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Management Group Report

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1 INTRODUCTION

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) requires that the European Commission (COM) by 15 July 2010 shall lay down criteria and methodological standards to allow consistency in the approach by which EU Member States (MS) assess the extent to which Good Environmental Status (GES) is being achieved. Scientific advice for guidance on this was sought from expert groups coordinated by ICES and JRC to arrange for the provision of scientific support for the COM in meeting this obligation.

A Task Group was established for each of the Descriptors (except Descriptor 7, Hydrographic conditions) of Annex I of the MSFD with the aim of developing criteria and methodological standards for each Descriptor. For each Task Group, independent experts were selected, drawing from experience related to the four marine regions (the Baltic Sea, the North-east Atlantic, the Mediterranean Sea and the Black Sea) and a variety of relevant scientific expertise. This helped to ensure a wide thematic and European wide regional representation. Observers from the Regional Seas Conventions were invited to each Task Group in order to help ensure the inclusion of relevant work done by the Conventions. The Management Group consisted of the Task Group chairs and members of a small Steering Group consisting of JRC and ICES representatives. The group was also joined by those in the JRC responsible for the technical/scientific work for the Task Groups coordinated by JRC. The conclusions in the reports of the Task Groups and Management Group are not necessarily those of the coordinating organisations.

Detailed reports for eight of the Descriptors have been prepared by groups of independent experts coordinated by JRC and ICES. The reports for Descriptors 9, Contaminants in fish and other seafood and 10, Marine litter were written by groups coordinated by DG SANCO and IFREMER respectively. All of these reports should aid Member States in implementing Article 10.1 and other Articles of the Directive. The executive summaries of the Task Group reports are included in Annex 1 for a summary overview of the Descriptors.

The analysis and drafting of the reports was carried out from April 2009 to March 2010. Most Task Groups and the Management Group met twice but much of the drafting and discussion was carried out through correspondence and web-conferences.

This report prepared by the Management Group provides information on a number of issues that are common to all of the Descriptors. Executive summaries and tables summarising key information for each of the Descriptors are also included. Readers are referred to the individual Task Group reports for more details on scientific and technical recommendations associated with each Descriptor. Discussion on implementation should be based on the full Task Group reports and not just this Management Group report. The Management Group has also provided some comments on what it believes are important next steps as they relate to scientific support of the MSFD.

2 MONITORING STRATEGIES

A vast diversity of environmental conditions exists across and among European seas with respect to physical and biological conditions and human activities and needs. The relationships between human activities and environmental conditions are context-dependent; temporal and spatial scales of impacts vary with different pressures and with system vulnerability, which, in turn, are dependent of the characteristics of the areas in question. In addition, different Descriptors are expressed on inherently different scales: Descriptors such as Commercial fisheries and Food webs on moderately large scales, Seafloor integrity generally on local scales, and for Descriptors such as Energy/Noise, Contaminants, Eutrophication, Invasive species, Litter, and Biodiversity, different attributes express themselves at a variety of scales from local to regional. These differences in scale among the Descriptors means that the Attributes of different descriptors may be disaggregated to various extent in several sections of this report.

2.1 Integrative approach to GES assessment

The diversity in environmental conditions and the issues of scale have implications for the implementation of the Descriptors in the assessment of Good Environmental Status (GES). Firstly, there is no single set of criteria and indicators which can meaningfully be applied to all marine regions/subregions, and often not even for a single Descriptor within a marine region/subregion. Secondly, there are a variety of degrees of overlap among Descriptors, attributes, and indicators. These overlaps were taken into account by each TG, and where such overlaps occur conclusions and recommendations for the Descriptors have been coordinated to ensure consistency.

The Annex III of the MSFD provides indicative lists of the characteristics of marine ecosystems and the possible pressures and impacts on them. These have been combined in tables (Tables 2-1a, 2-1b) with the 11 descriptors in order to show the relations among them.

The tables show that some Descriptors are specific covered by only one or a few characteristics and pressures, while others are more generic (see Table 2-1b and Chapter 5.1) covering a wider range of characteristics and pressures. The acknowledgment of these relations is of importance when selecting the parameters to be monitored.

In order to use resources wisely and maximize the information gathered, a pragmatic approach needs to be adopted for assessing the overall state of marine environments. The elements of monitoring programmes for the assessment of GES need to be tailored to the specific needs of each of the designated assessment areas. Informed decision-making will be required on what and where to monitor, to ensure that:

a. Monitoring (sampling) sites are selected according to maximal information gain and
b. The precise suite of indicators applied at each sampling site will be selected against a background understanding of the components of the ecosystem present and the pressures which exist at that site.

Such an approach makes maximum use of ongoing monitoring programmes, bringing these together and integrating them, wherever possible, to meet the needs of assessments for the MSFD. It also ensures that management efforts can be targeted efficiently at the most serious environmental problems, while not losing sight of other environmental challenges that also need action (e.g. protection of areas in GES) and places where progress is being made towards GES.

2.2 Prioritisation in monitoring

2.2.1 Risk-based approach

When the ecologically meaningful scale for variability in environmental conditions and impacts of pressures is relatively small, the best approach for selecting a set of indicators and monitoring schemes builds on the available knowledge on what ecosystem features are particularly vulnerable to and where pressures are confined. In such cases, the first step in prioritisation would be to map the spatial distribution of pressures, particularly the ones most likely to cause the largest impacts on the ecosystem, and the vulnerability of various properties of marine systems. The areas and indicators which should be priorities for monitoring are determined by prior assessment of

i. the distribution of the intensity or severity of the pressures across the region at large;
ii. the spatial extent of the pressures relative to the ecosystem properties possibly being impacted;
iii. the sensitivity/vulnerability or resilience of the ecosystem properties to the pressures;
iv. the ability of the ecosystem properties to recover from impacts, and the rate of such recovery;
v. the extent to which ecosystem functions may be altered by the impacts; and

vi. where relevant, the timing and duration of the impact relative to the spatial and temporal extent of particular ecosystem functions (e.g. shelter, feeding, etc).

The variation in scale of both environmental conditions and impacts of pressures means that assessments of GES should begin with sub-areas of both greatest vulnerability and highest pressures. If the environmental status in these areas is good, then it can be assumed that the status over the larger area is "good". On the contrary, if the environmental status in the sub-areas is not "good", then monitoring and assessments would be conducted stepwise at additional sites along the gradients of pressure or vulnerability. The size of the appropriate steps along the gradient will depend on the nature of the gradient and the way the environmental conditions are being degraded. It may vary significantly with different cases. This risk-based approach will be particularly effective for Descriptors that are spatially patchy and where pressures are applied at specific locations.

This pragmatic prioritisation of monitoring strategies enables general statements to be made about environmental status at large scales while keeping monitoring requirements manageable. It is referred to as a risk-based approach in several of the Task Group. The approach also facilitates the identification of actions needed to improve the environmental status, and represents a suitable methodological scheme for marine spatial planning.

2.2.2 Monitoring for Descriptors that inherently integrate spatially

Some Descriptors, such as Food webs (Descriptor 4) and some Biodiversity features (Descriptor 1) occur at broader scales where specific ecosystem components responding to specific manageable human activities are difficult to identify on local scales. For those "large scale" Descriptors, the recommended approach is to select attributes which integrate across a range of ecosystem properties. Such integrative indicators can then be linked to the pressures of human activity that are most likely to influence their status, such as for example the effects of fisheries exploitation in a regional sea and nutrient effects in shelf seas. In cases where the nature of the pressures or ecological processes denotes homogeneous environmental conditions over large scales, the choice of indicators should target on those that are most representative of the entire area, but which could be measured locally. In cases where the nature of the pressures or ecological processes denotes a spatially patchy environment and short time scale dynamics, then the choice of indicators should target on those that comprehensively integrate conditions in space.

Table 2-1a. Coverage of MSFD Annex III characteristics by Descriptors. D1 Biological diversity; D2 Non-indigenous species; D3 Commercial fish; D4 Food webs; D5 Eutrophication; D6 Sea floor; D7 Hydrogeographical conditions; D8 Contaminants and pollution effects; D9 Contaminants in fish and other seafood; D10 Litter; D11 Energy/Noise. X = characteristic is an intrinsic part of the Descriptor; (X) = characteristics with an indirect relation, or a relation of secondary relevance with the Descriptor.

Annex III Characteristics*	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**
Physico-chemical											
Topography	X					X					
Temperature	X			(X)		(X)	X				(X)
Salinity	X			(X)		(X)	X				
Nutrient	X			X	X	(X)					
pH	X			(X)			X				
Habitat types											
Predominant habitat types	X			X		X					
Special habitat types	X			X		X					
Habitat types meriting special reference	X			X		X					
Biological features											
Phyto-zooplankton	X	(X)		X	X	(X)					
Bottom fauna*	X	(X)	X	X		X					
Fish	X	(X)	X	X		(X)					
Mammals**	X	(X)		X							
Seabirds**	X	(X)		X							
Other species	X	(X)		X		(X)					
Non-indigenous**	(X)	X		X		(X)					
Other features											
Chemicals	(X)			X		(X)		X	X		
Others	(X)			X		(X)				X	X

* Characteristics are specified in MSFD Annex III, Table 1, Indicative lists of characteristics

** for D1, also bottom flora, reptiles and genetically distinct forms of native species are treated. ”Seabirds” should encompass all birds that use the marine environment and include species normally referred to as “waterbirds” such as waders, divers and ducks.

Table 2-1b. Relevance of MSFD Annex III pressures and impacts for Descriptors. X = pressure is of primary importance for the descriptor; (X) = pressure is of secondary importance.

Annex III Pressures and Impacts*		**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**
Physical loss	Smothering	X			X		X					
	Sealing	X			X		X					
Physical damage	Siltation	X			X		X					
	Abrasion	X			X		X					
	Extraction	(X)			X		X					
Other physical disturbance	Noise	(X)			(X)							X
	Marine litter	(X)					(x)				X	
Interference with hydrology	Change in thermal regime	(X)			X		(X)	X				X**
	Changes in salinity	(X)			X		(X)	X				
Contamination	Synthetic substances	(X)			X		X		X	X		
	Non-synthetic substances	(X)			X		X		X	X		
	Radionuclides	(X)			X		(X)		X	X		
Systematic release of substances	Introduction of other substances	(X)			X		X		X			
Nutrient and organic matter enrich-ment	Input of fertilizer	(X)			X	X	X					
	Input of organic matter	(X)			X		X					
Biological disturbance	Microbial pathogens	X			X	X	(X)					
	Non-indigenous species	(X)	X	(X)	X		X					
	Selective extraction	(X)		X	X	X	(X)					

* Pressure and impacts are specified in MSFD Annex III, Table 2, Indicative list of pressures and impacts

** This is an energy input too and is described in TG11 report but no indicator is provided.

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3 SETTING ENVIRONMENTAL TARGETS

Several phases in the implementation of the MSFD require setting of target values for indicators. The MSFD refers to such values as "environmental targets", but they are also identified under a variety of other names. In Annex I of the MSFD (referred to in Articles 3(5), 9(1), 9(3) and 24), the values are described as *levels* or *limits*. Annex IV (referred to in Articles 10(1) and 24) states that *reference points* (*target* and *limit reference points*) should be taken into account when setting environmental targets where appropriate. . There is a difference between targets and reference points as used in fish stock management. Targets are human constructs, often resulting from political process expressing societal values. Reference levels (or points) correspond to features that are intrinsic to the ecosystem and hence are not human constructs but the results of natural processes.

A target or reference level that is particularly important to implementation of the MSFD Descriptors is the position on an indicator at or beyond which "good environmental status" has been achieved (according to that indicator). Management must try to achieve at least that target or reference level in order to qualify as GES. Under the MSFD it is necessary that these targets or reference levels for delineating GES reflect ecologically comparable states. However, that does not require the same value everywhere; rather the target or reference level should be scaled to local conditions while maintaining a consistent ecological meaning. In addition, society may set targets that are more ambitious than the ecologically determined reference levels, to fulfill their values and aspirations. In such cases management should further strive to achieve those targets.

Most of the Task Groups did not establish reference levels or targets for their Descriptors as they were working at scales larger than those usually considered for those values. Some Task Groups (e.g. Task Group 3 on Commercial fish and shellfish) made recommendations on a methodology to set reference levels based on an existing well-established methodological framework.

Rather than setting reference levels and targets for the indicators the Task Groups described ecological characteristics across a pressure gradient (from bad to good). The points listed below identify important issues to consider when setting reference levels and targets:

- A level or target might be set at an "un-impacted" state, but it is highly likely that the values would exceed those for which Good Environmental Status would be achieved in the context of a sustainable use of the seas as defined in the Directive is founded on the concept of sustainable use.
- Any reference level or target should be set accounting for natural variation. For example, Europe's seas are affected by large-scale atmospheric fluctuations (such as the North Atlantic Oscillation) occurring at a number of temporal scales (up to 150 year cycles). Note that the longer-term variation in ecosystems is not always due to natural changes in forcing conditions. The ecological consequences of depleting populations of long-lived species (for example the great whales) or man-driven alterations of marine habitats may take decades to centuries to manifest themselves. Also at a smaller scale it is important to distinguish natural variations (both spatially and temporally) of the background conditions (e.g. nutrient enrichment from upwelling, import from pristine/good status rivers) from human related changes. This will help further in identifying what pressures require management, and what levels or targets are most appropriate to achieve GES.
- In setting reference levels and targets it is necessary to take into account drivers of large-scale change. Climate change is the most obvious example of this. Following are three examples from different Descriptors illustrating the effects of climate change:
    - Non-indigenous species (Descriptor 2): effect of climate change will be difficult to distinguish from human mediated introductions and this will have to be taken into account when using predictive modelling.

- Commercial fish stocks (Descriptor 3): a change in water temperature would affect the natural distribution and level of some of the commercial stocks thus requiring different biomass levels or targets.
- Energy/Noise (Descriptor 11): a rise in the level of ambient noise from waves at the sea surface would need to be considered in setting a level or target for ambient noise.

- Some hydrographic drivers of environmental status may change their state periodically due to natural processes (for example the state of the North Atlantic Oscillation or the intensity of upwelling off Iberia). These changes may cause large but natural changes in many biological features of the ecosystems, resulting in more than one natural stable state for a healthy marine ecosystem. In these cases, a number of different reference levels for GES for an indicator may be needed, with the appropriate one depending on the recent status of the hydrographic drivers.
- Several important pieces of European legislation have also prompted the development of indicators and setting of targets or reference levels. For example, the Habitats Directive is founded on the principle of protection, and the goal is to maintain endangered species and habitats. Consequently the targets or reference levels for GES under the MSFD may not be the same as those for "Favourable Conservation Status" under the Habitats Directive. This is not a contradiction; i.e GES should be met for all marine habitats whereas Favourable Conservation Status applies only to habitat types specifically listed under the Habitats Directive. Any features complying with 'Favourable Conservation Status' is likely to also fulfill requirements for GES. Conversely, achievement of Good Environmental Status may not suit all the conditions necessary to achieve Favourable Conservation Status.
- In many cases, research is needed to improve the understanding of suitable estimates of reference levels or targets required for the indicators. Nonetheless paucity of knowledge should not unduly delay assessment using existing knowledge. Often existing knowledge is adequate to establish reasonable values of levels or targets, or at least the range in which an appropriate level or target should lie relative to *status quo*. Management can thus start to identify an initial set of measures and management objectives, which can then be refined and improved iteratively as understanding is improved through research and monitoring.

