An environmental assessment of risk in achieving Good Environmental Status to support regional prioritisation of management in Europe.

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Abstract

The Marine Strategy Framework Directive (MSFD) aims to achieve Good Environmental Status (GES) in Europe's Seas. The requirement for regional sea authorities to identify and prioritize issues for management has meant that standardized methods to assess the current level of departure from GES are needed. The methodology presented here provides a means by which existing information describing the status of ecosystem components of a regional sea can be used to determine the effort required to achieve GES. A risk assessment framework was developed to score departure from GES for 10 out of the 11 GES descriptors, based on proposed definitions of 'good' status, and current knowledge of environmental status in each of the four regional seas (North-East Atlantic, Mediterranean Sea, Baltic Sea and Black Sea). This provides an approach for regional evaluation of environmental issues and national prioritization of conservation objectives. Departure from GES definitions is described as 'high', 'moderate' or 'low' and the implications for management options and national policy decisions are discussed. While the criteria used in this study were developed specifically for application toward MSFD objectives, with modification the approach could be applied to evaluate other high-level social, economic or environmental objectives.

Key-words: risk assessment; status; Marine Strategy Framework Directive; management; GES

1. Introduction

Ecosystem-based management (EBM) considers both ecological and human objectives in the exploitation of resources [1]. It aims to maintain ecosystems in a healthy, productive, resilient condition whilst still providing key marine resources for human consumption [2]. As such there are numerous policies and directives which aim to support EBM. In many cases, initiatives have been focused on single species or sectors at a relatively small-scale [3], although larger-scale initiatives have recently been proposed which require an array of different sectors, habitats and species to be considered. Within Europe, the Marine Strategy Framework Directive (MSFD) (2008/56/EC) [4] is one such policy; its key objective is the achievement of Good Environmental Status (GES) in each of the four European regional seas: The North-East Atlantic, The Mediterranean Sea, The Baltic Sea and The Black Sea (Fig. 1) by 2020.

The MSFD has used 11 descriptors of GES to broadly describe the natural environment and the pressures related to it. It has placed obligations on Member States to promote GES. There are four main steps in this process; the outcome of which is to support the identification of current aspects of the marine ecosystem under threat and lead to the implementation of management options to mitigate impacts and support sustainable use of marine ecosystems. The steps include: (1) completing an initial assessment of the current state of marine waters (by 2012); developing targets and indicators to demonstrate GES (by 2012); (3) setting up monitoring programmes to assess progress against GES (by 2014); and (4) implementing a programme of measures to help achieve GES (by 2016). The need for cooperation between member states bordering the regional seas, to take forward implementation of the MSFD, is emphasized strongly in the documentation [4]; see summary in [5].

Achieving GES may not be possible for all ecosystem components by 2020 (Article 29[4]) and Member States are not required to take steps to mitigate threats when there is no significant risk to the marine environment (Article 11[4]). ‘Failure’ to meet the Directive’s requirements only occurs when management measures are not implemented to address an identified threat (Article 11[4]). The need to

rationalise resource use may lead to the prioritisation of issues by Member States of management measures most likely to have a beneficial effect.

Whilst existing ecosystem status assessments are useful in the context for which they were developed, the specific criteria and methodology used to determine status and trends do not allow for easy inter-comparison across regional seas. The motivation for existing assessments can be wide-ranging and cover topics as diverse as sustainability of fish stocks, coastal, estuarine and whole marine ecosystem condition assessments to predicting potential impacts of future projects, programmes and policies [6]. In addition the assessments may have been undertaken at very different spatial scales adding complexity. For example, national ecosystem assessments may not account for transboundary pressure (e.g. exploitation of fish stocks straddling territorial boundaries) and hence, may underestimate the level of threat at a regional scale. Large-scale ecosystem assessments such as the OSPAR Quality Status Report 2010 [7] by comparison, go some way toward providing a regional overview of potential problem areas. However, differing regional interests and the wide range of goals and objectives of each assessment means that the information available, even if at a similar spatial scale, may not cover all of the issues highlighted by the MSFD's descriptors of GES. Furthermore where the same issues are covered, the objectives and baselines of the assessments may differ.

To fulfil the first step of implementing the MSFD and help prioritise monitoring and management, a regional overview of ecosystem status is required which is set around the 11 GES descriptors. To achieve this, existing national and regional assessments must be collated and their outcomes interpreted to form a coherent assessment that can cover all aspects of GES [5, 8]. Here, we present a methodology that can assess the wide range of existing assessments relevant to the different aspects of good environmental status. A risk assessment framework was used to assess the degree of departure of current ecosystem status from proposed definitions of GES, and indicated the likely level of effort required by Member States to achieve GES for each descriptor. Using a combination of existing assessments and/or expert judgement, the major challenges to the GES objectives are identified for each of Europe's four regional seas. The outcomes allow Members States to identify national and regional management priorities to support achievement of GES by 2020.

