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Report of the Workshop on guidance for the review of MSFD decision descriptor 6 – seafloor integrity II (WKGMSFDD6-II)

16–19 February 2015

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ICES International Council for the Exploration of the Sea

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Contents

Executive Summary **1**

1 Background **2**

2 Discussion sessions **7**

2.1 Session 1 - Regional-scale impact assessments 8

2.2 Session 2 - Structure and function link 9

2.3 Session 3 – Scouting and prioritizing indicators for function 12

2.4 Session 4 – Linking indicator options to criteria options 15

2.5 Session 5 - GES boundaries 17

3 Specific recommendations from Theme Sessions 1-5 ..... **21**

4 Workshop conclusions and recommendations **24**

5 MS Comments/ Response **27**

6 References **39**

Annex 1. Agenda **40**

Annex 2. WKGMSFDD6-II participants **44**

Annex 3. Terms of References **46**

Annex 4. Background paper **47**

Annex 5. Availability of seafloor integrity monitoring parameters for D6 indicators under different legal instruments (Zampoukas *et al.*, 2012, updated by F. Tempera and H. Teixeira in January 2015) **50**

Annex 6. Case study: Bioturbation potential in the North Sea. **121**

Annex 7. Link between existing and newly suggested criteria and the proposed criteria themes. **123**

Annex 8. Overview of methodology for the OSPAR indicator BH3 – Physical damage to seafloor habitats **124**

Annex 9. Review Group Technical Minutes **126**

Executive Summary

In September 2014, ICES was tasked with assessing the MSFD GES descriptor 6 (seafloor integrity) issues, focusing on methods and bounds for setting Good environmental status (GES). The results of this D6 workshop provided a guidance report with dedicated recommendations. However, when the D6 report was reviewed during the Marine Framework Directive Common Implementation Strategy meeting (MSFD CIS) of the Working Group on Good Environmental Status (WG GES) in October 2014, it was highlighted that more details will be required to guide Member States (MS) on: i) how to link higher level criteria to specific indicators and ii) how these indicators could be implemented in national monitoring and assessment programmes. The need for further clarification provided the opportunity to organize a follow-up workshop on Descriptor 6 seafloor integrity with the aim to review the 2010 Commission Decision on criteria and methodological standards on GES of marine waters (Copenhagen, 16–19 February 2015). The workshop was planned for by 5 vice-chairs and attended by 24 participants. The workshop adopted a *modus operandi* of dedicated discussions over two parallel subgroups and reporting the outcomes in plenary. The discussions covered the following themes: 1) using spatially explicit impact indicators, 2) linking structure to function, 3) scouting and prioritizing indicators for function, 4) linking indicator options to criteria options, and 5) options for setting GES. Scientific comments by the Member States were consolidated by the ICES Secretariat and addressed in plenary. This follow-up ICES workshop builds on the progress made in the earlier review of D6 in 2014. A series of Theme Sessions to compare and further elaborate on the existing and newly suggested criteria along the workshop's ToRs was organized. Theme Session 1 explored options to use an indicator for regional scale assessment and developed to support the existing criteria (6.1 "Physical damage" and 6.2 "Condition"), as well as addressing the newly suggested criterion "Recoverability". Theme Sessions 2 and 3 further elaborated on the function indicators, taking account of their link to existing structure indicators and function indicator prioritization. Theme Session 4 aimed at linking indicator options to criteria options, whereas Theme Session 5 scouted for options for setting Good environmental status (GES). The workshop concluded that (1) functional attributes are to be considered within seafloor integrity, (2) the inclusion of functional attributes do not necessarily necessitate the collection of new monitoring data (3) there is no consensus on the synonymy between the existing criteria "Physical damage" and "Condition" vs. newly proposed criterion "Recoverability", and (4) cumulative pressure effects have to receive better attention. The workshop therefore proposes to adopt a concept including three criteria themes (i.e. pressure, state and impact) when revising the Commission Decision. This concept has close links with the existing and newly suggested criteria. The criteria themes should be considered precedents for criteria specification, but the workshop lacked time to consolidate the criteria themes into solid criteria. The workshop identified further steps to be taken in operationalization of the proposed concept. Both short-term (2016) and long-term (2018) actions were distinguished that could be best addressed by a series of expert workshops, that include relevant scientific and operational expertise from all MSFD ecoregions together with key stakeholders, projects, and Regional Seas Conventions.