4 ATTRIBUTES, CRITERIA, AND INDICATORS

The following tables provide a summary of the attributes, criteria, and indicators that have been identified for each of the Descriptors. In addition, some important considerations in implementing monitoring and assessment programs are also provided. The individual Task Group reports should be consulted for complete information. This information is captured in 4 columns defined as following:

- *Attribute*: The combined attributes are considered to comprehensively describe all the qualities and characteristics of the Descriptor relevant for the GES assessment.
- *Criteria* to assess attribute of the Descriptor: These are defined by the MSFD Article 1(6) as "distinctive technical features that are closely linked to qualitative Descriptors".
- *Indicators* that can be used to make the criteria more concrete and 'quantifiable'.
- *Considerations for application*: These are intended to provide further guidance on how the information in the first three columns should be applied in the assessment of GES for a particular Descriptor.

Table 4-1 Tabulation of Attributes, Criteria and Indicators for Descriptor 1 Biodiversity.

BIODIVERSITY Attribute	Criteria	Indicators	Considerations to application
Species state (includes sub-species and populations where they need to be assessed separately; apply criteria to each recognised sub-species/population)	Species distribution	• Distributional range • Distributional pattern	During the preparatory phases of the assessment and monitoring process, the region/subregion should be characterised in terms of its biodiversity and the human activities and their associated pressures. Accordingly, the biodiversity components and locations which are potentially at risk are identified. All four attributes and their criteria need to be considered. Those assessed as being at risk of not meeting targets for GES should be identified and an appropriate selection of indicators should be made to form the basis of a monitoring programme. This table outlines the main classes of indicator for the criteria. Within each indicator class, specific indicators appropriate to the assessment area, biodiversity component and pressures need to be selected. Standardised methodology should be used when applying the indicators.
	Population size	• Population biomass • Population abundance (number)	

	Population condition	• Population demography e.g.:
		  ○ body size or age class structure
		  ○ sex ratio
		  ○ fecundity rates
		  ○ survival/mortality rates
		• Population genetic structure
		• Population health (sub-lethal condition, e.g. disease prevalence; parasite loading; pollutant contamination.)
		• Inter and intra-specific relationships (e.g. competition, predator/prey relationships.)	

	Habitat distribution, extent and condition	• Habitat distributional range • Habitat distributional pattern • Habitat extent • Physical condition • Hydrological condition • Chemical condition	

BIODIVERSITY Attribute	Criteria	Indicators	Considerations to application
Habitat/community state	Habitat distribution	• Habitat distributional range • Habitat distributional pattern	Certain criteria (e.g. population, community condition and habitat condition) can be applied to assess the local state of a species, habitat/community or landscape type against target conditions, whilst other criteria (e.g. habitat distribution, habitat extent) are applied at the scale of the assessment area. Guidance on these issues of quality and quantity is given in TG1 report Section 4.8 (defining targets). Consistency with the Habitats and birds directive is recommended. See also considerations under Landscapes.
	Habitat extent	• Areal extent of habitat • Habitat volume	
	Habitat condition	• Physical condition (structure and associated physical characteristics, incl. structuring species) • Hydrological condition (incl. water movement, temperature, salinity, clarity) • Chemical condition (incl. oxygen, nutrient and organic levels)	
	Community condition	• Species composition • Relative population abundance • Community biomass • Functional traits	
Landscape state	Landscape distribution and extent	• Landscape distributional range • Areal extent of landscape	The areal extent and distributional range of marine landscapes may not change much. If so, this criterion may not need a formal monitoring programme. However, the condition of the habitats and species in the landscape may change. For species, especially those which are mobile (associated with multiple habitats), and of functional importance (e.g. pelagic-benthic coupling, structuring) should be considered. See also considerations under Habitats.
	Landscape structure	• Habitat composition and relative proportions	
	Landscape condition	• As for habitat condition and community condition, as appropriate	

BIODIVERSITY Attribute	Criteria	Indicators	Considerations to application
Ecosystem state	Ecosystem structure	• Composition and relative proportions of the ecosystem components	Assessments of species, habitat/community and landscape state should provide the basis for assessment of ecosystem structure, and ecosystem functions and processes. Aspects of ecosystem functioning and processes are provided by other Descriptors (e.g. D4: food-webs). Further research may be needed to develop suitable indicators/metrics.
	Ecosystem processes and functions	• Interactions between the structural components of the ecosystem • Services provided by biological diversity within ecosystems	

Table 4-2 Tabulation of Attributes, Criteria and Indicators for Descriptor 2 Non-indigenous species (NIS).

NON-INDIGENOUS SPECIES Attribute	Criteria	Indicators	Considerations to application
Number of NIS recorded in an area	Reduced risk of new NIS introductions	CBD, "Trends in invasive alien species", EEA - Streamlining European 2010 Biodiversity Indicators (SEBI) Ratio between NIS and native species	Areas with elevated numbers of NIS are at greater risk of exposure to future invasions. GES direction is to reduce the number of new NIS introductions. Basic information on NIS (inventories) is available for all coastal MS. Such inventories, which preferably include also cryptogenic species, should be constantly updated by MS. The ratio between NIS and native species should be established at least in well studied taxonomic groups, as a measure of change in species composition.
Abundance and distribution range of NIS	Prevention of establishment and spread of NIS	Abundance of NIS Distribution of NIS	The degradation gradient in relation to NIS is a function of their relative abundances and distribution ranges, which may vary from low abundances in one given 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). The same measurement units of abundance (numbers per area, biomass or percentage of coverage) should be used for the NIS and native species. This attribute is a prerequisite for assessment of the magnitude of the NIS impacts; therefore at least most impacting NIS should be assessed.
Environmental impacts of IAS*	Absence or minimal level of IAS impacts adversely effecting environmental quality.	Bio-pollution index (BPL) based on ranking of the abundance and distribution range of IAS and the magnitude of their impacts on: (i) communities (structural shifts) – possible link to TG1, (ii) habitats (alteration, fragmentation and/or loss) –possible link to TG6, (iii) ecosystem (shifts in trophic nets and alteration of energy flow and organic material cycling), see also TG4	Sufficient data on abundance and distribution of impacting IAS present in the area and, at least, basic knowledge on local native biodiversity and environmental impacts of IAS is required. Both, the effects of newly established IAS and changes in environmental impacts due to previously established IAS should be taken into account.

Table 4-3 Tabulation of Attributes, Criteria and Indicators for Descriptor 3 Commercially exploited fish and shellfish populations.

COMMERCIAL FISH Attribute	Criteria	Indicators	Considerations to application
Sustainability of the exploitation	Are exploited sustainably consistent with high long-term yield	Based on analytical stock assessments: Fishing mortality (F)	Fishing mortality (including the F at maximum sustainable yield level, F_{MSY} reference level) is the preferred indicator. The aim should be to have this information available for as many stocks as possible, covering a large enough proportion of the commercial catches or revenue.
		Based on monitoring programmes: Ratio catch/biomass	The ratio catch/biomass indicator can be considered a fall-back option to be used for those stocks for which F is not available and to increase representativity. This indicator (without a reference level) is, however, considerably less sensitive than F, and this may hamper the GES assessment. The sensitivity can be improved if a reference level for the indicator is known. Otherwise, only the lack of a degradation gradient can be applied to assess whether GES is achieved. Reference direction to achieve GES is a decrease of both indicators .
Reproductive capacity	Reproductive capacity should not be compromised	Based on analytical stock assessments: Spawning Stock Biomass (SSB)	SSB is the preferred indicator and two reference levels are available: SSB_{pa} and/or SSB_{MSY}). The SSB_{pa} reference level should be enough to ascertain that reproductive capacity is not being compromised and should apply to 100% of the stocks. SSB_{pa}, however, should not be considered a target but a limit and a certain proportion of the stocks should also achieve $SSB>SSB_{MSY}$. A higher proportion reflects better ecological status. Instead of trying to establish what this proportion should be it could also be left to emerge by applying $F< F_{MSY}$ consistently and on all stocks which eventually should result in the appropriate proportion of stocks for which $SSB>SSB_{MSY}$ applies.
		Based on monitoring programmes: Log(abundance)	Log-transformed abundance together with 95% percentile of the population length distribution (see next attribute) should be an appropriate proxy for SSB. Alternatively a threshold size equal to the size at maturity could be used to select mature fish only if it turns out to be a better indicator and thus improve the GES assessment. The sensitivity can be improved if a reference level for the indicator is known. Otherwise, only the lack of a degradation gradient can be applied to assess whether GES is achieved. Reference direction to achieve GES is an increase of both indicators

COMMERCIAL FISH Attribute	Criteria	Indicators	Considerations to application
Age and size distribution	Enough older/larger fish to ensure the stocks resilience	Based on monitoring programmes: 95% percentile of the population length distribution	The sensitivity can be improved if a reference level for the indicator is known. Otherwise, only the lack of a degradation gradient can be applied to assess whether GES is achieved. Reference direction to achieve GES is an increase of the indicator. Applying F_{MSY} consistently should drive the indicator to this reference direction but it will not necessarily result in what can be considered a "healthy age and size distribution".

Table 4-4 Tabulation of Attributes, Criteria and Indicators for Descriptor 4 Food webs.

FOOD WEBS Attribute	Criteria	Indicators	Considerations to application
Energy flows in food webs	Production or biomass ratios that secure the long term viability of all components	One ratio indicator for example; • Ratio pelagic/ demersal fish production • Ratio macrobenthos / demersal fish production • Ratio zooplankton production requirement of landing/ zooplankton production • Ratio benthos requirements of landings/ benthos production	One region-specific ratio should be selected depending on food web structure. Broad scale datasets for e.g. plankton, fish and fisheries would be suitable. The spatial extent of the ratio indicator should be broad rather than regionally restricted. There has been some discussion of reference levels in the literature, but no fixed reference levels or directions are available. These should be based on assessment of recent trends.
	Predator performance reflects long-term viability of components	E.g.: OSPAR EcoQOs for seal population size and pup production, and seabird breeding population size and breeding success in the North Sea.	The performance of key species should be monitored using their production per unit biomass (productivity), to summarise the main predator-prey processes in the part of the food web that they inhabit. Methods developed by OSPAR can be applied in other regional seas. Guidance on setting reference levels has been provided by OSPAR.
	Trophic relationships that secure the long-term viability of components	Trophic Levels (Functional feeding groups)	Diet composition of a species or group of species describes the relative abundance of prey in a food web. Stomach contents indicate trophic level at which species feeds, and can be diagnostic of food web changes. Data should be collected at routine intervals, from sampling or stranding monitoring programmes. Analytical methods, including the use of Marine Trophic Index, should be further developed. No fixed reference levels or directions are available but should be based on assessment of recent trends.
Structure of food webs (size and abundance)	Proportion of large fish maintained within an acceptable range	OSPAR has selected the large fish indicator (proportion by weight) to achieve its ecological quality objective (EcoQO) for the demersal fish assemblage in the North Sea	Monitoring the rate of change in abundance of functionally important species will highlight important changes in food web structure. This indicator can be made operational using data from fish monitoring surveys, on an annual basis, and at the scale of a

FOOD WEBS Attribute	Criteria	Indicators	Considerations to application
			regional sea. Guidance on setting reference levels has been provided by OSPAR.
	Abundance /distribution maintained within an acceptable range	Indicators of abundance & spatial distribution, based on one or more of: a) groups/species with fast turnover rates, useful as early warning indicators (e.g. phytoplankton, bacterioplankton, microzooplankton, mesozooplankton, jellyfish, short-living pelagic fish) b) groups/species that are targeted by fisheries, responding to fishing impact (e.g. pelagic and demersal fish), and plankton-feeding pelagic fish c) habitat-defining groups/species (e.g. benthic fauna) d) groups/species at the top of the food web and charismatic indicator species (e.g. tuna, sharks, marine mammals, seabirds and turtles) e) groups/species that are tightly linked (via food web linkage) to other trophic levels	Assessment of this attribute should occur at regular intervals and account for seasonal changes. Indicators should be region-specific, and developed at an appropriate scale, taking account of their importance to local and regional food webs. At least one of the categories a) to e) should be selected and an indicator developed, using an assessment of risk within regional seas. Indicators in this criterion will also be developed by TG1, TG2 and TG6, at least. No fixed reference levels or directions are available but should be based on assessment of recent trends.

Table 4-5 Tabulation of Attributes, Criteria and Indicators for Descriptor 5 Eutrophication.

EUTROPHICATION Attribute	Criteria	Indicators	Considerations to application*[1]
Nutrient	Increase in the water column	*Pressure/Causative factor* Nutrient load Nutrient concentration	From riverine and direct inputs adjusted to the inflow, industrial and urban water treatment plant loads. OSPAR RID Programme and HELCOM Pollution Load Compilations (PLCs) could be used for guidance. *Use as directed (one/all/combination) by one of the appropriate tools*[*2]
Nutrient stochiometry	Deviate from normal proportions (e.g. Si is reduced in relation to other nutrients)	*Causative factor* Nutrient ratios (Si:N:P)	
Water clarity	Decrease due to increase in suspended algae	*Primary symptoms/Direct effects* Water transparency	
Primary production	Increase due to increased nutrient availability	*Primary symptoms/Direct effects* Chlorophyll	Use chlorophyll and other algal components as a proxy or use remote sensing plus modelling as appropriate and as resources allow. 90th percentile concentration, spatial area of high concentrations. Temporally appropriate datasets, which may (i) favour seasonal datasets (e.g. the productive period and/or winter nutrients); or (ii) an annual cycle, which may be more adequate for marine areas with less well defined seasonality.
Phytoplankton Biomass	Increase (e.g. can form blankets over the natural flora and suffocate benthic animals)	*Primary symptoms/Direct effects* Opportunistic macroalgae	Blooms that cause detriment to living resources, duration of blooms, approximate spatial coverage of blooms *Use as directed (one/all/combination) by one of the appropriate tools*[*2]
Organic decomposition	Decrease due to increased organic decomposition	*Secondary symptoms/Indirect effects* Dissolved oxygen	Monthly, or more frequent as appropriate and as possible especially for dynamic areas 10th percentile concentration, spatial area of low concentrations
Algal Community Structure	Species shifts (e.g. diatom: flagellate ratio, benthic to pelagic shifts, indica-	*Secondary symptoms/Indirect effects* Floristic composition	Annual Bloom events, changes in balance of diatoms/flagellates/ cyanobacteria. HAB: annual to multi-year changes in frequency

EUTROPHICATION Attribute	Criteria	Indicators	Considerations to application*[1]
	tor species, HAB)		and/or duration of blooms
Benthic flora	Decrease (e.g. fucoids and wracks, eelgrass and Neptune grass, that are adversely impacted by decreases in water transparency	*Secondary symptoms/Indirect effects* seaweeds and seagrasses	Annual to multi-year changes from perennials, fucoids/kelp to opportunistic green/brown algae. Guidance on approaches (region-specific) exists, e.g. "total algal cover", "cumulative algal cover" and "number of perennial algal species" *Use as directed (one/all/combination) by one of the appropriate tools*[*2]

*[1] The tools 'characteristics recommended by TG5, or additional/subsequent ones that meet requirements, are (TG5 report): robust, integrated, sufficiently sensitive, comparable, and with recognized scientific merit.

