 2011.

Available at:

http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/16069/1/lbna24743enn.pdf

Annexes

Annex 1: Timetable for the Marine Directive deliverables

The following table provides an indicative simplified timetable of the main obligations provided in the Marine Directive, combined with the foreseen revisions.

Table A1.1: Timetable of the MSFD products (MS = Member States, COM = European Commission)

Date	Responsible	MSFD Article	Task
2010 15th July	MS	4.2	Notification of subdivisions of marine regions or subregions
	MS	7.1	Designate the authority or authorities competent for implementation of the Directive
	COM	9.3	Definition of the criteria and methodological standards on Good Environmental Status
	MS	26.1, 26.2, 26.3	Transposition of MSFD in national legislation and communication to the COM
2011 15th January	MS	7.1	Report a list of competent authorities, international bodies and authorities competent for cooperation and coordination
2012 15th July	MS	4.2	Revision of subdivisions of marine regions or subregions
	MS	5.2a (i)	Prepare an initial assessment (I.A.) in accordance with Art. 8
	MS	5.2a (ii)	Prepare a determination of Good Environmental Status (GES) in accordance with Art. 9(1)
	MS	5.2a (iii)	Establish a series of environmental targets and associated indicators in accordance with Art. 10(1)
[2012 15th July]	MS	19.2 (a, b)	Publish, and make available to the public for comment, summaries of the I.A., the determination of GES and the environmental targets
	MS	19.3	Provide COM with access and use rights in respect of the data and information resulting from the initial assessments
2012 15th July latest	COM	20.2	Report assessing the contribution of MSFD to the implementation of existing obligations, commitments and initiatives of MS or the EU at EU or international level on environmental protection in marine waters

Date	Responsible	MSFD Article	Task
2012 15th October	MS	9.2	Notify COM on the initial assessment and the determination of GES
	MS	10.2	Notify COM of the environmental targets
2013 15th January	MS	19.3	Make information and data from the I.A. available to the EEA
2013 15th April	COM	12	Assess whether the elements notified by MS on Art. 9 and 10 constitute an appropriate framework to meet MSFD requirements and notify MS of the assessment and any modifications it considers necessary
2013 latest	MS	13.6	Make publicly available, in respect of each marine region or subregion, relevant information with regard to spatial protection areas contributing to coherent and representative networks of marine protected areas Address the competent authority or international organisation [regarding management of a human activity at EU or international level] for consideration and possible adoption of measures that may be necessary to achieve the objectives of the MSFD.
2014 15th July	MS	5.2a (iv)	Establish and implement a monitoring programme for ongoing assessment and regular updating of targets, in accordance with Art. 11
[2014 15th July]	MS	19.2(c)	Publish, and make available to the public for comment, summaries of the monitoring programmes
	MS	19.3	Provide COM with access and use rights in respect of the data and information resulting from the monitoring programmes
2014 15th October	MS	11.3	Notify COM of the monitoring programmes
2014	COM	11.4	Adopt specifications and standardised methods for monitoring and assessment which ensure comparability between monitoring and assessment results
2014	COM	21	Report on progress in the establishment of marine protected areas
2015 15th January	MS	19.3	Make the data and information resulting from the monitoring programmes available to the EEA

Date	Responsible	MSFD Article	Task
2015 15th April	COM	12	Assess whether the elements notified under Art. 11 [monitoring programmes] constitute an appropriate framework to meet the requirements of MSFD and notify MS of the assessment and any modifications it considers necessary
2015 latest	MS	5.2b (i)	Develop a programme of measures designed to achieve or maintain good environmental status in accordance with Art. 13(1, 2, 3)
	MS	15	Inform COM of issues which have an impact on the environmental status of its marine waters and which cannot be tackled at national level, or which is linked to another EU policy or international agreement Make recommendations to COM and the Council for measures where actions by EU institutions is needed
[2015 latest]	MS	5.3	Devise a plan of action which includes early entry into operation of programmes of measures, where the status of the sea in a region or sub-region is so critical as to necessitate urgent action
[2015 latest]	MS	19.2(d)	Publish, and make available to the public for comment, summaries of the programmes of measures
2016 March latest	MS	13.9	Notify COM and other MS concerned of the programme of measures
	MS	14.1, 14.4	Substantiate to COM instances where, for reasons in Art 14.1(a-d), the environmental target or GES cannot be achieved or, for reasons in Art. 14.1(e), they cannot be achieved within the time schedule. Provide COM with justification for decisions to not take specific steps to develop and implement marine strategies.
[2016 June latest]	COM	15	Respond to issues raised by MS
2016 15th July latest	COM	COM 2010/477/EU preamble 4	Revision of the Commission Decision on GES criteria
2016 September latest	COM	16	Assess whether the programmes [of measures] notified by MS constitute an appropriate framework to meet the requirements of the Directive, considering the coherence of programmes within the different