1 Background

In September 2014, ICES was tasked with assessing D6 seafloor integrity issues, focusing on methods and bounds for setting GES. The results of this D6 workshop provided a guidance report with dedicated recommendations. However, when the D6 report was reviewed during the MSFD Common Implementation Strategy meeting of Working Group on Good Environmental Status (WG GES) in October 2014, it was highlighted that more details will be required to guide MSs on: i) how to link higher level criteria to specific indicators and ii) how these indicators could be implemented in national monitoring and assessment programmes. The need for further clarification, provided the opportunity to organize a follow-up workshop on Descriptor 6 seafloor integrity with the aim to review the 2010 Commission Decision on criteria and methodological standards on good environmental status (GES) of marine waters. This workshop was held in Copenhagen on 16–19 February 2015. This report summarizes the result of this workshop, which was attended by experts in MSFD implementation and/or scientists specialising in assessing seafloor integrity. The workshop was planned by a five person expert group (one chair with four vice-chairs), together with an ICES and JRC secretariat member. The workshop participants came from across the ICES area and from other non-ICES EU countries (e.g. NE Atlantic, Baltic and Mediterranean MSFD regions). Those attendees from ICES countries were nominated by ICES Delegates and ACOM. Further invitations were provided by DGENV to the national marine directors from the non-ICES countries. To conform to best practice and ICES policy, NGOs and stakeholders were permitted to attend the workshop. A total of 24 participants from 8 nationalities (including the EC and JRC) were represented in the workshop. All participants were reminded that this was a scientific meeting, therefore, it was requested that lobbying or adopting institutional positions or dedicated policy objectives was not endorsed.

The topics covered at the workshop were:

1) Provide further input to the D6 Manual, specifically considering:
    a) How do we prioritize functions to be assessed under the criterion?
    b) How do we determine GES boundaries for seafloor integrity?
    c) How can the suggested revision be tangibly implemented?
2) Consolidate and address relevant scientific comments and requests for clarification received from WG GES and DG ENV on the earlier version of the MSFD review D6 manual.
3) Comment on implications for the MSFD review D6 manual in light of the DGENV cross-cutting workshop (21-22 January 2015).

The workshop adopted a *modus operandi* of dedicated discussions over two parallel subgroups and reporting the outcomes in plenary. The discussions covered the following themes: 1) using spatially explicit impact indicators, 2) linking structure to function, 3) scouting and prioritizing indicators for function, 4) linking indicator options to criteria options, and 5) options for setting GES. Scientific comments were consolidated by the ICES Secretariat and were addressed in plenary of the workshop. Comments considering the implications for the D6 Manual from the cross-cutting workshop were gathered by correspondence from the workshop participants immediately after ending the workshop. This was not successful and should be further elaborated upon. Both the workshop report and suggested changes to the D6 Manual will feed into an ICES review and advice drafting process.

The revised D6 manual (i.e. the advice product) will contribute to the MSFD WG GES meeting (22-23 April) as one of 13 background documents. Prior to the MSFD WGGES meeting DGENV will make the following documents available, i) cross-cutting paper ii) review of MSFD Annex III, and iii-xiii) revised descriptor 1-11 manuals.

Building on previous workshop findings

The follow-up ICES workshop (16–19 February 2015) on guidance for the review of MSFD decision descriptor 6 seafloor integrity II (WKGMSFDD6-II), builds on the progress made in the earlier review of D6 (seafloor integrity) in 2014. In the previous workshop it was suggested that existing criteria should better incorporate the key seafloor attributes that ensure that the structure and functions of the ecosystems are safeguarded. Thus, the workshop recommended merging existing D6 criteria (Decision 2010/477EU) and their developed indicators to a set of newly suggested criteria that were developed at the workshop that would be better suited for assessing progress towards GES for seafloor integrity (Figure 1).