*[2] The tools to be used <u>combine</u> causative factors, primary symptoms, and secondary symptoms (TG5 report). <u>All three groups</u> contribute to the assessment and lead to an overall status evaluation. Thresholds are defined for individual indicators within the specific methodological framework (tool) – indicators do not stand alone.

Table 4-6 Tabulation of Attributes, Criteria and Indicators for Descriptor 6 Seafloor integrity.

SEAFLOOR Attribute	Criteria	Indicators	Considerations to application
Substrate	Change in natural 3-dimensional structure Degree of alteration of original substrate composition/types Size of area exposed to pressures known to alter substrate Changes in ecological functions provided by substrate features	Spatial extent of benthic habitats % area with benthic invertebrates known to be associated with particular substrates Biomass/production above a given % of undisturbed areas % of area exposed to pressure X above level Y, where X and Y are location specific an take account of different backgrounds	ON SELECTION AND USE OF INDICATORS Spatial extent of habitats is valuable to inventory but costly to monitor change directly, and often insensitive to pressures impacting functions served by the habitats. Impacts of pressures on substrates are likely to be more sensitively assessed through Species Composition, Size Composition, and Life History Traits Attributes. Pressure indicators are likely to be more cost effective and sensitive than many direct indicators of substrate features. Where there are multiple human-induced pressures on substrate, cumulative effects should be evaluated. ON REFERENCE LEVELS Reference levels for extent of substrate types and abundance of species associated with specific substrates need to be evaluated relative to local historical baselines, which are often not quantified
Bio-engineers	Change in number and/or spatial extent of bio-engineers Change in availability of functions served by bioengineers Size of area exposed to pressures known to alter substrate or harm bio-engineers directly	Abundance of bio-engineer species Extent of habitats used by or provided by bio-engineers % of area exposed to pressure X above level Y, where X and Y are location specific an take account of different backgrounds	ON SELECTION AND USE OF INDICATORS Some types of bio-engineers are difficult to monitor directly. However, monitoring their functions through species-, size-, and life history indicators may be more cost-effective and sensitive to impacts on bio-engineers Assessments of bio-engineers must be local. Intervals between assessments depend on the type of bio-engineer Where there are multiple human-induced pressures on bio-engineers, cumulative effects should be evaluated. ON REFERENCE LEVELS Reference levels for abundance of bio-engineers and extent of habitats associated with them need to be evaluated relative to local historical baselines, which are often not quantified
Oxygen	Changing oxygen concentration of bottom water and/or upper	Extent of area with spatial and temporal hypoxia	ON SELECTION AND USE OF INDICATORS Instruments make direct measurements of oxygen and hydrogen

SEAFLOOR Attribute	Criteria	Indicators	Considerations to application
	sediment layer	Ratios of oxygen / hydrogen sulphide concentrations Presence of benthic communities associated with low oxygen conditions	sulphide feasible, but seasonal monitoring may be challenging. Thus, benthic community data may give time-integrated picture of past hypoxia. Assessments should be done in critical areas, and annually at critical times of year (often late summer and autumn) Guidance on Eutrophication (TG 5) is relevant here as well ON REFERENCE LEVELS Standards for setting reference levels are in TG 5
Contaminants	See TG 8 Accumulation of contaminants in sediment and biota	See TG 8	ON SELECTION AND USE OF INDICATORS Evaluations of Contaminants in marine ecosystem should always consider benthos Substrates might be reservoirs for contaminants and should be part of assessments of contaminants in marine systems. ON REFERENCE LEVELS See TG 8
Species composition of benthos	The number of species in the benthic community The relative abundances of species in the benthic community The presence of species know to be particularly sensitive or particularly tolerant to various pressures or to general disturbance regimes	Diversity and richness indices taking in account also species/area relationships Shape of cumulative abundance curves of numbers of individuals by species Position of samples in multivariate representations community composition Presence of diagnostic species	ON SELECTION AND USE OF INDICATORS Selection of diagnostic species requires good knowledge of communities in area being assessed, but can be effective when a specific pressure is a major concern. Many indices of richness and diversity, and methods of community ordination have been advocated for use. Expert guidance on choice is needed – see TG 1 – Biodiversity Assessment of this attribute should occur at regular intervals, and be standardized for seasonality ON REFERENCE LEVELS Reference levels for all species composition indicators need to be evaluated relative to local historical baselines, which are often not quantified. Knowledge from benthic habitats of similar depth, latitude, substrate type etc, can provide starting points for setting reference levels.

SEAFLOOR Attribute	Criteria	Indicators	Considerations to application
Size-composition of benthos	Changing proportion of the community comprised of small and large individuals	Proportion of number or biomass above some specified length Biomass size spectrum Shape of cumulative abundance curves of numbers of individuals by size group	ON SELECTION AND USE OF INDICATORS This Attribute often uses the same information as for species composition, but required less sample processing. Assessment of this attribute should occur at regular intervals, and be standardized for seasonality. ON REFERENCE LEVELS Reference levels for all size composition indicators need to be evaluated relative to local historical baselines, which are often not quantified. Knowledge from benthic habitats of similar depth, latitude, substrate type etc, can provide starting points for setting reference levels.
Trophodynamics	Rates of Nutrient supply, mobilisation, regeneration in the benthos and sediments Levels of secondary production in the benthos Changes in carrying capacity	See TG4	ON SELECTION AND USE OF INDICATORS TG 4 does not address indicators for secondary production and carrying capacity. However sensitive and cost effective direct indicators of these properties of tropho-dynamics are not available at this time. Indirect indicators of secondary production and carrying capacity are already covered under Species Composition; Size Composition, and Life History traits. ON REFERENCE LEVELS No guidance because there are presently no suitable indicators
Life-history traits	Changes in functional diversity Changes in relative abundance of traits associated with opportunistic and sensitive species	Opportunistic-sensitive species proportion (e.g. AMBI) Biological traits analysis Conceptually possible to apply for changing life history traits within a species / population over time.	ON SELECTION OF INDICATORS All Indicators for this Attribute use the same information as for species composition, but require more knowledge of life history traits of the species. Many proposed Indicators use discrete community stages, but continuous Indicators (e.g. ordinations) are also possible Assessment of this attribute should occur at regular intervals, and be standardized for seasonality ON REFERENCE LEVELS

SEAFLOOR Attribute	Criteria	Indicators	Considerations to application
			Reference levels for all life history trait indicators need to be evaluated relative to local historical baselines, which are often not quantified. Knowledge from benthic habitats of similar depth, latitude, substrate type etc, can provide starting points for setting reference levels

Table 4-7 Tabulation of Attributes, Criteria and Indicators for Descriptor 8 Contaminants and pollution effects.

CONTAMINANTS Attribute	Criteria	Indicators	Considerations to application
Presence of contaminants at concentrations which may adversely impact organisms, populations, communities and ecosystems.	Concentrations of contaminants in water, sediment and/or biota, as appropriate, are below threshold values identified on the basis of toxicological data. Concentrations of contaminants should not be increasing.	Contaminant concentrations and their trends in water, sediment and/or biota as appropriate. (Note that relevant contaminants should be identified at EU, regional or subregional level and existing regulatory provisions should be respected.)	Not all relevant contaminants are being monitored; validated and quality controlled methods and assessment criteria may not be available.
Presence of pollution effects at organism, population, community and ecosystem level.	Levels of pollution effects are below thresholds representing harm at organism, population, community and ecosystem level. The occurrence and severity of pollution effects should not be increasing.	Levels of pollution effects and their trends measured using appropriate methodologies. (Note that relevant biological effects should be identified at EU, regional or subregional level and existing regulatory provisions should be respected.)	A limited number of biological effects techniques are currently validated, quality controlled, and have assessment criteria, and so are available for use. Others are under development.

Table 4-8 Tabulation of Attributes, Criteria and Indicators for Descriptor 9 Contaminants in fish and other seafood.

CONTAMINANTS IN SEAFOOD Attribute	Criteria	Indicators	Considerations to application
Levels of contaminants (individual substances or groups of substances) in fish and other seafood for human consumption.	Compliance of levels of contaminants with regulatory provisions.	• actual levels detected • frequency that levels exceed regulatory levels (see report for detailed information) Number of contaminants for which exceeding levels have been detected in parallel.	Levels of contaminants (individual substances or groups of substances) in fish and other seafood for human consumption.

Table 4-9 Tabulation of Attributes, Criteria and Indicators for Descriptor 10 Litter.

LITTER Attribute	Criteria	Indicators	Considerations to application
Marine litter in the marine environment	Inputs, impacts on aesthetic values, the potential presence of toxic compounds and socio-economical damage Litter dynamics, accumulation areas	Amount, composition and source of litter washed ashore and/or deposited on coastlines	Provide organised and systematic collection of relevant data/information for setting up a pan-EU data base. An expert group needs to be established to undertake this. Introduce standardised and automated methods to monitor indicators and integrate methodologies which allow origin evaluation of marine litter. This will lead to common and comparable monitoring approaches, recommendations and guidelines to assess GES on a regional/European scale
		Amount, composition and source of litter floating at sea, in the water column and on the sea floor	Assess temporal trends, regional differences, Identify accumulation and representative areas to prioritise sites to be monitored. It will also include specific evaluations in special areas (discarded fishing gear in fishing areas, litter in convergence zones , important sources etc.). Use fish stocks assessment programmes (IBTS, MEDITS)
Impacts of litter on marine life	Time-trends and spatial variation in inputs and impacts on marine life	Amount and composition of litter ingested by marine animals	Evaluate the amounts and categories of litter ingested by representative species of wildlife, expressed in units of mass: The Fulmar EcoQO to assess temporal trends and regional differences for acceptable ecological quality in the North Sea area can be applied in other areas and similar species with adjusted targets. This will need flexibility to adapt protocols. Entanglement monitoring might be possible at hotspots (breeding colonies).
Degradation of litter at sea	Degradation of marine litter and potential sources of contaminants	Amount, composition and source of microparticles (<5mm)	Examine the presence of microparticles in various types of sediments/ depths/ locations/ water masses. This will provide a baseline for future temporal and geographical comparisons and evaluation of risks. The various sources of microparticles in the proximity of industrial locations should also be investigated, together with sampling of sewage outfalls.

Table 4-10 Tabulation of Attributes, Criteria and Indicators for Descriptor 11 Noise.

NOISE Attribute	Criteria	Indicators	Considerations to application
Underwater noise - Low and mid-frequency impulsive sound	High amplitude impulsive anthropogenic sound within a frequency band between 10Hz and 10 kHz, assessed using either sound energy over time (Sound Exposure Level SEL) or peak sound level of the sound source. Sound thresholds set following review of received levels likely to cause effects on dolphins; these levels unlikely to be appropriate for all marine biota. The indicator addresses time and spatial extent of these sounds.	The proportion of days within a calendar year, over areas of 15'N x 15'E/W in which anthropogenic sound sources exceed either of two levels, 183 dB re 1μPa^2.s (i.e. measured as Sound Exposure Level, SEL) or 224 dB re 1μPa$_{peak}$ (i.e. measured as peak sound pressure level) when extrapolated to one metre, measured over the frequency band 10 Hz to 10 kHz.	Direction to GES: A decrease in proportion of days (could set a % decrease target) starting in [Year] Measurement: Administrative recording of activities
Underwater noise – High frequency impulsive sounds	Sounds from sonar sources below 200 KHz that potentially have adverse effects, mostly on marine mammals, appears to be increasing. This indicator would enable trends to be followed.	The total number of vessels that are equipped with sonar systems generating sonar pulses below 200 kHz	Direction to GES: A decrease in total number of vessels (could set a % decrease target) starting in [Year] Measurement: Administrative registration
Underwater noise – low frequency continuous sound	Background noise without distinguishable sources can lead to masking of biological relevant signals, alter communication signals of marine mammals, and through chronic exposure, may permanently impair important biological functions. Anthropogenic input to this background noise has been increasing. This indicator requires a set of sound observatories and would enable trends in anthropogenic background noise to be followed.	The ambient noise level measured by a statistical representative sets of observation stations in Regional Seas where noise within the 1/3 octave bands 63 and 125 Hz (centre frequency) should not exceed the baseline values of year [2012] or 100 dB (re 1μPa rms; average noise level in these octave bands over a year).	Direction to GES: A decrease in ambient noise level [or maintaining ambient noise level against an increasing trend in ship traffic] Measurement: Needs development of [regional sea] specific networks of representative underwater noise observatories. Some are there already. Needs also technical standards (see TNO work).

5 LINKAGES BETWEEN DESCRIPTORS AND INTEGRATION ACROSS INDICATORS/ATTRIBUTES/DESCRIPTORS

5.1 Common data and indicators

There are a finite number of monitoring datasets that can be used in status assessments of marine regions, and it is likely that they will play a key role in the provision of indicators for GES descriptors. For example, surveys which record the relative abundance of marine species will be in particular demand to support state indicators for e.g. Biodiversity (TG1), Non-indigenous species (TG2), Commercial fish (TG3), Food webs (TG4) and Seafloor integrity (TG6) (see Table 2.1a). The dissolved oxygen concentration of marine waters and sediments will contribute to both Eutrophication (TG5) and Seafloor integrity (TG6). While each TG has used these data in ways that are specific to the needs of each descriptor, it is inevitable that the subsequent derived indicators will show varying degrees of overlap. The Commission and Member States are therefore encouraged to use the outputs of the TGs to identify indicators that support multiple criteria. This will ensure the greatest levels of synergy between descriptors and the most efficient use of resources.

5.2 Integration

The evaluation of GES will have to balance two undesirable but inescapable compromises: i) having an evaluation methodology that is scientifically sound and makes best use of available information; and ii) having an evaluation methodology that is consistent in all applications – consistent with regard to the types of information used and the methods applied in their use. Increasing consistency in methods at regional and large sub-regional scales may come at a cost of requiring use of suboptimal and sometimes inappropriate indicators, benchmarks, and analytical algorithms. Harmonizing methods to specific conditions within each regional sea (or sub-regional sea) may come at a cost of less consistency in practice within the larger scales.