Date	Responsible	MSFD Article	Task
			regions and sub-regions and across the EU, and provide guidance on any modifications it considers necessary.
2016 latest	MS	5.2b (ii); 13.10	Entry into operation of the programme of measures in accordance with Art. 13
2018 15th July	MS	17.2 (a, b)	Review of marine strategies: the initial assessment, the determination of GES and the environmental targets
2018 15th October	MS	17.3	Notify COM, Regional Sea Conventions and other MS concerned of updates on the review of marine strategies: the initial assessment, the determination of GES and the environmental targets
2018	MS	18	Submit to COM a brief interim report on progress in the implementation of the programme of measures
2019 15th April	COM	17.4	Assessment of the revised initial assessment, the determination of GES and the environmental targets according to Art. 12
2019 latest	COM	20.1, 20.3	First evaluation report on the implementation of the Directive
2020 15th July	MS	17.2 (c)	Review of marine strategies: monitoring programme
2020 15th October	MS	17.3	Notify COM, Regional Sea Conventions and other MS concerned of updates on the review of marine strategies: monitoring programme
2020 latest	MS	1.1	Achieve or maintain GES in the marine environment
2021 15th April	COM	17.4	Assessment of revised monitoring programme according to Art. 12
2021	MS	17.2 (d)	Review of marine strategies: programme of measures
2022 March	MS	17.3	Notify COM, Regional Sea Conventions and other MS concerned of updates on the review of marine strategies: programme of measures
2022 September	COM	17.4	Assessment of revised programme of measures according to Art. 16
2023 15th July	COM	23	Review the Directive and, where appropriate, propose any necessary amendments

Date	Responsible	MSFD Article	Task
2025 latest	COM	20.1, 20.3	Second evaluation report on the implementation of the Directive

The reference in Art.17(4) to a review of the various elements of marine strategies "every six years" suggests that further implementation cycles would be applicable from 2024 in the absence of a legislative amendment.

Annex 2: The GES descriptors and associated criteria and indicators

Table A2.1: The GES descriptors and associated criteria and indicators (the type of indicator is shown as follows: S = state, I = impact, P = pressure).

Descriptor	Criterion	Indicator	Type of indicator
D1 Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	1.1 Species distribution	1.1.1 Distributional range	S
		1.1.2 Distributional pattern within the latter, where appropriate	S
		1.1.3 Area covered by the species (for sessile/benthic species)	S
	1.2 Population size	1.2.1 Population abundance and/or biomass, as appropriate	S
	1.3 Population condition	1.3.1 Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)	S
		1.3.2 Population genetic structure, where appropriate	S
	1.4 Habitat distribution	1.4.1 Habitat distributional range	S
		1.4.2 Habitat distributional pattern	S
	1.5 Habitat extent	1.5.1 Habitat area	S
		1.5.2 Habitat volume, where relevant	S
	1.6 Habitat condition	1.6.1 Condition of the typical species and communities	S
		1.6.2 Relative abundance and/or biomass, as appropriate	S
		1.6.3 Physical, hydrological and chemical conditions	S
	1.7 Ecosystem structure	1.7.1 Composition and relative proportions of ecosystem components (habitats and species)	S