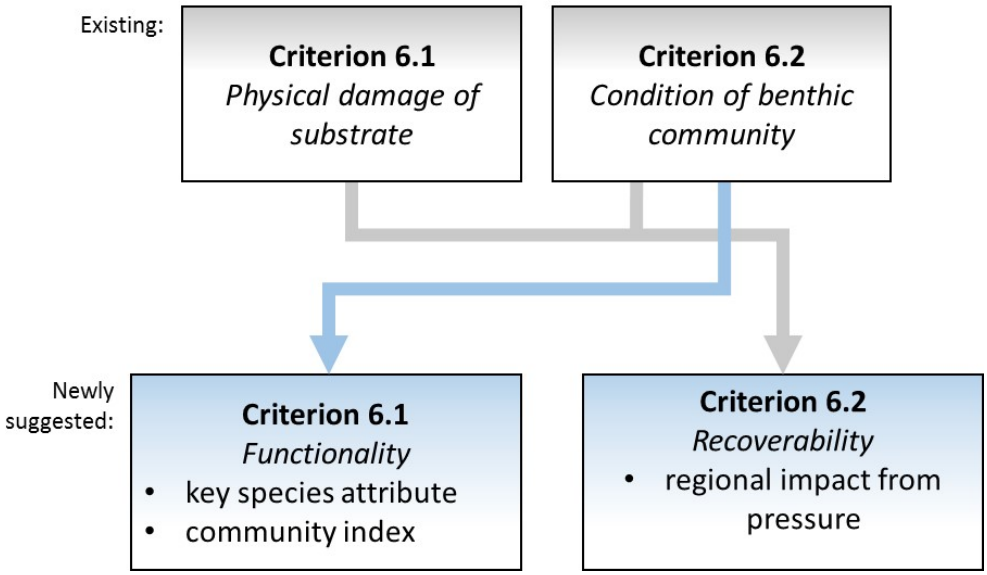

Figure 1. Conceptual diagram illustrating the suggested merging of existing and newly suggested criteria in the 2014 D6 workshop. "Existing criteria" are those at present set out in Decision 2010/477EU, i.e. "Physical Damage of Substrate" and "Condition of the benthic community". While "newly suggested criteria" are those suggested in the 2014 ICES workshop (WKGMSFDD6), i.e. "Functionality" and "Recoverability".

Agreed upon definitions for D6

The Marine Strategy Framework Directive (MSFD) addresses seafloor integrity under Descriptor 6. Good environmental status (GES) will be achieved when ***"seafloor 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."*** The 2014 ICES workshop (WKGMSFDD6, 2014) outlines some key definitions on how to interpret D6 (seafloor integrity). The following definitions were also adopted by the current workshop (WKGMSFDD6-II).

Seafloor is defined as a key compartment for marine life. It includes both the physical and chemical parameters of seabed (e.g. bathymetry, roughness (rugosity), sub-stratum type, oxygen supply, etc.) as well as the biotic composition of the benthic community. Different kinds of habitats for sedentary and mobile marine species are formed inside and above the seabed.

Integrity is interpreted as comprehending both (i) natural spatial connectivity (avoiding unnatural habitat fragmentation or connectivity), and natural ecosystem processes functioning in their characteristic ways.

Not adversely affected means that the cumulative effect of pressures associated with human activity are at a level that ensures the ecosystem maintains its respective components (structure) along with its natural levels of diversity, productivity, and dynamic ecological processes (functioning). Levels of disturbance (intensity, frequency, and spatial extent) must be at a level that ensures a dynamic recovery potential is maintained.

Recovery means that the impacted seafloor attributes show a clear trend towards their pre-perturbation conditions, and the trend is expected to continue (if pressures continue to be managed) until the attributes lie within their range of historical natural variation. Benthic communities are not static entities, and thus recovery does not re-quire that the ecosystem attributes return to their exact prior state.