For each regional sea (or sub-regional sea) for which GES must be assessed, the Task Group Reports provide sufficient guidance for experts to select an appropriate suite of classes of indicators, and for more local scales, specific indicators within the classes. Some of the Task Group Reports and Section 2 of this report also lay out frameworks for risk-based design of monitoring and sampling regimes that can be used to reflect both the spatial distribution of human pressures and the diversity of habitat types and disturbance regimes present in the regional sea. These provide part of the basis for a way forward.

There are three levels of integration required to move from evaluation of the individual indicators identified by the Task Groups to an assessment of GES;

- Indicators within individual Attributes of a Descriptor (for complex Descriptors)
- Status across all the Attributes within a Descriptor
- Status across all Descriptors

As one moves up these scales the diversity of features that have to be integrated increases rapidly. This poses several challenges arising from the diversity of metrics, scales, performance features (sensitivity, specificity, etc) and inherent nature (state indicators, pressure indicators, response indicators) of the measures that must be integrated.

5.2.1 Within Descriptor integration

Within Descriptor integration relates to the methods that might be required *within a Descriptor* to take account of multiple indicators, and a situation where not all indicators and/or attributes reach their desired levels or targets. For each Descriptor the task groups have outlined in their reports the best approach to be taken. Two approaches are recommended: (i) integrative assessments combining indicators and/or attributes appropriate to local conditions and; (ii) assessment by worst case. In this context "worst case" does not mean the full area of concern is assumed to be at the status of the worst part of the area. Rather, it means that the evaluation of GES will be set at the environmental status of the indicator and/or attribute assessed at the poorest state for the area of concern. Table 5-1 summarises the approaches to integrate attributes; information on integration of indicators can be found in the TG reports.

Table 5-1 Summary of Task Group approaches to integrate Attributes within a Descriptor.

Integration	Descriptor
Integrative assessments (Combining attributes appropriate to local conditions)	D 1 Biodiversity D 2 Non-indigenous species D 5 Eutrophication D 6 Sea floor
Assessment by worst case (Descriptor not OK if any attribute is not OK)	D 3 Commercial fish; 3 attributes D 4 Food webs; 2 attributes D 8 Contaminants; 3 attributes D 9 Contaminants in fish; 1 attribute D 10 Litter; 3 attributes D 11 Noise ; 3 attributes

5.2.2 Cross-Descriptor integration

The last level of integration relates to the methods that might be necessary to integrate the results *across all Descriptors*. Discussion of how to combine or integrate the results of each Descriptor into an overall judgement of GES for regions or sub-regions was not part of the Terms of Reference for the Task Groups. However, work within Task Group 6 (Sea floor integrity) identified a method for integration and assessment that might also be appropriate, if applied across all Descriptors, at a regional scale.

For policy and management questions addressed on *local scales* of a size where consistent sets of indicators, weightings and reference levels can be applied meaningfully, environmental status can be evaluated for the local area or specific pressure gradient. Those scales can only be chosen on a case-by-case basis, using expert knowledge *and* input from decision-makers and informed stakeholders. The evaluation should not focus on providing a single number for the local area, rather it should integrate the information in the suite of indicators into a clear, concise, but multi-factorial reflection of the status of the area. However, this evaluation may be achieved through a relatively fully specified algorithm using the set of indicators and reference levels. Such algorithms can only be developed and parameterized on the scale at which they will be used. No universal algorithms exist.

At *larger scales* of regional seas and sub-regional seas, and for some types of policy and management questions on smaller scales, it is neither feasible nor ecologically appropriate to specify prescriptive lists of indicators and analytical algorithms for evaluating GES. Too many compromises would have to be made in choosing indicators that are robust but could not make full use of available and relevant information and in assigning compromise weightings and reference levels that were likely to be suboptimal in each contributing area. More importantly, there could be a blending and likely obscuring of information of importance to understand where the successes and failures in progressing towards GES are occurring, and in informing decision-makers about where policies and management are working well and where adaptation or innovation in policy and management are needed.

5.3 A process rather than an analytical method

What is needed for combining the information available on the diverse attributes of e.g. seafloor integrity is not some fully specified and well-structured analytical method for assessing GES, but a fully specified and well-structured *process* for conducting assessments of GES. Elements of such a process are provided by the UNEP and IOC-UNESCO Assessment of Assessments Report. The key design features of reliable, consistent assessments include:

a. Specified objectives and scope of individual assessments;
b. An effective relationship between science and policy;
c. Modalities for stakeholder participation;
d. Nomination and selection of experts;
e. Data and information: sourcing, quality assurance and the availability and accessibility of underlying data and information;
f. Treatment of lack of consensus among experts;
g. Treatment of uncertainty;
h. Peer review;
i. Effective communication;
j. Capacity building and networking;
k. Post-assessment evaluation.

Designing a sound assessment process, incorporating those design features in the process and products produced, will provide the only realistic avenue for having regular evaluations of GES at regional and large sub-regional scales. The periodic (possibly, but not necessarily, annual) assessments would not have a single specified set of steps that would be the required approach. Rather the process could adapt practice from assessment to assessment with regard to indicators selected, weightings and benchmarks applied, and approaches to integrating local scale evaluations into regional conclusions based on the developing experience and knowledge.

6 FURTHER NEEDS FOR SCIENTIFIC ADVICE

The Management Group has considered the science needs to assist in the process of implementing the Marine Strategy Framework Directive over the short and medium term. Three main steps and processes are envisaged and described below.

6.1 Provision of science advice based on the Task Group reports to support Member States

Member States (MS) and the European Commission (COM) will be engaging in a process to decide which attributes, criteria (and in some cases, indicators) should be developed in order to define Good Environmental Status (GES). In doing this, it is likely that reference will be made to the Task Group reports. MS and the COM may have technical queries in relation to the reports, both individually and collectively. The Management Group recommends that it is maintained to respond to these queries and advise the process as necessary. This will help ensure also that MS decisions are based on a common understanding of the supporting information and of the implications of any decisions, and should reduce the risk of misinterpretations of the scientific information presented in the reports.

6.2 Provision of science advice on appropriate indicators to use in which circumstances

Once the COM and MS have concluded the Decision on criteria and methodological standards, which is informed by the outline above, there will be a need for science advice to support choice of specific indicators for use. For most criteria, there will be many alternative possible indicators from which to choose. Science advice is needed on the properties of alterative indicators from each class, including their relative cost and complexity to implement. The advice should review, for each available indicator in a suite of possible choices, the documented strengths and weaknesses of each potential indicator and summarize the conditions that affect its performance; under what conditions should each be preferred or avoided. This advice would aim to support MS in choosing indicators that are scientifically sound and robust in performance.

6.3 Provision of science and technical advice for methodological standards

The Task Group reports have provided either a clear list of indicators, or processes by which these indicators are prioritised. Once the process of selection of indicators nears completion there is a need for harmonisation of assessment and reporting between MS. It may not be appropriate to apply indicators in the same way within and between regions. However, the raw data obtained function as the fundamental building blocks for assessment. These data need to be compatible, reproducible and quality assured on a pan-European scale. This means that sampling and sample processing must follow internationally agreed procedures, independent of subsequent data analysis.

Within some Descriptors, international standard guidelines may exist for some, if not all, of the selected indicators (for example Contaminants). For other Descriptors, such as Biodiversity, Non- indigenous species, Food webs and Sea-floor integrity, there is likely to be a paucity of technical guidelines. Priority should be given to matching the emerging needs of the MSFD Descriptors with the availability of internationally approved technical guidelines/methodological standards. Where there is a lack of guidelines for specific indicators, measures should be taken to ensure these are developed, within the timeframe relevant to the MSFD assessment process.

The European Regional Seas Organizations, MS, and where relevant European Regional Fisheries Management Organisations should harmonise their technical guidelines/methodological standards where they have been adopted. In cases where technical guidelines/methodological standards have not been adopted, the professional bodies who conduct these certification/standardization tasks should be contracted to undertake the tasks at a European scale.

7 CONTACT DETAILS

Readers are urged to read the relevant Task Group reports to obtain a complete understanding of the rationale for and details of the recommendations in relation to the individual Descriptors.

Task Group 1: Biological diversity

Task Group 2: Non-indigenous species

Task Group 3: Commercially exploited fish and shellfish

Task Group 4: Marine food webs

Task Group 5: Eutrophication

Task Group 6: Sea floor integrity

Task Group 8: Contaminants and pollution effects

Task Group 9: Contaminants in fish and other seafood

Task Group 10: Marine litter

Task Group 11: Energy including underwater noise

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1 ANNEX 1. SUMMARY OVERVIEW OF DESCRIPTORS

The executive summaries from the reports of the individual Task Group reports are included here for the convenience of the readers. However readers are urged to read the individual reports to obtain a complete understanding of the rationale for and details of the recommendations.

TG1 BIOLOGICAL DIVERSITY

Descriptor 1: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. See TG1 report; Sections 2.3 and 3.1.

1.1 Definition of key terms

Biological Diversity, in accordance with the Convention on Biological Diversity (CBD, 1992), is defined as *"the variability among living organisms from all sources including, inter alia, [terrestrial,] marine [and other aquatic ecosystems] and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".*

Maintained equates to a) no further loss of the diversity within species, between species and of habitats/communities and ecosystems at ecologically relevant scales, b) any deteriorated attributes of biological diversity are restored to and maintained at or above target levels, where intrinsic conditions allow (cf. Art. 1.2a) and c) where the use of the marine environment is sustainable.

Habitats and species are key attributes of biological diversity; the term 'habitats' here is interpreted as including their associated communities of species (see Section 5.3.1). Aspects of quality, occurrence and distribution form the basis of the criteria upon which to assess GES.

Biological diversity shall be **in accordance with intrinsic environmental conditions** of the different geographic regions of Europe. The ongoing effects of climate change on biological diversity are considered, but not included in determining whether GES targets have been met. Human use of the environment shall not compromise maintenance of biological diversity (Art. 3.5).

The **Scope** of Descriptor 1, according to Annex III (Table 1) of the Directive encompasses angiosperms, macro-algae, invertebrates, phytoplankton, zooplankton, fish, mammals, reptiles and birds. Also considered are microbes, pelagic cephalopods and the range of marine habitat types that occur within the jurisdictional area of the Directive.

Descriptor 1 adheres to the geographic area defined by Art. 3(1) of the Directive, but areas beyond the jurisdictional limits of the Directive may have to be considered for migratory species. Vagrant species are excluded and non-indigenous species are treated under Descriptor 2, although they may be relevant to Descriptor 1 as a pressure. The elements of biological diversity treated under Descriptor 1 may be considered with those of the other descriptors when assessing overall **ecosystem function**.

A pragmatic approach is adopted throughout, to select key elements for assessment.

1.2 GES in relation to the descriptor "*Biological diversity*"

Good Environmental Status for Descriptor 1 will be achieved given no further loss of the diversity of genes, species and habitats at ecologically relevant scales and when deteriorated attributes, where intrinsic environmental conditions allow, are restored to target levels. See TG1 report Section 3.2.

1.3 The assessment of Biological diversity at different temporal and spatial scales

Spatial and temporal scales. GES is assessed at the scale of Region (for the Baltic Sea and Black Sea) or the Subregions defined for the Atlantic and Mediterranean Seas. See TG1 report Section 5.6.

A suitable set of ecological assessment areas should be defined, which can adequately reflect both the ecological scales exhibited by the biodiversity components in each region/subregion and links to areas which are effective for management measures. GES shall be assessed in 2012 and every six years thereafter. Further, TG1 recommends:

- Evidence used for the six-yearly GES assessments is updated before conducting these;
- Periodicity of evidence collection is determined according to changing conditions;
- Sufficient periodicity of evidence collection to distinguish anthropogenic impacts from natural/ climatic variability, and to determine progress against the Programme of Measures;
- Targets for GES take into account natural and climatic variability in biodiversity.

1.4 Key Attributes of the Descriptor

Attributes of biological diversity. The recommended levels of ecological organisation for assessment are as follows. See TG1 report Section 5.3.

- Species state (including intra-specific variation, where appropriate);
- Habitat/community state;
- Landscape state;
- Ecosystem state.

Biodiversity components. TG1 recommends appropriate treatment of the biodiversity components from Annex III of the Directive, in relation to appropriate criteria. See TG1 report Section 5.4.

- The predominant seabed and water column types;
- Special habitat types (under Community legislation or international conventions);
- Particularly important habitats (e.g. in pressured or protected areas);
- Biological communities associated with the predominant seabed and water column habitats;
- Fish, marine mammals, reptiles, birds;
- Other species (under Community legislation or international agreements);
- Non-indigenous, exotic species or (..) genetically distinct forms of native species are treated as pressures or within species state; see Scope;

A pragmatic, risk-based selection of components is recommended. This could use surrogates or proxies to assess the state of biodiversity of the region/subregion for:

- The predominant habitat/community types;
- The ecotypes of the groups of mobile species;
- The species and habitats listed under Community legislation and international agreements.

Predominant habitat types. The predominant habitats types, based on the EUNIS habitat classification system, should include the following broad ecological zones, where relevant to the region/subregion:

- Seabed habitats in intertidal, coastal, shelf and deep-sea zones;
- Water-column habitats in coastal, shelf and open sea zones;
- Sea-ice habitats.

Predominant habitat types are provisionally listed as:

Ecological zone/realm	Habitat
Seabed habitats	Littoral rock and biogenic reef Littoral sediment Shallow sublittoral rock and biogenic reef Shallow sublittoral sediment Shelf sublittoral rock and biogenic reef Shelf sublittoral sediment Bathyal rock and biogenic reef Bathyal sediment Abyssal rock and biogenic reef Abyssal sediment

Ecological zone/realm	Habitat
Pelagic habitats	Low salinity water (Baltic) Reduced salinity water (Baltic, Black Sea) Estuarine water Coastal water Shelf water Oceanic water
Ice habitats	Ice-associated habitats

Predominant ecotypes for mobile species. In addition to species closely associated with specific habitat types (see above), some species of fish, mammals, cephalopods, reptiles and birds are wide-ranging, and associated with several habitats during their life cycle. These are provisionally listed as:

Species group	Ecotype
Birds	Offshore surface feeders Offshore pelagic feeders Inshore surface feeders Inshore pelagic feeders Intertidal benthic feeders Subtidal benthic feeders Ice-associated seabirds
Reptiles	Turtles
Marine mammals	Toothed whales Baleen whales Seals Ice-associated mammals
Fish	Pelagic Demersal Elasmobranchs Deep sea Coastal/anadromous Ice-associated fish
Cephalopods	Coastal/shelf pelagic Deep-sea pelagic

Criteria for assessing the relevant attributes and components of biological diversity are summarised as follows. See TG1 report Section 5.5.

Attribute	Criteria
Species state (includes sub-species and populations where they need to be assessed separately apply criteria to each recognised sub-species/population)	• Species distribution • Population size • Population condition • Habitat distribution, extent and condition
Habitat/ community state	• Habitat distribution • Habitat extent • Habitat condition • Community condition
Landscape state	• Landscape distribution and extent • Landscape structure • Landscape condition
Ecosystem state	• Ecosystem structure • Ecosystem processes and functions

1.5 How are the indicators aggregated to assess GES for the descriptor?

Overall interpretation. Because the different elements of biological diversity may not respond to pressures in a similar manner, or at similar rates, the results of assessments for individual biodiversity components cannot be integrated into a single assessment for Descriptor 1. Each shall be assessed on its own merit relative to GES (GES or sub-GES conditions). Where sub-GES conditions are recorded for one or more indicators, the likely causes should be identified, and appropriate remedial actions identified and implemented within the Programme of Measures.