2. Methods

2.1 Definition of objectives

Each MSFD Descriptor of GES was defined in the Directive (Annex I, EC, 2008; listed here in Appendix A), but in many cases the definitions failed to provide sufficient detail to determine if GES is likely to be achieved. For example, Descriptor 2 (D2) is defined as "NIS (NIS) introduced by human activities are at levels that do not adversely alter the ecosystems" but it is not clear what would constitute adverse effects on the ecosystem, nor how these might be linked to the distribution or number of NIS.

For each of the descriptors assessed (here 10 of the 11 MSFD Descriptors[1]) a more detailed definition was developed against which to assess the extent of departure from the current ecosystem status, and thus the risk of failing to achieve the objective.

To define GES for each descriptor a number of key documents were consulted. These were: EC Commission Decision Document [9] which lists the indicators required to assess each Descriptor, and Cardoso et al. [10] which informed the Commission Decision Document [9] and draws together advice given by expert task groups set up to review knowledge and understanding of the GES descriptors. These more detailed definitions incorporated specific characteristics associated with achievement of GES to enable interpretation at a regional sea scale (Appendix B).

2.2 Definition of risk criteria

Having clarified the characteristics associated with achievement of each descriptor, criteria describing high, moderate and low levels of departure from GES were then defined, corresponding with different levels of risk of failing to achieve them (Appendix B). In order to apply the assessments across the

[1] Descriptor 7 (Hydrographical conditions) was not assessed since there has been little clarity on how this aspect of GES should be interpreted.

four European regional seas it was often necessary to define several different criteria for each level of risk corresponding with the indicators outlined in the Commission Decision document [9]. Criteria for assessing confidence in the application of the risk score were also developed. Confidence indicates the degree of certainty in our assessment of effort required to achieve GES in each of the four regional seas. These criteria were also of a qualitative nature (e.g. high, medium and low) and were based on the quality of information, the ease of interpreting the information with regards to the assessment criteria and the agreement within the expert group carrying out the assessment (Appendix B).

Cardoso et al. [10] also provided information about integrating several different pieces of evidence i.e. whether this should use an integrated or worst case scenario approach. An integrated approach meant that information should be combined before a final assessment was given whilst a worst case approach followed a 'one-out all-out' principle whereby if one set of evidence suggested that the risk was 'high' then 'high' was automatically assessed for the entire descriptor. Descriptors which applied an integrated approach were Biodiversity, NIS, Eutrophication and Seafloor Integrity. All other descriptors used a worst case approach.

2.3 Status and pressure assessments

Information required to evaluate GES include descriptions of the status and trends of ecological characteristics in the regional sea, and/or an assessment of the extent and frequency of human pressures and their impacts. The relationship between this evidence and each of the GES descriptors was initially described by Cardoso et al. [10] and here refined to only include direct linkages. These linkages were used to sort available evidence by descriptor therefore specifying which information should be used to assess each descriptor.

Status and Trend information

Many of the ecological characteristics described in the MSFD are already evaluated in accordance with various Directives, and other national or regional initiatives (e.g. OSPAR). However, these tend

to have different criteria, objectives and baselines, because they fulfil different purposes. Existing status and trend assessments from more than 100 reports, journal articles and grey literature were collated and linked to each ecological characteristic. Where status information was unavailable, trend information was used which describes a change in an indicator over time.

Pressures

Pressure is the mechanism through which an activity has an effect on any part of the ecosystem, and pressure has been explicitly recognised in some GES descriptors of the MSFD (e.g. Descriptor 10 on Marine Litter and Descriptor 5 on Eutrophication).

For those descriptors that require information on pressures, a pressure assessment was used to identify the potential pressure pathways or 'linkages' between activities and ecosystem characteristics followed by evaluation of those linkages in terms of their severity and persistence [11]. Coupled with estimates of human activity footprint (extent) and frequency of occurrence, the relative threat of each activity and pressure to the status of the relevant components of the ecosystem was evaluated. This method uses expert judgment evaluations of five criteria: (1) overlap between the pressure and ecological characteristic (extent), (2) frequency of occurrence of the pressure, (3) degree of impact of the pressure on the ecological characteristic, (4) ecological characteristic resilience (recovery time), and (5) pressure persistence beyond activity cessation. The interaction of each pressure combination was ranked using predefined categories each indicating a different level of threat to the ecological characteristic being evaluated. Information from the results of the pressure assessment undertaken in each regional sea were then used to inform the risk assessment for relevant descriptors.

2.4 The assessment

The assessment was carried out by 30 marine experts from 16 European countries assembled at a workshop in February 2011. Experts were divided into regional groups and assessments were carried out as a team. Biodiversity was disaggregated into five component parts: (1) Phyto-zooplankton, (2) Fish, (3) Seabirds, (4) Marine mammals and reptiles, and (5) Predominant habitat types, due to the

difficulties associated with an integrated assessment of all those characteristics. Experts used the GES descriptor definitions (Appendix B) and scored the effort required to achieve GES as high, moderate or low using the compiled status and trends database and information from the pressure assessment on their region. For each descriptor, a confidence score was also applied. Where it was not possible to distinguish between 2 risk categories (e.g. low or moderate), an intermediate score was applied e.g. low-moderate. A commentary sheet was also completed during the assessment; this provided a self-assessment framework to ensure consistency of methodology application and interpretation, as well as providing an audit trail for the assessment.