Rapid must be interpreted in the context of the life histories of the species and natural rates of change in the community properties being perturbed. For some seafloor habitats and communities, recovery dynamics from perturbation would require multiple decades or more, and in such cases management should strive to prevent perturbations.

Impairment of an ecological component occurs if the ecological consequences of the direct or indirect perturbations extend widely through the ecosystem in space and/or time, or if the normal ecological linkages among species act to extend and amplify the effects of a perturbation rather than to dampen its effects.

State of a functioning seafloor and integrity

"State" for seafloor integrity (*sensu* above definitions) assumes that key ecological processes (functions) of the seafloor and benthic communities are collectively being expressed. Thus evaluating the status of single structural indicators is an important but not final step in assessing overall GES for seafloor integrity. The previous workshop identified nine inherent and integrative attributes of the seafloor: 1) Substrate, 2) Bio-engineers, 3) Oxygen, 4) Contaminants and Hazardous Substances, 5) Species Composition, 6) Size Composition, 7) Trophodynamics, 8) Life-history Traits, and 9) Habitat/Environmental heterogeneity and regional connectivity (ICES 2010 and ICES 2014). Several of these seafloor attributes interact in ways that may synergistically or antagonistically allow functions to be served (or compromised).

Heterogeneity or patchiness is an inherent property of the seafloor, and thus assessing state will also require integration of results from local scales, to a broader (sub-) regional scales. Natural environmental conditions (e.g. oxygen, substrate, pH, depth, organic content) and dispersal potential vary among different seafloor systems and spatial scales ranging from small local scales to large biogeographic scales. Many processes also vary in temporal scales that potentially affect both the benthic habitats and

the realized benthic community composition (e.g. species abundance and richness), as well as the recovery potential (e.g. seasonal peaks in recruitment). Thus across a healthy and functioning seafloor representative community types will be maintained in a region (beta diversity) by the subsequent dispersal (larval, post-larval and adults) over relatively shorter distances between locations and can ensure that recovery is rapid (source-sink dynamics) when natural or anthropogenic disturbances impact specific subpopulations in the region. Thus, sound assessments of GES will require integration of results from local scales, where both natural benthic ecosystems and pressures may be very patchy, into much larger regional or subregional scales.

Pressure acting on the seafloor

Patchiness also extends to anthropogenic disturbances to the seafloor, which result from an increasingly number of activities carried out not only in the marine environment but also in more or less distant on-land locations and reaching the coasts more or less concentrated. Spatial and time-scales are crucial. Multiple anthropogenic pressures, acting in isolation or in concert on the seafloor have important impacts on its integrity. In the context of the MSFD pressures acting on the state of the seafloor are created by driving forces, which are human activities, policies and environmental changes at regional scales.

Pressures causing physical habitat loss and damage arise from activities such as bottom-trawling fisheries, waste dumping, coastal defence, ports and navigational dredging, and aggregate extraction. Other pressures arise from inland activities such as agriculture and industries resulting in chemicals, nutrients or other pressures that are carried by rivers, have their initial inputs concentrated at river mouths and plume in the coastal waters. Activities occurring on the coast and inputting products or pressures directly into the sea are still clustered along the coastline as municipalities, industry sites, recreational centres, etc. Some marine activities are centred in nearshore or coastal areas, such as mariculture, recreation, mechanical energy, ports development, etc. Activities are often unevenly distributed along the coast on a regional scales. Similarly, activities that occur offshore are also unevenly distributed in space; fishing, shipping, mining, hydrocarbon production etc. are all concentrated in specific habitats, corridors, or sites. Consequently assessments of environmental status are almost always going to be done for areas that are a mosaic of different degrees and types of perturbations by human activities, making general statements of a pressure-state relationship difficult. However, in general, seafloor integrity can be affected by anthropogenic changes in the natural disturbance regime (size, frequency, and intensity) exerted. Thus D6 has many links to other descriptors, especially, eutrophication status (D5), alterations in hydrography (D7), concentration of contaminants (D8) which will need to be incorporated in the overall MSFD GES review process. Despite these cross-cutting issues, at a practical level it should be highlighted that the main goal of the MSFD is to develop well-suited policies (i.e. response) when GES of a particular descriptor or criterion in not achieved.