1.6 Monitoring and research needs

Synergies and cooperation. Art. 5.2 of the Directive requires regional cooperation. Further synergies with existing monitoring, other policies and research programmes are recommended.

Assessment and monitoring programme. A pragmatic risk-based and synergistic approach is recommended. See TG1 report section 5.7. The following main questions are addressed:

- What is the current state of biological diversity?
- What is the deviation between observed and target conditions?
- What is the direction of deviation from target conditions, and the speed of change?
- What are the causes of observed changes in biological diversity?

<u>Preparatory tasks:</u>

Task 1: Collate environmental data to support assessment;
Task 2: Identify biodiversity components present in region or subregion;
Task 3: Define ecologically-relevant assessment areas;
Task 4: Define reference state (conditions);
Task 5: Define targets.

<u>Monitoring phases:</u>

<u>Phase 1:</u> Prioritising where to monitor in relation to the location and types of human activities and their associated pressures on and risks to biological diversity. This should give a predicted or modelled extent of the pressures and thus their potential impact on biodiversity components;

<u>Phase 2:</u> Prioritising <u>which biodiversity components and criteria</u> to monitor, based on an assessment of risk to the targets;

<u>Phase 3:</u> <u>Selecting indicators</u> to inform the state of the selected biodiversity components in relation to the targets set;

<u>Phase 4:</u> <u>Collecting the evidence (monitoring)</u> needed to support the assessment of state and trends. Sampling and analysis of parameters for the selected indicators at prioritised locations in the region/subregion;

<u>Phase 5:</u> <u>Assessment</u> of the evidence to draw conclusions on a) proximity to GES, b) direction of change and, if possible, the rate of change and c) progress towards (or away from) GES. <u>Reporting</u> of assessments;

<u>Phase 6:</u> Developing a <u>Programme of Measures</u> to define appropriate remedial actions, where GES targets are not yet achieved, and to advise on environmental management strategies;

Issues requiring further research and development are grouped within the following categories. See TG1 report Section 6:

- Integrating research and monitoring

- Harmonisation of assessments and reporting
- Mapping, assessment and management tools for biological diversity

TG2 NON-INDIGENOUS SPECIES

Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.

1.1 Definition of key terms

Non-indigenous species (NIS; synonyms: alien, exotic, non-native, allochthonous) are 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. 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 climate change or dispersal by ocean currents) do not qualify a species as a NIS. However, secondary introductions of NIS from the area(s) of their first arrival could occur without human involvement due to spread by natural means.

Invasive alien species (IAS) are a subset of established NIS which 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 regions. Species of unknown origin which can not be ascribed as being native or alien are termed cryptogenic species. They also may demonstrate invasive characteristics and should be included in IAS assessments.

The key term "…levels that do not adversely alter the ecosystems" is described as the absence or minimal level of "biological pollution". The later is defined as the impact of IAS at a level that disturbs environmental quality by effects on: an individual (internal biological pollution by parasites or pathogens), a population (by genetic change, i.e. hybridization), a community (by structural shift), a habitat (by modification of physical-chemical conditions) or an ecosystem (by alteration of energy flow and organic material cycling). The biological and ecological effects of biopollution may also cause adverse economic consequences.

1.2 GES in relation to the descriptor "*Non-indigenous species*…"

IAS cause adverse effects on environmental quality resulting from changes in biological, chemical and physical properties of aquatic ecosystems. These changes include, but are not limited to: elimination or extinction of sensitive and/or rare populations; alteration of native communities; algal blooms; modification of substrate conditions and the shore zones; alteration of oxygen and nutrient content, pH and transparency of water; accumulation of synthetic pollutants, etc. The magnitude of impacts may vary from low to massive and they can be sporadic, short-term or permanent.

The degradation gradient in relation to NIS 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.

There is a fundamental difference between various forms of pollution. IAS do not respond in the same way as a chemical pollution or eutrophication which may be diminished provided that appropriate measures are taken. 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 IAS is more challenging. NIS 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 NIS and environmental conditions within an invaded ecosystem.

1.3 The assessment of IAS at different temporal and spatial scales

The assessment of IAS impacts generally should begin at the local scale, such as "hot-spots" and "stepping stone areas" for alien species introductions (marinas, port areas, aquaculture installations, offshore structures, etc) or in areas of special interest (marine reserves, NATURA 2000 sites, lagoons, etc). Depending on the taxonomic/functional group an IAS belongs to, 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 sub-regional (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 IAS. The temporal scales will also be influenced by the purpose of the assessment. Initial baseline assessments are the prerequisite for further evaluation of any adverse effects of IAS in an area under consideration.

1.4 Key Attributes of the Descriptor

<u>Number of NIS recorded in an area</u>

This basic indicator addresses anthropogenic pressures regarding NIS introductions. There is a general acceptance that those areas with elevated numbers of NIS are at greater risk of exposure to future invasions. Further, the ratio between NIS and native species should be calculated, at least in well studied taxonomic groups, as a measure of change in species composition.

<u>Abundance and distribution range of NIS</u>

This attribute is a prerequisite for assessment of the magnitude of the NIS impacts. The abundance and distribution range of a NIS should be assessed in relation to the organism group the NIS belongs to. The same measurement units of abundance (numbers per area, biomass or percentage of coverage) should be used for the NIS and native species. The abundance and distribution range may vary from "low numbers in one locality" to "high numbers in all localities".

<u>NIS impact on native communities</u>

NIS may cause changes in community structure due to displacement of native species, shifts in community dominant species, loss of type-specific communities and keystone species. The magnitude of the impact in an assessment area may vary from no changes (NIS are present but do not cause any measurable shifts in community) to extinction of native keystone species in the worst case.

<u>NIS impact on habitats</u>

NIS may cause alteration, fragmentation and/or loss of native habitats. The magnitude may be ranked from no noticeable alterations in benthic or pelagic habitats to massive impacts with irreversible changes.

<u>NIS impact on ecosystem functioning</u>

NIS 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 quantified through the energy channelled through the food web by an IAS. However, such studies are rare; therefore the changes in functional groups may be used as a proxy for this attribute. 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.

1.5 How are the indicators aggregated to assess GES for the descriptor?

Efforts should be made to record all NIS known in the assessment area; however attention should be paid primarily to assessments of IAS impacts. Methods for aggregating indicators for GES assessments need to take into account the known IAS effects in other world regions or in neighbouring areas. One of the approaches may be estimation of the magnitude of bioinvasion impacts or "Biopollution level" (BPL) index which takes into account the abundance and distribution range of NIS in relation to native biota in the invaded area and aggregates data on the magnitude of the impacts these species have on: native communities, habitats and ecosystem functioning (free access to BPL assessment system is provided at: www.corpi.ku.lt/~biopollution). BPL aggregates the results of the assessment into five categories: "No bioinvasion impact", "Weak", "Moderate", "Strong" and "Massive". First two categories may indicate acceptable levels of biopollution for GES. The assessment has to be done for defined assessment units (a particular water body or its part) and certain periods of time.

1.6 Monitoring and research needs

Standard marine biological survey methods are recommended for monitoring of NIS; which may have to be adapted to obtain the level of taxonomic identification required. Habitats exposed to a high risk of receiving IAS also should be taken into account, even if they usually are not being monitored on a regular basis. There are many monitoring and recording systems in place and efforts should be made to collate and co-ordinate this information so that it can be used effectively for the GES assessment.

Further resource and research needs are varied and include a requirement for focused taxonomic training (or access to taxonomic expertise), increased effort to monitor poorly studied ecosystems, risk assessment methodologies and the further development of IAS environmental impacts assessment methodology. There is a need to quantify uncertainty in relation to propagule pressure (number of individuals of NIS multiplied by the number of introduction attempts), vector analysis, traits of introduced species, impacts and how the presence of these species relates to the evaluation of GES in all assessments regarding IAS.

TG3 COMMERCIALLY EXPLOITED FISH AND SHELLFISH POPULATIONS

Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

Definition of terms in Descriptor, and scientific Understanding of the key concepts associated with the Descriptor

'Populations of all commercially exploited fish and shellfish,..': **Commercially exploited populations applies to all living marine resources targeted for economic profit. Fish and shellfish represent all marine vertebrate and invertebrate taxa including bone-fish, elasmobranchs, starfish, crayfish, bivalves, molluscs (including cuttlefish, squid) and extended to also include jellyfish**.

For the phrase *'..within safe biological limits..'* we adopted two attributes that are currently used to assess the stocks both in the ICES area as well as in the Mediterranean by GFCM; a stock should be (1) exploited sustainably consistent with high long-term yields and (2) have full reproductive capacity. However, for the assessment of these attributes we differentiate from the current practice in that we now still propose the application of a formal rule that combines the two attributes, i.e. $SSB>B_{pa}$ and $F<F_{pa}$ but now suggest F_{MSY} be used as the reference level for exploitation instead of the precautionary value (i.e. $F<F_{MSY}$). This new reference level should still be used as a limit reference point, not a target.

'..exhibiting a population age and size distribution that is indicative of a healthy stock.'

The general consensus is that the health of the stock increases as the age and size distribution consists of more, older fish. This attribute is represented by an indicator best representing the proportion of older and larger fish in the population and because there is no scientifically agreed reference level for this indicator the absence of a degradation gradient was considered the best possible criterion for this attribute.

1.1 What is "Good environmental status" on the descriptor?

Good environmental status (GES) is achieved for a particular stock only if criteria for all attributes are fulfilled. However since there is broad scientific evidence that this can not be achieved for all stocks simultaneously, a realistic threshold for the proportion of stocks with GES needs to be established above which the descriptor has achieved GES. This is a political rather than a scientific decision.

1.2 How should "scale" be addressed with the Descriptor

For this descriptor the relevance of spatial scale is only apparent in the selection of appropriate stocks for each (sub-)region. For a particular region only those stocks that mostly occur in that region will be selected. The temporal scale is determined by the timing of the analytical assessments or surveys on which the data are based.

1.3 Key Attributes of the Descriptor

For the commercial species three attributes were identified that determine GES:

1. **Exploited sustainably consistent with high long-term yield**
2. **Full reproductive capacity**
3. Healthy age and size distribution

Pertaining to the criteria of the attribute with respect to GES we distinguished two approaches for assessment that differ in terms of their robustness and data requirements. If possible the first approach should be preferred but this can be decided on a stock-by-stock basis depending on the quality of the information available:

- **High robustness and data requirements, b**ased on an analytical stock assessment such as conducted by e.g. ICES, GFCM, ICCAT or STECF. This allows a comparison of the indicator to a reference level..
  1. Are exploited sustainably ($F<F_{MSY}$);
  2. Have full reproductive capacity. The TG was unable to reach consensus on the adoption of appropriate reference levels for this attribute. There were two points of view:
     a. Some members felt that it is necessary and sufficient to use $SSB > SSB_{MSY}$ for x% of the stocks;
     b. Other members however felt that this was not sufficient since it provided no protection for the remaining (100-x)% of the stocks. There should be an additional requirement that SSB for all stocks should be greater than SSB_{PA} to avoid the risk of impairing recruitment for those stocks. Their recommendation is therefore: $SSB > SSB_{MSY}$ for x% of the stocks with an additional requirement that for all stocks $SSB > SSB_{pa}$
  3. Have a healthy age and size distribution (no degradation gradient of indicator)
- **Low robustness and data requirements**, based on monitoring programmes such as conducted within the Data Collection Regulation. Without information that allows the setting of reference levels only trends are available for an assessment of GES.
  1. Are exploited sustainably (no degradation gradient ratio catch/biomass)
  2. Have full reproductive capacity (no degradation gradient log-transformed abundance)
  3. Have a healthy age and size distribution (no degradation gradient of indicator)

This approach requires either a measure of abundance or biomass based on surveys or commercial catches (attributes 1 and 2) or a length-frequency distribution (attribute 3).

The following indicators were chosen to cover the attributes of this descriptor. In selecting the most appropriate indicators we preferred those that described the attribute best while requiring the least elaborate data thereby increasing the number of stocks for which such information is available.

1. Fishing mortality (F). Indicator of exploitation rate. Outcome of an analytical stock assessment

2. Spawning Stock Biomass (SSB). Indicator of reproductive capacity. Outcome of an analytical stock assessment
3. Ratio catch/biomass. Abundance and/or biomass can be obtained from any consistent CPUE series, preferably based on surveys as this increases the chance of consistency. Catch data (or landings data as a proxy) should also be based on a consistent CPUE series of a fishery that can be expected to deliver a representative time-series.
4. Log(abundance). For this abundance was chosen as a proxy because in combination with the indicator describing the age/size distribution it is considered to sufficiently cover the reproductive capacity attribute. The log-transformed population abundance is used because it is considered to provide a better signal to noise ratio.
5. 95% percentile of the population length distribution. The general consensus is that the health of the stock increases as the age and size distribution consists of more, older fish. The indicator that probably captures this best is the 95% percentile of the population length distribution which, according to literature, provides a good summary of the size distribution of fish with an emphasis on the large fish and is expected to be sensitive to fishing and other human impacts. The indicator can be based on any standard survey that provides a length-frequency distribution.

1.4 Aggregation of indicators within the Descriptor to achieve an overall assessment

For each (sub)region two assessments in relation to GES can be conducted:

1. based on the most robust methodology (comparison of indicators to reference levels and based on stock assessments) but which cover only a limited proportion of the stocks. This measure of GES is most reliable but compromised in terms of the representativity of this assessment (i.e. proportion of the stocks in a region for which this can be determined). A stock can only achieve GES if all three criteria for the attributes are fulfilled. However, when aggregating across stocks only the sustainable exploitation criterion and full reproductive capacity criterion need to be fulfilled by all stocks (i.e. $F<F_{MSY}$ and $SSB>SSB_{pa}$ for 100% of the stocks), Because $SSB>SSB_{MSY}$ cannot be achieved for all stocks simultaneously (e.g. if compared to the current situation where many stocks are at or below the precautionary level the SSB of a predator is increased to SSB_{MSY} it is unlikely that it will also be possible to increase the SSB of its main prey from precautionary to MSY level) and since just by chance one or more stocks can be showing a trend, the other two criteria should apply to a specific proportion of the stocks (i.e. $SSB>SSB_{MSY}$ for x% of the stocks and no degradation gradient for L0.95 for y% of the stocks).
2. based on the less robust methodology (indicator trends based on surveys and catch statistics) but which covers a much larger proportion of the stocks. Even though this assessment can be considered considerably less sensitive it performs better in terms of the representativity of this assessment. A stock can only achieve GES if all three criteria for the attributes are fulfilled. However, since for any of the attributes a proportion of the stocks may be showing a trend just by chance all three criteria should apply to a specific proportion of the stocks (i.e. z% of the stocks).