3 Results

The level of risk in the achievement of GES varied across descriptors and between regions, however when summarized across descriptors, there was little difference in the overall level of risk between regions (Table 1). For the North East Atlantic, six of the 14 descriptor categories were assessed to be at high risk, whilst seven were assessed as high for the other three regions combined. In general pressure based objectives (i.e. underwater noise, marine litter) or those directly related to impacts from pressures (e.g. commercial fish and shellfish and seafloor integrity) exhibited higher risk than state objectives (e.g. biodiversity).

Five descriptors were assessed as having a high risk in all four regions (NIS, fish and shellfish, food webs, seafloor integrity and marine litter) (Table 1). Underwater noise was scored as high risk in the NE Atlantic, Mediterranean Sea and Black Sea and moderate-high risk in the Baltic Sea. Only contaminants in fish and shellfish in the Mediterranean Sea was considered at low risk (Table 1).

Of the descriptors classified as high risk in all four regions, risk for Commercial Fish and Shellfish was associated with the number of over-exploited species. The Food Web descriptor was at high risk due to declining populations of many of the biodiversity components that form essential parts of the food web (e.g. top predators such as some of the marine mammals) and the poor status of several commercial fish stocks, which both act as a proxy for food web functioning. Seafloor Integrity was

assessed using the results of the pressure assessment and indicated several sectoral activities result in widespread detrimental effects to seafloor habitats and species. In general, increases in the abundance and number of NIS were reported in all regions, and in many cases, evidence of adverse effects shown. The availability of data describing trends in the quantity of Marine Litter was limited, but reports of litter on beaches, the concentration of microplastics in the environment and plastic ingested by seabirds indicated a high risk of failure to achieve our potential GES definitions. Underwater Noise was classified as high risk in three of the four regions; an assessment largely driven by high levels of shipping activity in all regions (see also QSR 2010).

The analyses also highlighted some issues specific to each region. For example, Eutrophication was scored as high risk in the Baltic Sea, but classified as moderate risk in all other regions. Both Contaminant descriptors were at higher risk of failing to achieve GES in the Baltic Sea and the Black Sea. There was high risk to Biodiversity in three of the four regional seas. High risk categorisation was achieved when a species/habitat was thought to be of high likelihood to be lost within the next 10 years (Table 1) e.g. the critically endangered Monk seal in the Mediterranean Sea[12]. Based on this criterion, high risk Biodiversity sub-groups included marine mammal and reptiles in the Mediterranean, predominant habitats in the Baltic Sea, and seabird diversity in the Black Sea (Table 1).

Confidence in assessments

A high degree of confidence was reported for ~40% of assessments, and 89% of assessments scored as moderate confidence or better (see confidence criteria in Appendix B). In general, low confidence in assessment was rare in the majority of regions, for example no descriptors in the Baltic and Mediterranean Sea and only Contaminants in Fish and Shellfish in the Black Sea was classified as a low confidence assessment. In contrast, uncertainty in assessments was reported in Biodiversity-plankton (L-M); Biodiversity-Marine mammals and reptiles (L); Biodiversity-Predominant habitat types; and Contaminants in Fish and Shellfish (L) in the NE Atlantic.

There was more variation in the assessment of confidence between regions than in the assessment of risk itself. For example, the Baltic Sea recorded highest levels of confidence in their assessment (eight out of 14 descriptor categories were recorded as high confidence whilst the other regions only allocated high confidence to five out of 14 descriptor categories). In general, the confidence in assessment of descriptors Eutrophication, Seafloor Integrity and Contaminants was high. However, there were only three descriptors (Marine litter, Biodiversity-predominant habitat types and Biodiversity- marine mammals) which differed by more than one whole confidence score between regions (i.e. low in one region and high in another). Less than half of assessments (41%) were given both a high risk and a high confidence score (i.e. 11 assessments out of 27 total assessments scored as high risk and high confidence). Only three assessments in total were considered to have a low confidence and none of these was considered to have high risk of failure.

4 Discussion

The Marine Strategy Framework Directive (MSFD) is the first piece of legislation applied across Europe's regional seas that requires assessment of the range of issues that should encompass overall marine environmental sustainability [13]. Prior to this coming into place, legislation tended to focus primarily on a single activity or issue. As such, most status, trend and impact assessments also focused on these specific issues. Broader assessments of the status of marine ecosystems do exist for particular sea areas (e.g. under the regional sea conventions), but although their focus may in some cases align with the MSFD's overall objective of healthy, productive, safe and biologically diverse seas, the reporting does not tend to cover all aspects of GES (the 11 GES descriptors) (Appendix A).

We have presented a methodology that combines information on status and human impacts within a regionally consistent framework to assess the level of risk to GES. Over 100 sources were included in the risk analysis and included broad-scale assessments of status (e.g. [14]), pressure distribution (e.g. [15]), impacts (e.g.[16]) and trends in ecosystem characteristics (e.g. [17]). Sources covered a range

of assessment timelines, reference conditions and were of varying spatial coverage. However, in the majority of cases, the regional expert groups felt confident and could agree on a suitable risk category.