Impact: interaction between state and pressure

Most impact indicators of human activities on the seafloor are usually expected to apply to the biological attributes of the seafloor. However, direct and indirect ecological consequences of human activities may also be spread out considerably by physical and biotic processes although initial impacts are often local and patchy. In general, changes

to the seafloor habitats can have a homogenizing effect (eutrophication, hazardous substances) favouring specific disturbance tolerant species that are able to disperse and colonize more areas. This can be detected by changes in the community structure (dominance). Changes in connectivity can also change source-sink dynamics, and recovery potential of a disturbed site. Physical habitat loss can increase fragmentation of key habitats limiting the availability of source areas from which recruitment can occur. Ensuring seafloor integrity can minimize biodiversity loss (closely linked to D1). Depending on the region and habitat, useful regional scale state indicators can be beta-diversity (either the degree of change in species composition along a gradient or the variation between point locations) within predefined areas.

2 Discussion sessions

A series of Theme Sessions to compare and further elaborate on the existing and newly suggested criteria along the workshop's ToRs was organized by the chair and vice-chairs (Figure 2, Annex 1). Theme Session 1 (TS1) explored options to use an indicator for regional scale assessment and developed to support the existing criteria (6.1 "Physical damage"and 6.2 "Condition"), as well as addressing the newly suggested criterion "Recoverability". Theme Sessions 2 and 3 (TS2 and TS3) further elaborated on the function indicators, taking account of their link to existing structure indicators and function indicator prioritization. Theme Sessions 4 (TS4) aimed at linking indicator options to criteria options, whereas Theme Session 5 (TS5) considered options for setting boundaries for Good environmental status (GES).

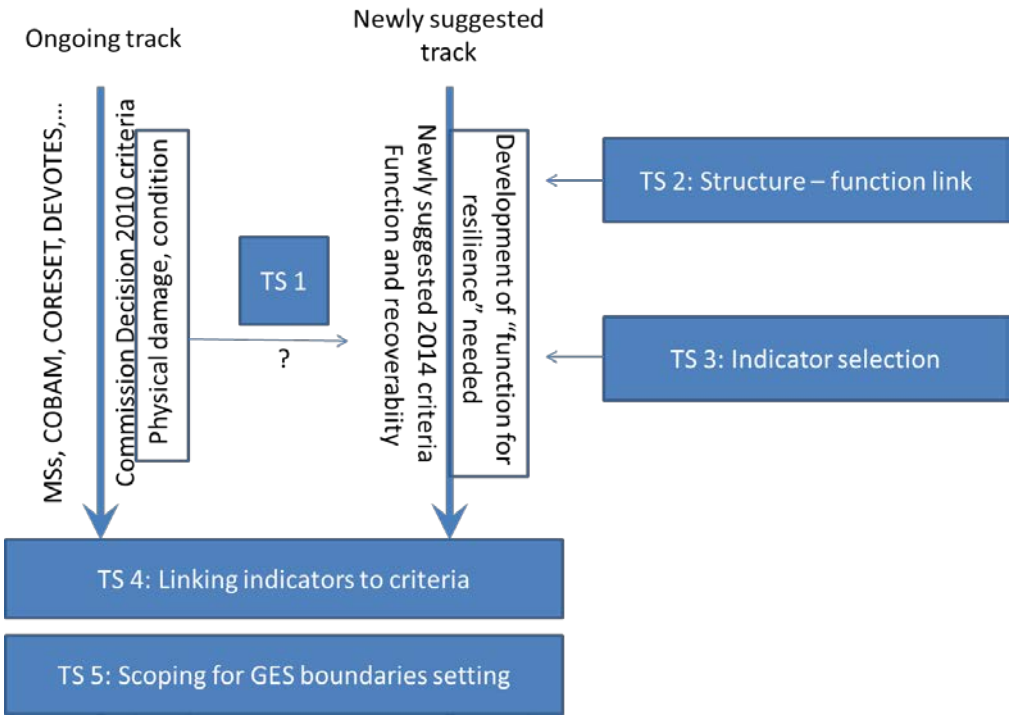

Figure 2. Overview diagram illustrating the ongoing and newly suggested tracks of MSFD implementation. Theme Sessions (TS 1-4) were used to provide the clarification and operationalization during the workshop.