As there is currently no scientific information available that would allow the setting of the proportions x%, y%, z%, these should probably be based on a political rather than a scientific decision. Pertaining to the x%, however, it should be realized that instead of trying to establish what this proportion should be it could also be left to emerge by applying $F< F_{MSY}$ consistently and on all stocks as this should by definition result in the appropriate proportion of stocks for which $SSB>SSB_{MSY}$ applies.

TG4 FOOD WEBS

Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

The 2008 European Marine Strategy Framework Directive (2008/56/EC) includes a requirement for EU Member States to report on the environmental status of the seas under their jurisdiction and to work to achieve Good Environmental Status (GES). This is defined by eleven qualitative descriptors, and one of them deals with 'Food Webs'.

The Task Group 4 'Food Webs' descriptor reads: *All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.*

This report defines the terms used in this descriptor (section 2), describes the scientific understanding (section 3) and the relevant spatial and temporal scales (section 4). A framework to describe attributes of GES for food webs is provided in section 5.

1.1 Definition of terms, and scientific understanding of the key concepts associated with Food Webs

Food webs are networks of feeding interactions between consumers and their food. The species composition of food webs varies according to habitat and region, but the principles of energy transfer from sunlight and plants through successive trophic levels are the same. This descriptor addresses the functional aspects of marine food webs, especially the rates of energy transfer within the system and levels of productivity in key components.

'All elements.' All components of food webs have been considered, i.e. all trophic and functional groups, comprising either one or several species. This potentially includes all living organisms and non-living organic components.

'..to the extent that they are known..' While examination of food webs should in principle include 'all elements', for practical purposes it would include only those food web components that can effectively be sampled by established robust methods of monitoring.

'..normal abundance and diversity and at levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.' This provides guidance on the reference points and/or target values selected to correspond to good environmental status. Full reproductive capacity refers to the maintenance of fertility and avoidance of reduction in population genetic diversity.

1.2 Good Environmental status of Food Webs

The interactions between species in a food web are complex and constantly changing, making it difficult to identify one condition that represents 'good' status. However, changes in species relative abundance in an ecosystem will affect interactions in several parts of a food web, and may have an adverse effect on food web status. There is, however, a significant lack of understanding to assess the ecosystem consequences of such change, or the value that society should attribute to it. As all marine food webs have already been adversely affected by humans, a judgement will need to be reached by Member States to identify regional limit reference points.

Good Environmental Status of Food Webs will therefore be achieved when the indicators describing the various attributes of the descriptor reach the thresholds set for them. These should ensure that populations of selected food web components occur at levels that are within acceptable ranges that will secure their long-term viability. Components must be selected carefully to avoid use of large numbers of species for which abundance / biomass trends are required (i.e. avoid use of general terms such as 'predators' or 'prey'). Assessment of food webs will need to include;

(i) biological groups with fast turnover rates (e.g. phytoplankton, zooplankton, bacteria) that will respond quickly to system change;

(ii) groups that are targeted by fisheries;

(iii) habitat-defining groups; and

(iv) charismatic or sensitive groups often found at the top of the food web.

1.3 How should “scale” be addressed

Attributes of food webs can in principle be applied on any spatial scale or time scale, however, there are clear interpretational and practical limitations. The fundamental time scale over which ecosystem assessments might be required is annual. The temporal scale necessary to assess growth, mortality and feeding fluxes between food web components should be annual to integrate over seasonal variability at the lowest trophic levels. More frequent assessments, for example those that could be undertaken monthly, are operationally difficult to undertake and maintain, and their interpretation becomes complicated by seasonal dynamics. For the higher trophic levels, some smoothing of annual rates may be required to eliminate inter-annual variability. For longer lived species such as piscivorous fish, mammals and birds, assessments on an annual basis may be too frequent since variability at this scale becomes more influenced by unexplained processes such as recruitment variability, and less by internal population processes.

Similar issues apply to considerations of appropriate spatial scales: at small spatial scales, such as parts of a MSFD Sub-Region, immigration and emigration by advection and migrations become important components of change. For large, long-lived taxa, spatial scales which integrate over migration ranges may be appropriate, but these scales may span fundamentally different habitats and communities for lower trophic levels, for example plankton or benthos, to the point that a synthesis at this scale becomes questionable.

1.4 Key Attributes of the Descriptor;

The effects of fishing are the most important pressures which directly affect target species, and indirectly affect other non-target components of food webs. While these effects respond to management action, the components which they influence are also subject to climate variation and other natural drivers making precise attribution of cause and effect difficult. It is also likely that other pressures will need to be considered in the development of measures, and particularly the cumulative effects of multiple activities.

1.4.1 Attribute 1; Energy flows in food webs

Description of attribute and why it is important

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 the North Sea, where they are a key species in the food web, will remove food for birds, mammals, piscivorous fish, and release predation pressure on zooplankton. There may also be indirect consequences for a range of other species. Managing human activity to achieve a desired balance between species in the system is therefore a major challenge. Energy flows through the food web are an attribute which allows us to diagnose the state of the system.

Indicators of the attribute

We identify three criteria of energy flows in the food web which are feasible to measure and apply at a regional scale: a) ratios of production at different trophic levels, b) the productivity (production per unit biomass) of key species or groups, and c) trophic relationships. Many indicators within each criterion require further elaboration to become operational, and it is not yet possible to robustly define thresholds or limit reference points, or the full extent to which climate change may affect the metrics.

a) Production or biomass ratios that secure the long term viability of all components. Ratios of production or biomass between different trophic levels in the food web provide measures of the pattern of energy flow, and the efficiency of energy transfer through the web. It is proposed that a ratio indicator is developed, specific to each marine Regions or Sub-Regions, and based on either ratios of pelagic to demersal fish biomass and/or production, or benthos to fish production, or the proportions of plankton and benthos production required to support fisheries.

b) Predator performance reflects long-term viability of components. Some species, or groups of species, may act as guides to change in the ecosystem. The performance of these species, as measured by their productivity, effectively summarises the main predator-prey processes in the neighbourhood of the food web that they inhabit. The basis for such measures is already established in OSPAR EcoQO, for example in terms of the fledging success of kittiwakes, which relates to the availability of sandeels. Following the same principle, we propose indicators based on the nutritional status of marine mammals or seabirds.

c) Trophic relationships that secure the long-term viability of components.

The diet composition of a group of species is dependent on the consumption by each component species and can be a valuable measure of the relative abundance of prey in a food web and the degree of connectivity in the food web. The diet of some single species, particularly top predators, can provide similar insights. For group-level assessment, the Marine Trophic Index has been used to calculate the mean feeding level of a group from species composition data, assuming a particular diet for each species. At the species level, changes in stomach contents (which indicate the trophic level of diet) can also be diagnostic of underlying change in the food web.

1.4.2 Attribute 2; Structure of food webs (size and abundance)

Description of attribute and why it is important

Size structure of food webs is an important attribute and integral to the maintenance of predator prey relationships. Most life history traits are correlated with size, which constrains metabolic rate and controls growth, reproduction and survival, so body size is also a proxy for trophic level. Fishing is usually size-selective within species, so larger individuals generally suffer greater rates of mortality. Exploited populations and communities therefore contain relatively fewer large fish and 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. The abundance (and distribution) of carefully selected indicator populations (e.g. jellyfish, plankton, etc) can describe food web status and/or levels of human perturbation.

Criteria: characteristics of the attribute with respect to GES

Changes in the mean size of fish and the proportion of large species in the community can be detected by indicators of the mean size and size distribution. It is, however, difficult to determine reference values for size-based community indicators. Attempts to do so have been based on modelling the expected community structure in the absence of fishing, or by selecting a time in the past when the community structure was judged to have been acceptable.

Changes in absolute or relative abundance can be assessed in relation to reference directions and limit reference points, rather than specific targets. For many species, minimum viable populations can be inferred from ecosystem models.

Indicators of the attribute

Monitoring the rate of change of functionally important species to highlight rapid increased or decreased abundance will help to identify where future management action may be required. The following two criteria are proposed;

a) Proportion of large fish maintained within an acceptable range. This criterion describes the changes in the proportion of large fish, and hence the average weight and average maximum length of the fish community in a Region or Sub-Region. The OSPAR EcoQO (Proportion of large fish), provides a protocol that can be applied in other regional seas.

b) Abundance maintained within an acceptable range; To make this criterion operational requires an assessment of the most suitable species in a Region or Sub-Region to represent food web integrity, based on key biological groups present. Indicators should describe regional abundance trends to identify changes in population status that may have implications for food web status.

1.5 Method for aggregating indicators within the Descriptor to achieve an overall assessment, if available.

TG4 identifies two main attributes of food webs, 'Energy flows in food webs' and 'Structure of food webs (size and abundance)'. It is necessary that both attributes must be addressed for an assessment to be acceptable. Within each attribute TG4 suggests a number of promising criteria, but there may be others. To overcome the burden of proof within an attribute, it will be necessary to address the entire spatial extent of the assessment Region or Sub-Region. This can be achieved using a suite of localised indicators which together cover the domain, or a single spatially comprehensive indicator. More work is required to understand the practical implications of this requirement for Member States or Regional Seas Conventions.

1.6 Emergent messages about monitoring and research, and Final Synthesis

There are several operational indicators already in use that are relevant to this descriptor of GES, and that can contribute to the assessment of food web dynamics. It is encouraging to note that these are coherent with other international activities to ensure sustainable fisheries and maritime strategy in European waters, therefore allowing coordinated activity by Member States. While it is therefore possible to begin work now, some further development is required for indicators that cover all the criteria identified in TG4.

The practical process for achieving GES for this descriptor is not well defined. The completion of monitoring programmes and delivery of food web indicators for a Regional Sea in which several Member States have a stake will require substantial levels of coordination. This will have a major influence on successful implementation of the Directive

TG5 EUTROPHICATION

Descriptor 5: 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.

1.1 Definition of terms in Descriptor and understanding of the key concepts

TG5 arrived at the following definition as the basis for interpreting the MSFD descriptor:

Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services.

These changes may occur due to natural processes; management concern begins when they are attributed to anthropogenic sources. Additionally, although these shifts may not be harmful in themselves, the main worry concerns 'undesirable disturbance': the potential effects of increased production, and changes of the balance of organisms on ecosystem structure and function and on ecosystem goods and services.

1.2 What is "Good Environmental Status" of the descriptor?

GES with regard to eutrophication has been achieved when the biological community remains well-balanced and retains all necessary functions in the absence of undesirable disturbance associated with eutrophication (e.g. excessive algal blooms, low dissolved oxygen, declines in seagrasses, kills of benthic organisms and/or fish) and/or where there are no nutrient-related impacts on sustainable use of ecosystem goods and services.

1.3 How should "scale" be addressed with the Descriptor?

Due to the wide extent of eutrophic zones in some places, the sampling effort at sea necessary to assess algal biomass with reliability/\confidence will increase in some countries relatively to WFD needs. Systematic use of additional tools such as remote sensing of surface chlorophyll, ferry boxes, and smart buoys is recommended.

Further breakdown into sub-units is expected. These smallest divisions should be defined according to oceanographic characteristics aiming for spatially homogeneous areas.

Eutrophication indices must consider temporally appropriate datasets, which may:

(i) favour seasonal datasets (e.g. the productive period, and/or winter nutrients), or

(ii) an annual cycle, which may be more adequate for marine areas with a less well defined seasonality.

In order to detect acute effects, which often pose serious threats to the ecosystem, monitoring and modelling must be temporally adjusted to rapidly developing events, such as the sudden and sharp peaks of oxygen depletion in bottom waters or harmful algal blooms. Numerical models that integrate data assimilation may provide short-term predictive capacity for such events, which are by nature unpredictable on a longer time scale.

1.4 Key Attributes of the Descriptor

a. Description of attribute and why it is important

Attribute	Why it is important
Water clarity	Related to phytoplankton biomass and important for growth of benthic plants
Primary production	Associated with the loading of nutrients to marine waters
Organic decomposition	Registers fate of ungrazed production and potential for oxygen consumption. Potentially leads to oxygen depletion (hypoxia/anoxia)
Algal community structure	Reflects the ecological balance of primary producers. Undesirable shifts in balance can include the appearance of harmful algal blooms (HAB)

b. Criteria: characteristics of the attribute with respect to GES and degradation gradient(s)

- ❑ Compliant with GES target conditions (all)
- ❑ Decreased water clarity
- ❑ Increased primary production
- ❑ Increased organic decomposition
- ❑ Undesirable changes in algal community structure

c. What are the pressures that act upon the attribute

Nutrient loads, especially nitrogen and phosphorus. Physical processes (i.e. climate, upwelling, ocean circulation and currents, water column stratification) may act to modify the response to nutrients.

Nutrient sources and loads should be included so that loads can be associated with impairment and successful management measures can be developed.

d. What are the indicators or classes of indicators that cover the properties of the attribute and linkages to the pressures?

Indicator class	Indicator[1]	Linkage to pressure increase
Physico-chemical	Nutrient load	Increase
	Nutrient concentration	Increase
	Nutrient ratios (Si:N:P)	Deviate from normal proportions (e.g. Si is reduced in relation to other nutrients)
	Water transparency	Decrease due to increase in suspended algae
	Dissolved oxygen	Decrease due to increased organic decomposition
Biological	Chlorophyll	Increase due to increased nutrient availability
	Opportunistic macroalgae	Increase (e.g. can form blankets over the natural flora and suffocate benthic animals)
	Floristic composition	Species shifts (e.g. diatom: flagellate ratio, benthic to pelagic shifts, indicator species, HAB)
	Perennial seaweeds and seagrasses	Decrease (e.g. fucoids and wracks, eelgrass and Neptune grass, that are adversely impacted by decreases in water transparency

[1]*Not all indicators in this list may be relevant in particular systems/regions.*

1.5 How are the indicators aggregated to assess GES for the descriptor?

The question of aggregation was discussed at two levels: (i) the integration of different indicators into attributes for the descriptor; and (ii) A range of tools was reviewed. No specific method (i.e. tool) is recommended to be used for GES, but those used must be robust, integrated, sufficiently sensitive, comparable, and with recognized scientific merit.

1.6 Emergent messages about monitoring and research and final Synthesis

Monitoring

Monitoring is addressed under Art. 5 of the MSFD, in the context of the elaboration of the Initial Assessment. Its main objective is to characterize present state and trends as well as to identify the environmental impact of human activities as possible causes for observed environmental impairments. The design of Monitoring Programmes must take into account scientific questions and policy/management issues.

The General Guidelines to develop Monitoring Programmes include the definition of spatial domain and location of sampling stations, the frequency and timing for measurements, and the list of variables and sampling methodology. Consideration shall also be given to those pressures and impacts relevant for Human Induced Eutrophication. An inventory of national programmes, assessment of available methodological standards and definition of associated requirements must be carried out.

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.