The need for such a methodology was highlighted in the process of conducting the assessments, when specific national or sub-regional status reports were inconsistent with overall regional views. For example, UK predominant habitats [14] are reported as being in poor status, but when assessing risk to GES based on Biodiversity of predominant habitats for the whole regional sea (in this case the NE Atlantic), the level of risk was classified as 'moderate' (see Figure 1) indicating the importance of considering spatial scale of assessments when evaluating status at a regional sea level.

The assessment of risk of failing to achieve these GES definitions identified issues for regional prioritization in addition to those identified in existing status reports. For example, the Baltic Sea and Black Sea Action Plans [18] [19] focus on issues relating to the descriptors (1) Biodiversity, (5) Eutrophication, (6) Seafloor Integrity and (8&9) Contaminants and Contaminants in Fish and Shellfish. However, the risk assessment undertaken here suggests that NIS, Food Webs, Marine Litter and Underwater Noise are also potential areas of concern. This shows that translation of the outcomes of even spatially comparable assessments and their placement in the context of the MSFD may be precluded by differences in assessment objectives.

Levels of risk to achieving GES

Application of the risk methodology to Europe's four regional seas identified GES descriptors at high risk that were common to all regional seas, suggesting a similar level of effort required within all regions to achieve the MSFD objectives. In most cases, the contributing threats to the high risk classification were logical and fit well with documented areas of concern e.g. commercial fish sustainability, the establishment and spread of NIS, amount of marine litter, the state of food webs and the extent of human activities. Similarly, descriptors classified as at moderate or low risk, such as Contaminants and Eutrophication, are already focus issues of regional sea conventions and in some cases, have been regulated for many years.

Surprisingly, there were few high risk Biodiversity components, despite some other descriptors that we might expect to have consequences for Biodiversity such as NIS classified as at high risk. Risk outcomes are closely linked to the level of ambition of the descriptor and these differed between the descriptors. Using the example of NIS and Biodiversity, the crucial difference in GES ambition is in the definition of acceptable 'loss'. High risk under Biodiversity requires the likelihood of "loss of biodiversity or maintained change in dominance/assemblage structure" (Appendix B) (both of which are major changes at a regional sea scale), whereas for NIS, significant adverse effects of an invasive species do not have to be as severe as elimination of a population and can include effects such as increased seasonal dominance of algal blooms in the region.

Disparities may also be the result of the level of precaution adopted. The timeline for biodiversity loss was defined as <10 years (i.e. within the 2020 reporting timescale of the MSFD). However, this timeline is perhaps not precautionary enough to help prioritise management. For example, a species or habitat faced with loss from an area as large as one of Europe's regional seas within the next 10 years may be beyond recovery [20] and therefore, high risk criteria should reflect a period before the condition/status of the habitats/species becomes irrecoverable. Doing so would potentially result in a high risk score for a greater number of biodiversity components.

Difficulties in assessing risk criteria may also account for differences in risk score. The availability of reliable information on threatened and declining species or changes in dominance of assemblages (the two types of criteria for biodiversity) can vary widely and thus, affect the outcome of the assessment. Confidence in assessment can be interpreted in terms of prioritization of action to help achieve GES for particular descriptors where there are data or an understanding of the limitations of the data. As such, when confidence is low or low-moderate, recommended actions might include: (i) implementing monitoring programmes to improve data knowledge, (ii) re-analysing data to make our current data more useful for the MSFD, (iii) further development and research to improve understanding and use of the descriptors.

Where improving data provision is not possible, it may be more sensible to use a precautionary approach whereby high risk in one descriptor (e.g. Seafloor Integrity) automatically triggers high risk categorisation of a related descriptor i.e. Biodiversity of predominant habitats. This would ensure that at a minimum, monitoring and evaluation of biodiversity aspects would occur. There are clear inter-relationships between some of the descriptors of Europe's MSFD [5] and our results suggest that it will be important to recognise the links between descriptors such that high risk issues identified for one descriptor can trigger a similarly high level of priority in others.

Implications for prioritisation of management and monitoring

Given the high number of high risk issues for GES in each of Europe's regional seas as illustrated here, it is clear that member states (MSs) will need to implement management measures for many of the descriptors by 2016. A number of MSs are reviewing the types and performance of existing management measures and mapping the suitability of these in tackling areas of concern. For some descriptors, existing measures may already be helping to reduce the likelihood of status deteriorating beyond GES thresholds. Depending on the spatial scale of those measures e.g. national vs. regional programmes, dialogue between MSs could support the objectives of existing management options and also address the collaborative requirement of the MSFD (Article 13). However, the complexity in achieving GES at a regional sea scale should not be underestimated and may limit potential collaboration [21]. For example, for some regional seas the proportion of countries bordering the sea that are MSs (and obligated under the MSFD) is low and/or in other cases, the natural conditions within a region may require targets for GES that are less ambitious.