Descriptor	Criterion	Indicator	Type of indicator
D2 Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	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 of such species	P
	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)	I
		2.2.2 Impacts of non-indigenous invasive species at the level of species, habitats and ecosystems, where feasible	I
D3 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)	P
		3.1.2 Ratio between catch and biomass index ('catch/biomass ratio')	P
	3.2 Reproductive capacity of the stock	3.2.1 Spawning Stock Biomass (SSB)	S/I
		3.2.2 Biomass indices	S/I
	3.3 Population age and size distribution	3.3.1 Proportion of fish larger than the mean size of first sexual maturation	S/I
		3.3.2 Mean maximum length across all species found in research vessel surveys	S/I
		3.3.3 95% percentile of the fish length distribution observed in research vessel surveys	S/I
		3.3.4 Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation	S/I
D4 All elements of the marine food webs, to the extent that they	4.1 Productivity (production per unit biomass) of key species or trophic groups	4.1.1 Performance of key predator species using their production per unit biomass (productivity)	S

Descriptor	Criterion	Indicator	Type of indicator
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.	4.2 Proportion of selected species at the top of food webs	4.2.1 Large fish (by weight)	S
	4.3 Abundance/distribution of key trophic groups/species	4.3.1 Abundance trends of functionally important selected groups/species	S
D5 Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.	5.1 Nutrients level	5.1.1 Nutrients concentration in the water column	S/P
		5.1.2 Nutrient ratios (silica, nitrogen and phosphorus), where appropriate	S/P
	5.2 Direct effects of nutrient enrichment	5.2.1 Chlorophyll concentration in the water column	I
		5.2.2 Water transparency related to increase in suspended algae, where relevant	I
		5.2.3 Abundance of opportunistic macroalgae	I
		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	I
	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	I
		5.3.2 Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned	I

Descriptor	Criterion	Indicator	Type of indicator
D6 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	S/I
		6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types	I
	6.2 Condition of benthic community	6.2.1 Presence of particularly sensitive and/or tolerant species	S/I
		6.2.2 Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species	S/I
		6.2.3 Proportion of biomass or numbers of individuals in the macrobenthos above some specified length/size	S/I
		6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community	S/I
D7 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	P
	7.2 Impact of permanent hydrographical changes	7.2.1 Spatial extent of habitats affected by the permanent alteration	I
		7.2.2 Change 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	I
D8 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 assessments under Directive 2000/60/EC	P

Descriptor	Criterion	Indicator	Type of indicator
	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	I
		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	P/I
D9 Contaminants in fish and other seafood for human consumption do not exceed levels established by EU 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	P/I
		9.1.2 Frequency of regulatory levels being exceeded	P/I
D10 Properties and quantities of marine litter do not cause harm to the coastal and 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	P
		10.1.2 Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source	P
		10.1.3 Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics)	P
	10.2 Impacts of marine litter on marine life	10.2.1 Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis)	I

Descriptor	Criterion	Indicator	Type of indicator
D11 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 1µPa2.s) or as peak sound pressure level (in dB re 1µPapeak) at one metre, measured over the frequency band 10 Hz to 10 kHz	P
	11.2 Continuous low frequency sound	11.2.1 Trends in the ambient noise level within the 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	P

Annex 3: Linkages between Annex I and Annex III of the Directive through the Decision criteria and indicators