Member States must determine to what extent data needs are covered by national monitoring programmes, and what aspects of the descriptor are not or are poorly covered. The framework for a monitoring program should also be guided by existing programs, such as the OSPAR Comprehensive Procedure. On this basis it will be possible to optimize existing monitoring information, and identify where improvements may be made through targeted and focused additional monitoring.

On an EU level, the importance of infrastructure improvements is highlighted, in order to provide long-term datasets and information to help avoid misdiagnosis of new events/changes, improve interpretation of trends, and facilitate development of management measures.

Quality Assurance guidelines for the descriptor are an essential requirement for successful monitoring, allowing for appropriate intercalibration and comparative assessment.

Research

Coupled atmosphere-river-coastal sea models need to be developed at the regional scale for the estimate of critical nutrient loads from terrestrial sources, in relation to transitional/ coastal retention, and chemical and biological target indicators (Cat. I); natural background nutrient enrichment (e.g. import by upwelling; import from pristine/ good status rivers) for determination of unimpacted state and separation of naturally productive status from anthropogenically eutrophic status; climate change impacts on availability and transformation of nutrients and organic matter from land to the sea.

Nutrient regulation for algal biomass production; selection of dominant species, functional groups, and community structure, nutrient competition and needs (nutrient stoichiometry);

Impact of top-down (e.g. shellfish filtration, zooplankton grazing) control, grazing-resistant species, and other food-web interactions (viral infections, parasitism…) on fate/ sinks of algal biomass and transmitted/ amplified effects; regulation of harmful algal blooms (HABs); the link to land-based inputs is not always well established: blooms may be linked to upwelling relaxation events, cyst formation etc; research is needed to categorize to what extent events are manageable; Setting the GES targets (with safety margins) for algal production/ biomass ensuring none or minor undesired secondary effects on zoobenthic or fish communities;

Research on factors that govern the occurrence and extension of hypoxic/ anoxic sediment surface: there is a need to distinguish between natural range and increase of spatial extension of anoxic sediments due to anthropogenic organic loading; ecoregion and/ or habitat-specific relationships between the indicators/ parameters and proxies for nutrient loading pressures; identification of critical nutrient loading thresholds beyond which the whole system is changing into an alternative steady state; recovery pathways and the outcome of the restoration.

Development of phytoplankton assessment tools that account for shifts in species composition and frequency of blooms in the scoring; Development of monitoring tools that account for rapid changes in algal communities, allowing detection of bloom peaks (continuous measurements, ships-of-opportunity, remote sensing tools, algorithm development, real-time monitoring, etc.

TG6 SEAFLOOR INTEGRITY

Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

1.1 Concepts

"Sea Floor" includes both the physical structure and biotic composition of the benthic community. "Integrity" includes the characteristic functioning of natural ecosystem processes and spatial connectedness. There are no points of significant disagreement among experts regarding key terms or what constitutes gradients of degradation in environmental status. However serious problems of sampling and measurement and high scientific uncertainty about aspects of benthic ecology and tolerances of benthic ecosystems to perturbations pose challenges to application of "good environmental status". Sound assessments of GES are possible, but they will have to integrate results from local scales where both natural benthic ecosystems and pressures may be very patchy, to much larger regional and subregional scales.

Many common uses of the sea necessarily impact the sea floor and benthic communities. "Good environmental status" of the seafloor requires that diversity and productivity are maintained and the uses do not cause serious adverse impacts to the natural ecosystem structure and functioning in both space and time. The pressures associated with those uses do not hinder the ecosystem components to retain their natural diversity, productivity and dynamic ecological processes. Perturbations due to the uses should be small enough that recovery is rapid and secure if a use ceases. Many benthic areas do not meet these standards and management must improve status.

Scale for assessing GES of the sea floor is particularly challenging for four reasons. First, benthic ecosystem features are patchy on many scales. Second, a wide range of human activities cause pressures on the sea floor, and they usually operate at patchy spatial scales. Third, although initial impacts of human activities are often local and patchy their direct and indirect ecological consequences may be transported widely by physical and biotic processes. Fourth, all monitoring of the seafloor is also patchy and often local. In all evaluations of impacts the scale of the impact relative to the availability of the ecosystem properties being impacted is an important consideration.

To deal with these challenges, the measurement of GES for seafloor integrity has three steps. First: identify the ecological structures and functions of particular importance. Second: identify the human pressures known or likely to reach levels that degrade environmental status. Third, for the ecosystem components and pressures identified as being of greatest importance, use a suite of appropriate Attributes and Indicators to assess status relative to pre-identified standards for GES, along gradients reflecting meaningful scales of the seafloor attributes and pressures. The standards for GES on various Indicators must reflect the different sensitivity and resilience of the Indicators and their functions in ecosystem processes. Risk-based approaches to monitoring and assessment are proposed to deal with the local-scale patchiness of seafloor Attributes, pressures, and impacts.

1.2 Attributes

Substrate: The physical properties of the seabed such as grain size, porosity, rugosity, solidity, topography and geometric organization (e.g. three-dimensional habitats). Substrate is a driver of patterns in diversity, function and integrity of benthic communities. Together with hydrodynamics, it is a main factor structuring benthic habitats. Four types of Substrate are considered separately, both because they contribute differently to ecosystem processes and they are affected differently by diverse pressures: soft sediments, gravels, hard substrates, and biogenic substrates. Indirect Indicators of functions are often more practical to use in assessing GES than Indicators of substrate itself.

Bioengineers: Organisms that change the structure of the seafloor environment in ways not done by geophysical processes alone, by reworking the substrate or by providing structures that are used by other species. Bioengineers may serve functions such as providing shelter from predation or substrate for other organisms, reworking of sediments, transporting interstitial porewater, and facilitating material exchange at the sediment-water interface. Bioengineers are sensitive to many pressures, but often prove difficult to monitor directly. Indirect indicators of the functions they serve or indicators from mapping the pressures on bioengineers are often practical alternatives for assessing GES.

Oxygen: Concentration of dissolved oxygen in the bottom water and/or in the upper sediment layer of the seafloor. Decreasing oxygen supply of bottom water and/or the upper sediment results in significant changes of the benthic communities and can lead to mass mortality. Oxygen depletion is particularly associated with excessive nutrient and organic enrichment of the seafloor. Important indicators for Oxygen concentration include abundance of organisms sensitive or tolerant to oxygen level and the spatial distribution of oxygen/hydrogen sulphide concentrations conducted in critical regions and in critical seasons.

Contaminants and Hazardous Substances: Guidance on including these substances in assessments of GES is presented in the report of TG-8. Particular attention should be given to applying that guidance for seafloor communities and habitats. 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.

Species Composition: The list of species present in an area, their abundances, and/or their evolutionary and ecological relationships, including their pattern of occurrence in space and time. Species composition captures information on the biological diversity, structure, and dynamics of communities. It represents a fundamentally valued feature of ecosystem's potential to function well, to resist potential threats, and be resilient. Of the large number of indicators of species composition, those focusing on diversity among samples (space or time) and measures of species/area relationships may be most useful. These must be applied on local scales to account for natural scales of community structure and pressures on them.

Size Composition: Abundance or biomass of individuals of different sizes in the community, with "Size" either continuous or as categories. The size composition of a community integrates information of about productivity, mortality rate, and life histories of the full community. Indicators include the proportion of numbers (or biomass) above some specified length, parameters (slope and intercept) of the "size spectrum" of the aggregate size composition data, and shape of a cumulative abundance curve of numbers of individuals by size group.

Trophodynamics: A complex attribute with many subcomponents. Key ones include Primary and Secondary Production, Carrying Capacity, Energy Flows, and Food Web Relationships. TG 4, on Food webs, deals thoroughly with primary production, energy, flow and food webs. When evaluating Seafloor Integrity it is important to follow the expert guidance from TG 4 in the specific context of the benthic community, its food web relations, and benthic-pelagic relationships. Secondary Production and Carrying Capacity are also important to Seafloor Integrity but at this time there are no practical indicators for their assessment.

Life History Traits: Life History Traits are the categorisation of characteristics of the life cycle that species can exhibit, i.e. growth rates, age or size or maturation, fecundity and the seasonality of life history features such as reproduction. Various combinations of these traits lead to species differing in their natural productivity, natural mortality, colonization rates, etc. They are important to GES as they reflect the status of ecosystem functioning. Their changes are direct measures of the condition of the biota, may uncover problems not apparent with other Attributes, or provide measurements of the progress of restoration efforts. Many synthetic indices based on representation of species with different sensitivities and tolerances for general or species pressures have been used.

1.3 Combining Indicators

Because of the patchiness of seafloor attributes, pressures and impacts on many scales, the optimal suites of Indicators and their reference levels will differ on all but local scales. This means that monitoring must be adapted to local conditions, and expanded for the seafloor – both in terms of area covered and types of attributes measured. It also means that no single algorithm for combining Indicator values will be appropriate for evaluating GES or providing a meaningful "index" of GES for Seafloor Integrity. It may be possible to conduct such analytical syntheses of Indicators for individual Attributes on local scales. However across Attributes and on even moderate scales expert assessments rather than algorithmic formulae will be needed for evaluation of GES of Seafloor Integrity.

TG8 CONTAMINANTS AND POLLUTION EFFECTS

Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects.

We recommend that the assessment of achievement of Good Environmental Status (GES) under the Marine Strategy Framework Directive 2008/56/EC (MSFD) Descriptor 8 "Concentrations of contaminants are at levels not giving rise to pollution effects" should be based upon monitoring programmes covering the concentrations of chemical contaminants and also biological measurements relating to the effects of pollutants on marine organisms in each of the assessment regions. The combination of conventional and newer, effect based, methodologies, with the assessment of environmental concentrations of contaminants provides a powerful 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.

Therefore, for the purpose of implementing Descriptor 8 under the MSFD, three core elements of data assessment are recommended:

- Concentrations of contaminants in water, sediment and biota are below assessment thresholds identified on the basis of toxicological data;
- Levels of pollution effects are below assessment thresholds representing harm at organism, population, community and ecosystem levels;
- Concentrations of contaminants in water, sediment and biota, and the occurrence and severity of pollution effects, should not be increasing.

Monitoring programmes should include the assessment of concentrations of contaminants in 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. The selection of contaminants, monitoring species and biological effects measurements should be made for each assessment region by the Member States (MS) with responsibility for implementation of MSFD in each region. Therefore, the priority monitoring matrices, and chemical and biological measurements made may vary between assessment regions in response to regional concerns and environmental conditions. However, monitoring and assessment should be harmonised to the greatest possible degree between assessment regions eventually allowing comparison between regions.

Monitoring data should be interpreted against the objective described by Descriptor 8 through a series of assessment thresholds, expressed as concentrations of chemical contaminants, or levels of biological response. In particular, monitoring data should be interpreted against assessment thresholds that are designed to protect against the occurrence of pollution effects. Examples of suitable assessment thresholds include Environmental Quality Standards (EQSs) derived under the Water Framework Directive 2000/60/EC (WFD), Environmental Assessment Criteria (EACs) as defined within OSPAR for water, sediment and biota, and parallel assessment thresholds used by other Regional Conventions or MS for the interpretation of monitoring data. Biological effects should be assessed against threshold levels of response that are indicative of significant harm to the organisms concerned. The aim is to prevent pollution effects occurring at the organism, population, community and ecosystem level.

In addition, monitoring data should be assessed against background concentrations of contaminants or levels of biological response to enable added-risk approaches to be used in the derivation of assessment thresholds, to enable greater use to be made of monitoring data in interpreting the causative agents of pollution effects, and to give early warnings of potential developing problems.

Increasing contaminant concentrations increase the likelihood of pollution effects. In order to minimize the risk of deleterious effects, concentrations of contaminants in water, sediment and biota, and the occurrence and severity of pollution effects, should not be increasing. Regional Conventions have developed robust statistical approaches to the analysis of time series of monitoring data to detect significant trends over time. These should be applied to chemical and biological effects monitoring data.

The integration of the results of chemical monitoring programmes, and combination of data from chemical and biological effects monitoring, is an active area of science within the Regional Conventions (i.e. OSPAR, HELCOM, and MEDPOL). Current experience indicates that integration is greatly facilitated by coherent and consistent sets of assessment thresholds (EQSs, EACs, etc). Further development work is necessary, through the EU, Regional Conventions or MS, to expand the range of assessment thresholds to include a greater number of contaminants and biological effects. Integrated monitoring programmes, data collation, interpretation and presentation schemes are being developed and applied by the Regional Conventions, and we recommend that this work continues and that MS apply the best international advice applicable to MSFD regions for which they have responsibility.

A core of both chemical analytical methods and biological effects methods exists which can be applied now. There are considerable benefits to be gained from the international experience in programme design, measurement methodology and data management and interpretation available from the Regional Convention programmes, and the EU (e.g. WFD). Detailed implementation of programmes for MSFD Descriptor 8 should build upon these, and upon existing data, to ensure that assessments against GES are as robust as possible. However, marine monitoring science continues to develop, and the implementation strategy for MSFD should allow for programmes and procedures to evolve with time so as to maintain and improve the level of protection for marine ecosystems.

TG 9 CONTAMINANTS IN FISH AND OTHER SEAFOOD

(9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.

Descriptor 9 considers the presence of hazardous 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 wild caught fish, crustaceans, molluscs, echinoderms, roe and seaweed harvested in the different (sub) regions destined for human consumption against regulatory levels set for human consumption. Substances for which regulatory levels are in the process of being set are also discussed.

The presence of contaminants in fish and other seafood for human consumption at levels above the regulatory levels established in community legislation for protection of public health will have a negative influence both on the health of the consumer and on the sustainable use of marine resources.

Contaminants in fish and other seafood for human consumption might arise from numerous anthropogenic sources such as land-based industrial activity, discharge, municipalities, pesticide use, nuclear accidents & discharge, aquaculture, heavy shipping lines, petrogenic sources, but natural oceanographic and geological factors including geothermal activity) might also be responsible for elevated levels of contaminants in fish and seafood.

A number of contaminants in marine environment giving rise to concern both from an environmental and public health of view have been selected. Regulatory levels have been laid down for lead, cadmium, mercury, polycyclic aromatic hydrocarbons, dioxins & dioxin-like PCBs and radionuclides. Other substances of concern are arsenic, non-dioxin like PCBs, phthalates, organochlorine pesticides, organotin compounds, brominated flame retardants and polyfluorinated compounds.

The indicators covering the properties of the attribute are basically laid down in the descriptor: "contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards".

Assessment of the indicators should at least take account of the actual levels that have been detected, the frequency that levels exceed the regulatory levels, the number of contaminants for which exceeding levels have been detected in parallel and the origin of the contamination. An intake assessment taking into account the importance in the human diet of the species showing exceeding levels could also be taken into account.

Strictly spoken, Good Environmental Status (GES) would be achieved if all contaminants are at levels below the levels established for human consumption or showing a downward trend (for the substances for which monitoring is ongoing but for which levels have not yet been set). However, it is generally felt that GES for descriptor 9 must be judged in view out the monitoring of descriptor 8, also dealing with contaminants in marine environment.