For other descriptors (e.g. NIS, Commercial Fish and Shellfish, Marine Litter) existing measures are clearly not sufficient in any of Europe's regional seas. The recent consultation on the Common Fisheries Policy [22] (CFP) reflects the widespread understanding that fisheries management in Europe must change if we are to support sustainable fisheries. Irrespective of the level of implementation, it is likely that MSs will still be required to assess their own stocks and need to

reduce the number of species that are overexploited. Measures required to improve status will certainly require international coordination and agreements to be effective. For example, the Convention on Biological Diversity (CBD) has recently provided guidance for some descriptors, such as NIS by the major sources and pathways of introduction and suggesting that stricter reduction measures should be introduced [23].

Conclusions

Key elements of the MSFD include the need for a knowledge-based approach driven initially by what we already know [24] and the need for co-ordinated efforts within and between regional seas [4, 5, 8, 9]. Given the current global economic downturn it is likely that MSs will first look to existing data gathering exercises to support the MSFD. This is reflected in the approach taken by several member states (e.g. UK, Germany, Netherlands) who have begun to develop targets and indicators based on outcomes of existing monitoring programmes and regional assessments [25]. The results presented here are a first attempt to take the existing status and trends assessments to assess risk to GES using a transparent and consistent risk based approach. Our experience of applying this approach across Europe's regional seas supports the need for a common tool if the results from the initial assessments are to be in any way comparable.

This first look at regional priorities identified five high risk issues common across regional seas, and several other areas where there is high risk in particular regional seas. This supports existing suggestions that joined up, cross regional work on the development of objectives, targets, monitoring programmes and management should be undertaken [5]. High risk outcomes also provide an initial prioritization of management measures and in association with tools such as Management Strategy Evaluation (MSE; e.g. [26]) and Cost Benefit Analysis (CBA; e.g. [27]), measures that confer the greatest benefits in terms of environmental, socio-cultural and economic status can be identified. Our analyses suggest the need for a pragmatic approach which links descriptors so that the introduction of

management measures could lead to multiple gains in terms of the environmental, social and economic benefits while increasing the likelihood of GES being achieved in Europe's regional seas.

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Tables

Table 1. Results of the risk assessment for each descriptor per regional sea. Darker grey colour indicates high risk whilst a lighter grey indicates a lower risk. High risk/confidence was scored 3, moderate risk 2 and low risk 1. Total indicated the overall risk in assessments per region across descriptors and per descriptor across all regions.

	NEA	MED	Baltic	Black	Total across regions
Biodiversity-Phyto-zooplankton	LM	M	M	M	7.5
Biodiversity-Fish	M	M	M	M	8
Biodiversity-Marine mammals and reptiles	LM	H	M	MH	9
Biodiversity-Seabirds	M	M	M	H	9
Biodiversity-Predominant habitat types	M	M	H	MH	9.5
Non-indigenous species	H	H	H	H	12
Fish and shellfish	H	H	H	H	12
Food webs	H	H	H	H	12
Eutrophication	M	M	H	M	9
Sea floor integrity	H	H	H	H	12
Contaminants	M	M	MH	MH	9
Contaminants in fish and shellfish	LM	L	M	M	6.5
Marine litter	H	H	H	H	12
Underwater noise	H	H	MH	H	11.5
Total score	32.5	34	36	36.5	

Risk

High	H
Moderate-high	MH
Moderate	M
Low-moderate	LM
Low	L

Table 2. Results of the confidence assessment for each descriptor per regional sea. Darker grey colour indicates higher confidence in the risk assessment whilst a lighter grey colour indicates a lower confidence in the risk assessment.

	NEA	MED	Baltic	Black
Biodiversity-Phyto-zooplankton	LM	M	M	M
Biodiversity-Fish	MH	M	H	M
Biodiversity-Marine mammals and reptiles	L	H	H	H
Biodiversity-Seabirds	M	M	H	H
Biodiversity-Predominant habitat types	L	M	H	M
Non-indigenous species	MH	H	H	H
Fish and shellfish	H	M	MH	M
Food webs	M	M	H	M
Eutrophication	H	H	H	H
Sea floor integrity	M	M	M	M
Contaminants	H	H	H	H
Contaminants in fish and shellfish	L	M	MH	LM
Marine litter	LM	H	M	M
Underwater noise	H	M	M	M

Confidence	
High	H
Moderate-high	MH
Moderate	M
Low-moderate	LM
Low	L

Figure 1

Figure 1. The four European regional seas included in the Marine Strategy Framework Directive.

Appendix A

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. (Biodiversity)

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

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. (Fish and Shellfish)

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. (Food Webs)

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. (Eutrophication)

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. (Sea-floor integrity)

Descriptor 7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems. (Hydrographical Conditions)

Descriptor 8. Concentrations of contaminants are at levels not giving rise to pollution effects. (Contaminants)

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

Descriptor 10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment. (Marine Litter)

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

Appendix B

Descriptor 1: Biodiversity

Good status is achieved when biodiversity is maintained in the regional sea such that the quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. Failure of GES is defined to occur where there is loss of biodiversity beyond that expected under prevailing conditions before 2020. Loss of biodiversity can be described as occurring where there is a reduction in genetic, species, habitat or ecosystem diversity within the regional sea over this time scale. More specifically loss of particular meta-populations, species, habitat types or ecosystem properties within the region (e.g. extirpations) would certainly count as a loss of biodiversity, but so could a noticeable change in diversity based on changes in evenness (e.g. shifts in dominance). However, both of these cases would need to be a loss/change beyond that expected under prevailing conditions. GES under Biodiversity should be assessed individually for each of the major ecosystem characteristics listed in Annex iii of the MSFD as recommended in the Commission decision. Consideration should be given separately to listed species and habitats under the Habitats Directive. Consistency should be checked against the level of risk identified for other relevant Descriptors (e.g. seafloor integrity for the aspects of habitats-ecosystem level diversity).