Table A3.1: Annex III Table 1 Characteristics

Characteristic	Component	Criteria (state)	Indicators (state)	Indicators (impact)	Section
Physical and chemical features	- Topography and bathymetry			6.1.1 biogenic substrata 6.1.2 extent of seabed affected	3.1, 4.10
	- Temperature regime, ice cover, current velocity, upwelling, wave			5.2.2 water transparency 7.2.2 change in habitats	
	- Salinity				
	- Nutrients (DIN, TN, DIP, TP, TOC) and oxygen	5.1 Nutrients level	5.1.1 nutrient concentration 5.1.2 nutrient ratio	5.3.2 dissolved oxygen	
	- pH, pCO profiles or equivalent				
Biological features -at the level of individual species	- Seabirds	1.1 Species distribution	1.1.1 species distributional range	2.2.1 ratio invasive and native species	3.2, 3.3, 3.6
	- Mammals		1.1.2 species distributional pattern	2.2.2 impacts of non-indigenous species	
	- Reptiles		1.1.3 area covered by species	[indicators for D6.2 for other species which are benthic]	
	- Fish	1.2 Population size	1.2.1 population abundance	7.2.2 change in habitats due to hydrographical changes	
	- Other species of EU legislation and international agreements			8.2.1 level of pollution effects	
	- Genetically distinct forms of native species	1.3 Population condition	1.3.1 population demographics	8.2.2 occurrence acute pollution events	
			1.3.2 population genetic structure	10.2.1 trends in amount of litter ingested	
	- Commercially exploited fish and shellfish —additional relevant indicators	3.2 Reproductive capacity of the stock		2.2.1 ratio invasive and native species	3.2 , 3.3, 3.6
			3.2.1 spawning stock biomass	2.2.2 impacts non-indigenous species	
			3.2.2 biomass indices	7.2.2 change in habitats due to hydrographical changes	
		3.3 Population age and size distribution	3.3.1 proportion of larger fish	8.2.1 level of pollution effects	
			3.3.2 mean max length	8.2.2 occurrence acute pollution events	
			3.3.3 fish length distribution	9.1.1 actual level of contaminants in seafood	
			3.3.4 size at first sexual maturation	9.1.2 frequency of levels exceeded in seafood	
				10.2.1 trends in amount of litter ingested	
	- Non-indigenous species			2.2.1 ratio invasive and native species	3.2, 3.3, 4.2
				2.2.2 impacts non-indigenous species	
Biological features -at the level of functional groups	- Seabirds	1.6 Habitat condition		2.2.1 ratio invasive and native species	3.2, 3.3, 3.6
	- Mammals		1.6.1 condition typical species	2.2.2 impacts non-indigenous species	
	- Reptiles		1.6.2 relative abundance	7.2.2 change in habitats due to hydrographical changes	
	- Fish		1.6.3 habitat condition	8.2.1 level of pollution effects	
	- Cephalopods			8.2.2 occurrence acute pollution events	
Habitat types -at the level of habitat types	- Predominant seabed and water column habitat types, including their biological communities (phytoplankton, zooplankton, angiosperms, macro-algae, bottom fauna) - Special habitat types, especially those under EU legislation and international conventions			2.2.1 ratio invasive and native species	3.2, 3.4, 3.6
		1.4 Habitat distribution	1.4.1 habitat distributional range	2.2.2 impacts non-indigenous species	
			1.4.2 habitat distributional pattern	5.2.1 chlorophyll concentration	
		1.5 Habitat extent	1.5.1 habitat area	5.2.3 abundance of macroalgae	
			1.5.2 habitat volume	5.2.4 species shift	
		1.6 Habitat condition	1.6.1 condition typical species	5.3.1 abundance of seaweeds and seagrasses	
			1.6.2 relative abundance	5.3.2 dissolved oxygen 6.1.2 extent of seabed affected	
			1.6.3 habitat condition	7.2.1 spatial extent of habitats affected	
		6.2 Condition of benthic communities	6.1.1 biogenic substrata	7.2.2 change in habitats	
			6.2.1 presence sensitive species	8.2.1 level of pollution effects	
			6.2.2 multi-metric indexes	8.2.2 occurrence acute pollution	
			6.2.3 proportion biomass of individuals above size	9.1.1 actual levels of contaminants in seafood [seafood spp.]	
			6.2.4 size spectrum of benthic community	9.1.2 frequency of levels exceeded in seafood [seafood spp.]	
				10.2 Impacts of litter	
	- Particular areas				3.4
Ecosystems -at the level of ecosystems				2.2.2 impacts non-indigenous species	3.2, 3.5, 3.6
		1.7 Ecosystem structure	1.7.1 composition ecosystem	5.3.2 dissolved oxygen	
		4.1 Productivity of key species or trophic groups	4.1.1 performance key predator	6.1.2 extent of seabed affected	
		4.2 Proportion of species at the top of food web	4.2.1 large fish	7.2.1 spatial extent of habitats affected	
		4.3 Abundance/ distribution of key trophic groups/species	4.3.1 abundance trends selected groups	7.2.2 change in habitats	
				8.2.1 level of pollution effects	
				8.2.2 acute pollution events	
Other features	- Chemicals			8.2.1 level of pollution effects 8.2.2 acute pollution events 9.1.1 actual levels of contaminants in seafood 9.1.2 frequency of levels exceeded in seafood	4.8
	- Typical features or characteristics				3.7