The report points out the lack of a well-defined established simple quantitative link between levels of contaminants in marine environment and levels in fish and other seafood, clearly demonstrating a general research need on transfer of contaminants from the marine environment to the fish/fishery species. In general, it would be interesting to identify possible relations between contaminant levels in sediment, and tissues of fish and other seafood.

TG 10 LITTER

Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

1.1 Definition of terms descriptors and scientific understanding of key concepts associated with the descriptor.

Marine litter is any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment.

Marine litter 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, paper etc. This definition does not include semi-solid remains of for example mineral and vegetable oils, paraffin and chemicals that sometimes litter sea and shores.

1.2 What is good environmental status

"Harm" can be divided into three general categories: 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 ecological (mortality or sublethal effects on plants and animals through entanglements, captures and entanglement from ghost nets, physical damage and ingestion including uptake of microparticles (mainly microplastics) and the release of associated chemicals, facilitating the invasion of alien species, altering benthic community structure).

Definitions of the acceptable levels of harm in these categories and good environmental status must consider impacts as assessed by the amount of litter in different compartments of the marine environment (seabed, sea surface, water column, coastline), ecological effects of the litter (e.g. plastics ingested by marine organisms; entanglement rates) and problems associated with degradation of litter (microparticles) as well as social and economic aspects. Tourism is strongly negatively affected by the presence of litter. An overriding objective will be a measurable and significant decrease (e.g. 10%/year for litter on coastlines) in the total amount of litter in the environment by 2020.

1.3 How should scale be addressed with the descriptor

Litter enters the marine environment from numerous sources and is dispersed throughout the seas by winds and currents. Evaluations of sources alone will not be sufficient to measure harm and long term monitoring in the marine environment will be required. Working at the European scale will be possible for litter evaluation on beaches, at sea and measuring degradation processes using standard protocols. Evaluating the impact of litter on marine organisms will be done at regional or basin scale, enabling transposition of protocols to local species. Highly affected areas will be monitored locally. Temporal scales should take into account seasonal variations.

1.4 Key attributes of the descriptor

Description of it and subcomponents, why the attribute is important

The group recommends the overriding objective to be a measurable and significant decrease in comparison with the initial baseline in the total amount of marine litter by 2020 using the following criteria and methodologies for the evaluation of the state of good environmental status.

- Amount, source and composition of litter washed ashore and/or deposited on coastlines. The attribute will indirectly measure inputs, impacts on aesthetic values, the presence of toxic compounds and socio-economical damage.
- Amount and composition of litter in the water column - including floating and suspended litter - and accumulation on the sea floor. The attribute will measure litter dynamics and potential interactions with marine life. Accumulation areas will be located.
- Amount and composition of litter ingested by marine animals. The attribute measures time-trends and spatial variation in inputs of litter and its impact on marine life.
- Amount, distribution and composition of microparticles (mainly microplastics). The attribute will measure quantities, types, degradation processes and potential sources of contaminants.

Monitoring results combined with research on social, economic and ecological harm will lead to improved knowledge of critical thresholds.

1.5 Criteria; which subcomponent of the attribute reflect a gradient of degradation and why?

Quantities, composition and distribution of litter, including the distribution and concentrations of degradation products of litter (microparticles in sediments and the water column) as well as impact rates on organisms and the potential chemical pollution resulting from plastics are good trend indicators of degradation through marine litter and monitor direct harm in the marine environment.

Monitoring the quantities and distribution of litter in the different compartments of the marine environment will give a basis for actual and potential assessment of socio-economic and ecological impacts of litter. Impacts on organisms, distribution and concentrations of microparticles and chemical burdens monitor direct harm to the marine ecosystem.

1.6 Where appropriate, which human activities and pressures are closely linked to/reflect by the attribute or specific subcomponents

a) Presence of point and diffuse sources of litter such as municipal landfills, untreated sewage discharges, coastal industries, tourism and specific activities such as shipping, load of litter from ships, fishing, aquaculture and various offshore activities.

b) The origin, drift and fate of litter as a consequence of rainfalls, rivers, currents, winds and geomorphological factors are important issues when evaluating effects as those will influence the distribution and abundance of litter.

1.7 What are the important classes of indicators related to the attribute to cover properties and linkages to pressures, including examples and methodological standards

Evaluation of quantities and composition of litter (amount on the coastline, the sea floor, in the water column and on the waters surface), the amount ingested by animals and entanglement rates are the best links to pressures.

Methodological standards in Europe are currently available for the assessment of:

- Litter on coastlines: In the OSPAR, HELCOM and Black sea regions, standards for the Beach Litter Survey have been developed which could, if necessary, be adjusted, harmonized and applied to other regions.
- Litter at sea: Pilot projects indicated that litter on the sea floor could be measured along side international biological trawling surveys (e.g. IBTS) or dedicated dive or photographic transects. Impact of "ghost" nets will be considered in fishing areas. Litter in the water column can be measured by using (plankton) nets or filtered water samples. Floating litter can be assessed at large scale by aerial surveys.
- Litter in seabird stomachs: In the OSPAR system of Ecological Quality Objectives for the North Sea, amounts of plastics in Fulmar stomachs are already used as the EcoQO to assess temporal trends, regional differences and compliance with a set target for acceptable ecological quality in the North Sea area. Such monitoring can be applied in other areas by either fulmars or similar species with adjusted targets, and may also include entanglement rates of representative species.
- Particle abundance, especially microplastics can be assessed in the water column by concentrating the particles from water or by washing low-density particles from sediment samples.

1.8 Methods for aggregating the indicators (indices) within the descriptor to achieve an overall assessment

OSPAR QSR 2010 and HELCOM based regional approaches which link pressures and activities to the quality of ecosystem components will be considered for implementation and extension to other areas.

1.9 Emergent messages about monitoring and research, final synthesis

An initial evaluation is needed by all member states on the current state of research in their region/subregion to give a scientific and technical basis for monitoring, define knowledge gaps and priority areas for research. Harmonisation will require coordination by relevant representatives from each member state; this will lead to common and comparable monitoring approaches, recommendations and guidelines to assess GES on a regional/European scale. Research will need to include the improvement of knowledge concerning impacts on marine life, degradation processes at sea, the study of litter-related microparticles, the study of chemicals associated with litter, 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. The assessment and monitoring of socio-economic harm will also need to be addressed.

TG 11 ENERGY AND NOISE

Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

In relation to the underwater energy, Good Environmental Status certainly occurs when there is no adverse effect of energy inputs on any component of the marine environment. However, such an objective is probably not achievable if, for instance, behavioural disturbance or mortality of plankton (including planktonic larvae) is considered an adverse effect. Such an objective is probably not also measurable for a very large proportion of organisms in the marine environment. The Task Group aimed to provide an indicator or indicators of environmental status, not to define Good Environmental Status.

Energy input can occur at many scales of both space and time. Anthropogenic sounds may be of short duration (e.g. impulsive) or be long lasting (e.g. continuous); impulsive sounds may however be repeated at intervals (duty cycle) and such repetition may become "smeared" with distance and echoing and become indistinguishable from continuous noise. Higher frequency sounds transmit less well in the marine environment (fine spatial scale) whereas lower frequency sounds can travel far (broad spatial scale). There is however great variability in transmission of sound in the marine environment.

Organisms that are exposed to sounds can be adversely affected over a short time-scale (acute effect) or a long time-scale (permanent or chronic effects). Adverse effects can be subtle (e.g. temporary harm to hearing, behavioural effects) or obvious (e.g. worst case, death). These considerations have been described above in relation to sound, but can equally apply to other types of energy. With sufficient resources and research, it might be possible to develop indicators for these many facets of harm from energy input; however the initial indicators described below focus on sounds that affect relatively broad areas rather sounds that affect local parts of the marine environment.

The Task Group developed three possible indicators of underwater sound. In no case was the Task Group able to define precisely (or even loosely) when Good Environmental Status occurs on the axes of these indicators. This inability is partly to do with insufficient evidence, but also to no fully accepted definition of when, for example, a behavioural change in an organism is not good. The indicators all provide axes that would enable authorities to define targets that should be relatively easy to measure.

1.1 Indicator 1. Low and mid-frequency impulsive sounds

High amplitude, low and mid-frequency impulsive anthropogenic sounds are those that have caused the most public concern, particularly in relation to perceived effects on marine mammals and fish. These sounds include those from pile driving, seismic surveys and some sonar systems. Laboratory studies have found both physiological and behavioural effects in a variety of marine organisms, while field studies have shown behavioural disturbance and in some cases death (physiological effects are difficult to study in the field). There will be a variety of degradation gradients caused by such noise, the scale of these depending on the marine organism under consideration and the loudness, frequency and persistence of the sound. In principle, sound input is likely to have greater adverse effects at higher sound amplitudes (loudness) and with a greater number of inputs (persistence). Lower frequency sounds will affect a wider area, but this is complicated by the ability of organisms to detect a limited range of sound frequencies; sounds outside their range of detection will be less likely to have an adverse effect. The following initial indicator is proposed as a way of geographically quantifying the occurrence of loud impulsive anthropogenic noise.

1.1.1 Underwater noise indicator 1

The proportion of days within a calendar year, over areas of 15′N x 15′E/W in which anthropogenic sound sources exceed either of two levels, 183 dB re 1μPa^2.s (i.e. measured as Sound Exposure Level, SEL) or 224 dB re 1μPa$_{peak}$ (i.e. measured as peak sound pressure level) when extrapolated to one metre, measured over the frequency band 10 Hz to 10 kHz.

This indicator would be based on reports of occurrence by those undertaking activities likely to generate these sounds, rather than on direct independent measurement. Recording would be on the basis of Regional Seas [or national parts of Regional Seas]. We would expect that sounds made by most commercial seismic surveys, by pile-driving, by low and mid-frequency sonar and by explosions to be included. We would expect most sources to be included therefore be quantifiable from either relevant impact assessments or reports from activities required under national licensing regimes. The proportion of days would be set by Member States and could be based on a review of relevant activities in the immediate past and on their view on sustainable impact.

The size of grid rectangle was chosen as a compromise. An index sensitive to small changes in activity would have small rectangles, while large rectangles are likely to be administratively easier to use. The Task Group recommends the choice of 15′N x 15′E/W rectangles, but other choices would be possible at approximately this scale. It should be noted that a rectangle off Shetland would be about 60% of the area of a rectangle off Gibraltar, so it might be possible to have variation of grid rectangle by regional sea.

The choice of frequency bandwidth (10Hz to 10kHz) is based on the observation that sounds at higher frequencies do not travel as far as sounds within this frequency band. Although higher frequency sounds may affect the marine environment, they do so over shorter distances than low frequency sounds. This choice of bandwidth also excludes most depth-finding and fishery sonars.

The indicator is focussed on those impulsive noise sources that are most likely to have adverse effects. The source levels will include all classes of high intensity sounds that are known to affect the marine environment adversely for which the activities that generate such sounds are routinely licensed or are assessed, but not to include some lower intensity sounds that are rarely subject to licence. The Task Group recommends that these levels be reviewed in the future in the light of any new scientific publications.

1.2 Indicator 2. High frequency impulsive sounds

Depth sounding sonar systems on small vessels typically use frequencies between 50 and 200 kHz. Sonar usage, particularly on leisure boats, is increasing and is unregulated. These vessels tend to operate in coastal areas throughout the EU; these waters are often important for some marine mammals. These animals use frequencies up to about 180 kHz for communication and thus there is an overlap in frequency usage. There has been little research on the effects of these sonar systems and the scientific evidence for adverse effects is limited. However, the sounds are similar to those used in acoustic alarms (pingers) that are designed to scare away small cetaceans from gill and tangle nets used in the fishery, and can therefore be expected to cause adverse effects. A precautionary approach would be to reduce the usage of sonar systems working at frequencies below 200 kHz. Frequency is related to depth range; however in shallow areas, 200 kHz would be sufficient for most purposes and would not affect marine mammals. A possible initial indicator for high frequency impulsive noise would be:

1.2.1 Underwater noise indicator 2

The total number of vessels that are equipped with sonar systems generating sonar pulses below 200 kHz should decrease by at least x% per year starting in [2012].

This indicator does not include a measure of the use of small vessels, or the use of sonar on them, since this is virtually impossible to monitor, but the number of vessels with such sonar systems will be a sufficient proxy. The target percentage decrease (x) in usage would be set by Member States depending on how rapidly a reduction is deemed necessary.

1.3 Indicator 3. Low frequency, continuous sound

Ambient noise is defined as background noise without distinguishable sound sources. It includes natural (biological and physical processes) and anthropogenic sounds. Research has shown increases in ambient noise levels in the past 50 years mostly due to shipping activity. This increase might result in the masking of biological relevant signals (e.g. communication calls in marine mammals and fish) considerably reducing the range over which individuals are able to exchange information. It is also known that marine mammals alter their communication signals in noisy environments which might have adverse consequences. It is further likely that prolonged exposure to increased ambient noise leads to physiological and behavioural stress. Thus chronic exposure to noise can permanently impair important biological functions and may lead to consequences that are as severe as those induced by acute exposure. A possible initial indicator for low-frequency, continuous noise would be:

1.3.1 Underwater noise indicator 3

The ambient noise level measured by a statistical representative sets of observation stations in Regional Seas where noise within the 1/3 octave bands 63 and 125 Hz (centre frequency) should not exceed the baseline values of year [2012] or 100 dB (re 1µPa RMS; average noise level in these octave bands over a year).

This indicator would be based on direct independent measurements. The choice of representative sets of observation stations is left to Member States working together and should benefit from existing networks of underwater observatories (e.g. ESONET). Recording would be on the basis of Regional Seas [or national parts of regional seas].

The choice of these octave bands is on the basis of scientifically justifiable signatures of anthropogenic noise that avoids most naturally generated sources. The baseline year would be set at whenever the observatory system for a regional sea is established, while the suggested cap on ambient noise is suggested to avoid ambient noise levels that are likely to be harmful.

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Abstract

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) requires that the European Commission (by 15 July 2010) should lay down criteria and methodological standards to allow consistency in approach in evaluating the extent to which Good Environmental Status (GES) is being achieved. ICES and JRC were contracted to provide scientific support for the Commission in meeting this obligation.

A total of 10 reports have been prepared relating to the descriptors of GES listed in Annex I of the Directive. Eight reports have been prepared by groups of independent experts coordinated by JRC and ICES in response to this contract. In addition, reports for two descriptors (Contaminants in fish and other seafood and Marine Litter) were written by expert groups coordinated by DG SANCO and IFREMER respectively.

A Task Group was established for each of the qualitative Descriptors. Each Task Group consisted of selected experts providing experience related to the four marine regions (the Baltic Sea, the Northeast Atlantic, the Mediterranean Sea and the Black Sea) and an appropriate scope of relevant scientific expertise. Observers from the Regional Seas Conventions were also invited to each Task Group to help ensure the inclusion of relevant work by those Conventions. This is the report of the MSFD Management Group.

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