Table B.1 Risk categories for Biodiversity

High (3)	Continued decline in a genotype, species, habitat or ecosystem type at the regional scale (decline in biodiversity) to the extent that there is a high likelihood of its loss from the region (= extirpation)within the next 10 years *and/or* Maintained change in the dominance of genotypes, species, habitat types or ecosystem types (change in evenness) where this change is likely to last for at least the next 10 years
Moderate (2)	New or further decline in extent and/or condition of genotypes, species, habitat types or ecosystem types at the regional scale within the next 10 years *and/or*

	Alterations in the dominance of genotypes, species, habitat types or ecosystem types (change in evenness) within the next 10 years, not necessarily having led to a maintained change
Low (1)	No notable changes in extent and condition of genotypes, species, habitat types or ecosystems at the scale of the region beyond that expected given prevailing conditions within the next 10 years *and* No clear change in dominance of genotypes, species, habitat types or ecosystem types (change in evenness) given prevailing conditions within the next 10 years

Descriptor 2: Non-indigenous species introduced by man

GES for Non-indigenous species (NIS) is a function of their relative abundances and distribution ranges, and environmental impact. These may vary from low abundances in one locality with no measurable adverse effects, up to occurrence in high numbers in many localities resulting in significant impacts. Good status will be maintained when significant adverse effects on environmental quality from NIS are avoided, including no elimination or extinction of sensitive and/or rare populations, alteration of native communities, seasonal dominance of algal blooms, alteration of water chemistry (oxygen, nutrient content, pH and transparency) or accumulation of synthetic pollutants. Invasive NIS 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 environmental quality. Therefore it is invasive NIS that are of most concern in terms of posing a risk to GES.

Table B.2 Risk categories for NIS

High (3)	High abundance and increasing trends in abundance of established invasive NIS in many sub-regions *and/or* High numbers of invasive NIS in many sub-regions. *and* Clear evidence of significant adverse effects on environmental quality in those sub-regions

Moderate (2)	High abundance of some established invasive NIS in some sub-regions or generally increasing trends in abundance in some areas. *and/or* High numbers of invasive NIS in some sub-regions *and* Evidence of adverse effects at species, habitat or ecosystem level but only in some sub regions
Low (1)	Low abundance of established invasive NIS in the region with no apparent increasing trends. *and/or* Low numbers of invasive NIS *and* No evidence of adverse effects at species, habitat or ecosystem level

Descriptor 3: Commercial Fish and shellfish

GES for commercially exploited fish and shellfish will be achieved when stocks are sustainably exploited consistently with high long-term yields and have full reproductive capacity. To achieve GES it will also be necessary, in addition to sustainably exploited stocks at full reproductive capacity, for the age and size distribution of fish and shellfish populations to be representative of a healthy stock, assessed by reference to the proportion of older and larger fish in the population. GES is achieved for a particular stock only if criteria for all attributes are fulfilled.

Table B.3 Risk categories for commercially exploited fish and shellfish

High (3)	SSB < SSBpa for some stocks *and/or* exploitation rate F exceeds precautionary levels for some (>25%) stocks *and/or* the age and size distribution of fish and shellfish stocks shows consistent long-term degradation. i.e. smaller, younger fish.

Moderate (2)	25% stocks are exploited sustainably (F<FMSY) *and/or* all stocks SSB > SSBpa
Low (1)	All stocks are exploited sustainably (F<FMSY) *and/or* SSB > SSBMSY for >50% of stocks *and/or* all stocks SSB > SSBpa *and/or* the age and size distribution of fish and shellfish stocks show no degradation. i.e. smaller, younger fish.

Descriptor 4: 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, some changes in species' relative abundance in an ecosystem can have significant adverse effects on food web status. Good Environmental Status of Food Webs will be achieved when energy flows through the food web, and the size, abundance and distribution of key trophic groups/species, are all within acceptable ranges that will secure the long-term viability of all food web components in line with prevailing natural conditions.