Table A3.2: Annex III Table 2 Pressures and impacts

Pressure theme	Pressure	Criteria (pressure)	Indicators (pressure)	Indicators (impact)	Section
Physical loss	- Smothering - Sealing	6.1 Physical damage, having regard for substrate types		6.1.1 biogenic substrata 6.1.2 extent of seabed affected	4.4
Physical damage	- Siltation - Abrasion - Extraction			6.2.1 presence sensitive species 6.2.2 multi-metric indexes 6.2.3 proportion biomass of individuals above size 6.2.4 size spectrum of benthic community	
Other physical disturbance	- Underwater noise	11.1 Distribution in time and place of loud, low and mid frequency impulsive sounds 11.2 Continuous low frequency sound	11.1.1 proportion of days with loud sound levels 11.2.1 trends in ambient noise levels		4.6
	- Marine litter	10.1 Characteristics of litter in the marine and coastal environment	10.1.1 trends in litter on shore 10.1.2 trends in litter in water column 10.1.3 trends in micro-plastics	10.2.1 trends in amount of litter ingested	4.7
Interference with hydrological processes	- Thermal regime (change) - Salinity regime (change)	7.1 Spatial characterisation of permanent alterations	7.1.1 extent area affected by permanent alteration	7.2.1 spatial extent of habitats affected 7.2.2 change in habitats	4.5
Contamination by hazardous substances	- Synthetic compounds - Non-Synthetic substances - Radio-nuclides	8.1 Concentration of contaminants 8.2 (acute pollution events) 9.1 Levels, number and frequency of contaminants	8.1.1 concentration of contaminants 8.2.2 occurrence acute pollution events 9.1.1 actual levels contaminants in seafood 9.1.2 frequency of levels exceeded in seafood	8.2.1 level of pollution effects 8.2.2 acute pollution events 9.1.1 actual levels of contaminants in seafood 9.1.2 frequency of levels exceeded in seafood	4.8
Systematic and/or intentional release of substances	- Other substances	8.1 Concentration of contaminants	8.1.1 concentration of contaminants	8.2.1 level of pollution effects	4.9
Nutrient and organic matter enrichment	- Fertilisers and other nitrogen- and phosphorus-rich substances - Organic matter	5.1 Nutrients level	5.1.1 nutrient concentration 5.1.2 nutrient ratio	5.2.1 chlorophyll concentration 5.2.2 water transparency 5.2.3 abundance of macroalgae 5.2.4 species shift 5.3.1 abundance of seaweeds and seagrasses 5.3.2 dissolved oxygen	4.10
Biological disturbance	- Microbial pathogens				4.3
	- Non-indigenous species and translocations	2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species	2.1.1 trends in abundance non-indigenous species	2.2.1 ratio invasive and native species 2.2.2 impacts non-indigenous species	4.2
	- Extraction of species, including non-target catches	3.1 Level of pressure of the fishing activity	3.1.1 fishing mortality 3.1.2 ratio between catch and biomass index	3.2.1 spawning stock biomass 3.2.2 biomass indices 3.3.1 proportion of larger fish 3.3.2 mean max length 3.3.3 fish length distribution 3.3.4 size at first sexual maturation	4.1

Annex 4: Indicative list of human activities and their possible pressures on the marine environment

Indicative list of human activities		Biological disturbance			Physical loss	Physical damage	Interference with hydrological processes	Other physical disturbance		Contamination by hazardous substances	Systematic and/or intentional release of substances	Nutrient and organic matter enrichment
Activity theme	**Activity**	- Extraction of species including non-target catches	- Non-indigenous species and translocations	- Microbial pathogens	- Smothering - Sealing	- Siltation - Abrasion - Extraction	- Thermal regime - Salinity regime	- Underwater noise/energy	- Marine litter	- Synthetic compounds - Non-synthetic substances - Radio-nuclides	e.g. produced water, carbon storage	- Fertilisers and other nitrogen- and phosphorus-rich substances - Organic matter
Extraction of living resources	Fisheries incl. recreational fishing (fish and shellfish)											
	Seaweed and other sea-based food harvesting											
	Extraction of genetic resources/bioprospecting/maerl											
Food production	Aquaculture (fin-fish and shellfish)											
Man-made structures (incl. construction phase)	Land/sea physical interaction: land claim, coastal defence											
	Port operations											
	Placement and operation of offshore structures (other than for energy production)											
	Submarine cable and pipeline operations											
Extraction of non-living resources	Marine mining (sand and gravel, rock)											
	Dredging											
	Desalination/water abstraction											
Energy production	Marine-based renewable energy generation (wind, wave and tidal power)											
	Marine hydrocarbon (oil and gas) extraction											
Transport	Shipping											
Waste disposal	Solid waste disposal incl. dredge material											
	Storage of gasses											
Tourism and recreation	Tourism and recreation incl. yachting											
Research and survey	Marine research, survey and educational activities											
Military	Defence - recurrent defence operations											
	Defence - dumping of unwanted munitions											
Land-based activities/industries	Coastal, riverine and atmospheric inputs from land - industrial discharges and emissions											
	Coastal, riverine and atmospheric inputs from land - agricultural and forestry run-off and emissions											
	Coastal, riverine and atmospheric inputs from land - municipal waste water discharge											

Annex 5: Integration table, linking state characteristics to pressures through impacts