Table B.4 Risk categories for food webs

High (3)	Spatially extensive and long-term changes have occurred in energy flows

	through the food web, as recorded by changes in the productivity (production per unit biomass) of several key species or trophic groups, which have both direct and indirect effects on different trophic levels. *and/or* Trends in the abundance and distribution of carefully selected indicator populations, and in the proportion of species at the top of food webs, show continuous decline across the Region and provide evidence of adverse impacts on food web integrity.
Moderate (2)	Recent changes in the productivity (production per unit biomass) of some key species or trophic groups suggest that direct and indirect effects have occurred on different trophic levels. *and/or* Trends in the abundance and distribution of local indicator populations, and in the proportion of species at the top of food webs, suggest that adverse impacts to food web structure have occurred in some sub-regions.
Low (1)	Recorded changes in energy flows through the food web, as recorded by changes in the productivity (production per unit biomass) of key species or trophic groups, have no significant direct and indirect effects on different trophic levels. *and/or* Trends in the abundance and distribution of carefully selected indicator populations, and in the proportion of species at the top of food webs, vary in accordance with natural cycles and show no cause for concern in relation to food web structure.

Descriptor 5: Eutrophication

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 harmful 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.

Table B.5 Risk categories for Eutrophication

High (3)	Undesirable disturbance* caused by eutrophication is widespread (even or patchy) and frequent in the region (> once a year)
Moderate (2)	Undesirable disturbance* caused by eutrophication is widespread but rare in the region (< once a year) *And/or* Undesirable disturbance* caused by eutrophication only occurs at a site or local scale in the region, but it occurs at least once a year
Low (1)	Undesirable disturbance* caused by eutrophication does not occur in the region, or where it does occur it only occurs rarely (<once a year) and on a very local scale (site or local patchy)

*Undesirable disturbance includes one or more of the following: harmful algal blooms, low dissolved oxygen, associated declines in perennial seaweeds or seagrasses, kills of benthos and fish, dominance by opportunistic macroalgae

Descriptor 6: Sea-floor integrity

GES is achieved where seafloor integrity is at a level that ensures that the structures and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. "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. "Not adversely affected" is interpreted as meaning that impacts may be occurring, but at a level where natural levels of diversity, productivity, and dynamic ecosystem processes are not degraded

Seafloor integrity will be assessed here for the broad predominant habitat types only where the assessment will be based on the outcomes of the pressure assessment undertaken in ODEMM and any other useful information on status/trends at the broad habitat level. Thus the integrity of the seafloor is

assessed in terms of the extent of damage caused by the various human activities that interact with it. This is done indirectly through a pressure assessment.

The habitats listed under the Habitats Directive will be assessed against the FCS criteria of the Habitats Directive (listed after the MSFD descriptors). If they are achieving FCS they will also be meeting the criteria for GES for seafloor integrity. If they are failing against the FCS criteria that in itself identifies a regional mismatch to the relevant HLO.

Table B.6 Risk categories for Sea-floor integrity

High (3)	Where the pressures and habitats overlap: 1. Extent is widespread (even or patchy), severity is acute or chronic and the persistence of the pressure is high or continuous, irrespective of frequency of occurrence *and/or* 2. Extent is widespread (even or patchy), severity is acute and the frequency of occurrence is occasional or higher, irrespective of Persistence category *and/or* 3. Extent is widespread (even or patchy), severity is chronic and the frequency is persistent or common, irrespective of Persistence category *and/or* 4. A combination of multiple local pressures which result in a widespread extent with a severity, frequency and persistence combination equivalent to one of the above *and/or* 5. The overlap of multiple low severity pressures which combine to form a severe (acute or chronic) impact combination equivalent to one of the above
Moderate (2)	Any combination other than high or low
Low (1)	Where severity is classified as 'low' for all interactions with pressures in the region even when they are combined *and/or*

	Where any severe effects (chronic or acute) occur and frequency of occurrence is rare, persistence of the pressure is low, and resilience of the habitat is high

Descriptor 8: Contaminants in the environment

Assessment of whether concentrations of contaminants are at levels not giving rise to pollution effects should be based on monitoring programmes for chemical contaminants, and on biological measurements relating to the effects of pollutants on marine organisms in each of the assessment regions. GES will therefore be achieved when concentrations of contaminants in water, sediment and biota are below assessment thresholds identified on the basis of toxicological data; pollution levels are below assessment thresholds representing harm at organism, population, community and ecosystem levels; and trends in concentrations of contaminants in water, sediment and biota, and the occurrence and severity of pollution effects, are within acceptable limits and declining.

Table B.7 Risk categories for contaminants in the environment

High (3)	Concentrations of all contaminants in biota, sediments and water exceed the relevant Environmental Quality Standards over extensive areas of the Region. *and/or* Significant impacts on and risk to the marine environment have recently been shown by the occurrence and extent of pollution effects throughout the Region.
Moderate (2)	Concentrations of some contaminants in biota, sediments and water exceed the relevant Environmental Quality Standards in some sub-regions of the Region. *and/or* Impacts on and risk to the marine environment have recently been shown by the occurrence and extent of pollution effects in sub-regions.
Low (1)	Concentrations of contaminants in biota, sediments and water do not exceed the relevant Environmental Quality Standards established for the

	Region. *and/or* The occurrence and extent of pollution effects throughout the Region indicate no significant impacts on or risk to the marine environment

Descriptor 9: Contaminants in fish and shellfish

A number of contaminants in the marine environment giving rise to concern both from an environmental and public health point 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. 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 of the monitoring of descriptor 8, also dealing with contaminants in the marine environment.