Annex III Table 1			COM Decision	Annex III Table 2	Pressure theme	Biological disturbance			Physical loss	Physical damage	Interference with hydrological processes	Other physical disturbance	Other physical disturbance	Contamination by hazardous substances	Systematic and/or intentional release of substances	Nutrient and organic matter enrichment
					Pressure	- Extraction of species, including non-target catches	- Non-indigenous species and translocations	- Microbial pathogens	- Smothering - Sealing	- Siltation - Abrasion - Extraction	- Thermal regime - Salinity regime	- Underwater noise	- Marine litter	- Synthetic compounds - Non-synthetic substances - Radio-nuclides	e.g. produced water, carbon storage	- Fertilisers & other nitrogen- & phosphorus-rich substances - Organic matter
Characteristic		**Component**	**State criteria & indicators**		**Pressure criteria & indicators**	3.1 Level of pressure of the fishing activity 3.1.1; 3.1.2	2.1 Abundance & state characterisation of non-indigenous species, in particular invasive species: 2.1.1		6.1 Physical damage, having regard to substrate characteristics	6.1 Physical damage, having regard to substrate characteristics	7.1 Spatial characterisation of permanent alterations: 7.1.1	11.1 Distribution in time & place of loud, low & mid frequency impulsive sounds: 11.1.1 11.2 Continuous low frequency sound: 11.2.1	10.1 Characteristics of litter in the marine & coastal environment: 10.1.1; 10.1.2; 10.1.3	8.1 Concentration of contaminants: 8.1.1 8.2.2: Acute pollution events 9.1 Levels, number & frequency of contaminants: 9.1.1; 9.1.2	8.1 Concentration of contaminants: 8.1.1	5.1 Nutrients level: 5.1.1; 5.1.2
Physical and chemical features	Physical	- Topography and bathymetry							6.1.1 Type, abundance, biomass & areal extent 6.1.2 Extent of seabed significantly affected	6.1.1 Type, abundance, biomass & areal extent 6.1.2 Extent of seabed significantly affected						
		- Temperature regime, ice cover, current velocity, upwelling, wave exposure, mixing characteristics, turbidity, residence time									7.2 Impact of permanent hydrographical changes: 7.2.2					5.2 Direct effects of nutrient enrichment: 5.2.2
	Chemical	- Salinity														
		- Nutrients (DIN, TN, DIP, TP, TOC) and oxygen	See pressure criterion 5.1		See 5.1.1, 5.1.2											5.3 Indirect effects of nutrient enrichment: 5.3.2
		- pH, pCO_2 profiles or equivalent														
Biological features (other than habitat types and ecosystems)	At level of individual species	- Fish - Mammals - Reptiles - Seabirds - Other species of Community legislation & international agreements - Genetically distinct forms of native spp.	1.1 Species distribution		1.1.1; 1.1.2; 1.1.3		2.2 Environmental impact of invasive non-indigenous species: 2.2.1; 2.2.2				7.2 Impact of permanent hydrographical changes: 7.2.2		10.2 Impacts of litter on marine life: 10.2.1	8.2 Effects of contaminants: 8.2.1; 8.2.2 (impact on biota)		
			1.2 Population size		1.2.1											
			1.3 Population condition		1.3.1; 1.3.2											
		- Fish & shellfish (commercially exploited) - additional criteria/indicators	3.2 Reproductive capacity of the stock		3.2.1; 3.2.2	3.2 Reproductive capacity of the stock: 3.2.1, 3.2.2 3.3 Population age & size distribution: 3.3.1, 3.3.2, 3.3.3, 3.3.4								8.2 Effects of contaminants: 8.2.1; 8.2.2 (impact on biota) 9.1 Levels, number & frequency of contaminants: 9.1.1; 9.1.2		
			3.3 Population age and size distribution		3.3.1; 3.3.2; 3.3.3; 3.3.4											
		- Non-indigenous species	See pressure criterion 2.1													
	At level of functional groups	- Fish - Mammals - Reptiles - Seabirds	1.6 Habitat condition		1.6.1; 1.6.2; 1.6.3		2.2 Environmental impact of invasive non-indigenous species: 2.2.1; 2.2.2							8.2 Effects of contaminants: 8.2.1; 8.2.2 (impact on biota)		
Habitat types	At level of habitats	- Predominant seabed & water column habitat types, including their biological communities (phytoplankton, zooplankton, angiosperms, macro-algae, bottom fauna) - Special habitat types, especially those under Community legislation & international conventions	1.4 Habitat distribution		1.4.1; 1.4.2	6.2 Condition of benthic community 6.2.1, 6.2.2, 6.2.3, 6.2.4	2.2 Environmental impact of invasive non-indigenous species: 2.2.1; 2.2.2		6.1.1 Type, abundance, biomass and areal extent of biogenic substrata 6.1.2 Extent of seabed significantly affected	6.1.1 Type, abundance, biomass & areal extent of biogenic substrata 6.1.2 Extent of seabed significantly affected 6.2 Condition of benthic community 6.2.1, 6.2.2, 6.2.3, 6.2.4	7.2 Impact of permanent hydrographical changes: 7.2.1; 7.2.2		10.2 Impacts of litter on marine life	8.2 Effects of contaminants: 8.2.1; 8.2.2 (impact on biota)		5.2 Direct effects of nutrient enrichment: 5.2.1; 5.2.3; 5.2.4 5.3 Indirect effects of nutrient enrichment: 5.3.1
			1.5 Habitat extent		1.5.1; 1.5.2											
			1.6 Habitat condition		1.6.1; 1.6.2; 1.6.3											
			6.2 Condition of benthic community		6.1.1; 6.2.1; 6.2.2; 6.2.3; 6.2.4											
		- Habitats in particular areas (e.g. intense/ specific pressures, specific protection)														
Eco-systems	At level of ecosystems		1.7 Ecosystem structure		1.7.1		2.2 Environmental impact of invasive non-indigenous species: 2.2.2		6.1.2 Extent of seabed significantly affected	6.1.2 Extent of seabed significantly affected	7.2 Impact of permanent hydrographical changes: 7.2.1; 7.2.2			8.2 Effects of contaminants: 8.2.1; 8.2.2 (impact on biota)		5.3 Indirect effects of nutrient enrichment: 5.3.2
			4.1 Productivity of key species or trophic groups		4.1.1											
			4.2 Proportion of species at the top of food webs		4.2.1											
			4.3 Abundance/ distribution of key trophic groups/spp.		4.3.1											
Other features		- Chemicals giving rise to concern, sediment contamination, hotspots, health issues & contamination of biota (esp. for human consumption)	See pressure criterion 8.1											8.2 Effects of contaminants: 8.2.1; 8.2.2 (impact on biota) 9.1 Levels, number & frequency of contaminants: 9.1.1; 9.1.2		
		- Features or characteristics typical or specific to region or subregion														

KEY:	Characteristics: Annex III table 1	Pressures and impacts: Annex III table 2	State criteria & indicators	Pressure criteria and indicators	Impact criteria and indicators