Table B.8 Risk categories for contaminants in fish and shellfish

High (3)	Many contaminants in edible tissues are currently exceeding regulatory limits in some areas of the Region *and/or* Regulatory levels of one or more contaminants in edible tissues are being exceeded on a regular basis in large areas of the Region.
Moderate (2)	Some contaminants in edible tissues are currently exceeding regulatory limits in some areas of the Region. *and/or* Regulatory levels of one or more contaminants in edible tissues are being exceeded occasionally in large areas of the Region.
Low (1)	Levels of contaminants in edible tissues do not currently exceed regulatory limits anywhere in the Region.

	or
	Regulatory levels are rarely exceeded in large areas of the Region.

Descriptor 10: Marine litter

GES occurs when the properties and quantities of marine litter do not cause harm to the coastal and marine environment. This can be achieved through a measurable and significant decrease in comparison with the baseline (i.e. the situation up until 2012) in the total amount of marine litter by 2020 using as attributes the characteristics of litter in the marine and coastal environment and the impacts of litter on marine life. In addition, it is possible to use information from the ODEMM pressure assessments on the the intertidal habitats for criterion 1 and the pelagic water column habitat for criterion 2 in all risk categories below. The information in the pressure assessment can be used to summarise the spatial extent and frequency of any activities adding marine litter to the environment, since marine litter is one of the pressure categories used. Any additional information on the future trends in activity for the major sectors contributing litter can also be used to ascertain whether the extent of marine litter currently recorded in the pressure assessment is likely to change in the future.

Table B.9 Risk categories from Marine Litter

High (3)	Unchanged or increasing trend in the amount of litter washed ashore and / or deposited on coastlines over widespread areas (patchy distribution within this fine) of the region. *and/or* Unchanged or increasing trend in the amount of litter in the water column over widespread areas of the region. *and/or* Unchanged or increasing trend of micro particles over widespread areas of the region *and/or* Unchanged or increasing trend in litter ingested by large numbers of marine

	animals in the region
Moderate (2)	Unchanged or increasing trend in the amount of litter washed ashore and / or deposited at coastlines in some sub-regions *and/or* Unchanged or increasing trend in the amount of litter in the water column in some sub regions *and/or* Unchanged or increasing trend of micro particles in some sub regions *and/or* Unchanged or increasing trend in litter ingested by marine animals in some sub regions
Low (1)	Decreasing trend in the amount of litter washed ashore and / or deposited at coastlines over extensive areas of the region *and/or* Decreasing trend in the amount of litter in the water column over extensive areas of the region. *and/or* Decreasing trend of micro particles over extensive area of the region. *and/or* Decreasing trend in litter ingested by marine animals over extensive areas of the region.

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560 Descriptor 11: Underwater noise

561 In relation to underwater noise, GES would occur when there is no adverse effect of noise inputs on
562 any component of the environment. However such an objective is probably not achievable or
563 measurable. Therefore indicators for environmental status have been developed that are based on
564 pressures addressing two main issues with regards to underwater noise. One is the distribution in time
565 and place of loud, low and mid frequency impulsive sound that is mainly introduced by offshore

construction using pile driving (e.g. for offshore wind farms) and seismic surveys. The other is the trend of continuous low frequency sound indicated mainly by shipping activity.

Table B.10 Risk categories for underwater noise

High (3)	High activity and increasing trend of offshore construction using pile driving (e.g. oil and gas platforms, offshore wind farms), seismic surveys and sonar systems, which is widespread in the region. *and/or* High activity and increasing trend of shipping (commercial and recreational) indicated by the number of tourist vessels and commercial shipping activity (number and intensity of shipping lanes) over widespread areas of the region.
Moderate (2)	High activity of offshore construction using pile driving (e.g. oil and gas platforms, offshore wind farms), seismic surveys and sonar systems in some sub regions, or an increasing trend in some areas. *and/or* High activity of shipping (commercial and recreational) indicated by the number of tourist vessels and commercial shipping activity (number and intensity of shipping lanes) in some sub regions or an increasing trend in some areas.
Low (1)	Little offshore construction works using pile driving throughout or moderate activity only in a few places (local or site under the pressure assessment) in the region. *or* Little shipping activity throughout or moderate activity only in a few places in the region (local or site).

Confidence assessment criteria:

Confidence should be assessed based only on the criteria that is listed to be used for the assessment. Any further sources of ambiguity with regards the risk score for that descriptor should be listed in the commentary sheet under the question about confidence. E.g. impacts of noise on the marine environment.

Table B.11 Confidence categories

High	Good quality information is available for the majority of the criteria used for the assessment

	and Information available for that descriptor is easy to interpret in terms of the criteria *and* There is complete agreement amongst experts in the group
Moderate	Good quality information is available for some criteria used for the assessment *and/or* There is some information available for all criteria *and/or* Information that is available for that descriptor can be interpreted in terms of the criteria with expert judgement *and* There is majority agreement amongst experts within the group
Low	Information is available for few criteria used in the assessment *and/or* There were difficulties with interpretation of available information in terms of the criteria used for the assessment *and/or* The group could not reach a common agreement about the risk score

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Figure 1

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