Each Theme Session was populated with three questions (Annex 1), mainly to assist in directing and encouraging the discussion among participants. The Theme Session reports reflect on the main outcomes of these discussions and were structured along the main conclusions from the discussions, which may deviate from a mere addressing of the questions.

The following Theme Session reports summarize the breakout groups and open plenary discussions. The sessions as such allowed approaching the subject from different angles. The Theme Sessions hence proved to be a vehicle to facilitate the discussion and provide context setting, indispensable to achieving the final conclusion as outlined in section 5.

2.1 Session 1 - Regional-scale impact assessments

Introductory presentation

"Regional-scale impact indicators for assessing benthic habitats" (Jochen Krause, vice-chair)

It has been suggested that indicators to assess progress towards GES under criteria "6.1 – physical damage" and "6.2 – recoverability" will need to consider how pressure(s) and sensitivity of benthic habitats can be combined to evaluate impact across a large regional scale. A worked example (i.e. BH3) of this from the HELCOM and OSPAR approach was presented.

Key questions for subgroups:

Is the concept (so far developed) of BH3 in principle suitable to measure physical damage?

Is the concept (so far developed) of BH3 in principle suitable to measure recoverability?

In case the two concepts of BH3 and recoverability are different, how can they be merged?

Background

The actual state of development of an indicator for the existing criterion 6.1 "Physical damage" was introduced and conceptual parallels and differences with the newly suggested criterion "Recoverability" were discussed.

The existing criterion 6.1 "Physical damage" relies on the criss-crossing of pressures on seafloor and the benthic habitat cover/sensitivity. Therefore, the spatial extent and intensity of pressures induced by each source need to be assessed taking into account the environmental context, which fits in the MSFD's DPSIR approach. With the prior knowledge of the sources of pressure, estimating the actual pressures is a first step to the BH3 development. A presentation on this issue was given in plenary.

Status of the BH3 indicator for the existing criterion "physical damage"

The development of an indicator for the existing criterion 6.1 "Physical damage" of the COM Dec 2010 is conducted under OSPAR COBAM and in the HELCOM CORESET IIproject (Annex 8). A manual on the indicator is foreseen for the second half of 2015. In a nut shell, the indicator ("BH3" hereafter) is an index of the spatial footprint of the cumulative anthropogenic impact from physically damaging activities in a bioregion on predominant and special habitats according to Annex III of the MSFD. This is derived from interfacing a map of the spatial footprint of physical (mechanical) disturbance to the seabed with a map of the seabed habitat to which sensitivity scores to the disturbance are assigned. The resultant output is a prediction (model) of the spatial extent of physical impact per habitat type.

The indicator development is feasible as it does not require additional field sampling. Furthermore, BH3 includes recoverability and resilience as intrinsic aspects of the sensitivity of the different habitat types.

Suitability of the indicator for the criterion 6.1 "Physical damage"

The BH3 indicator is a model based index developed under the principle of a risk based approach for physical damage of the seafloor. The suggested scale of the analysis is the total area of a certain predominant or special habitat within a bioregion. Resistance is

considered taken into account as the ability of a given habitat or community to cope with a pressure measured by mortality. Recoverability is considered as recovery rate from an impact measured by reproduction rates and frequency. The development of BH3 so far, reflects physical damage, but has the potential to integrate physico-chemical disturbances (e. g. anoxic seafloors in the Baltic Sea).

As the BH3 is still under development, it was suggested to assess (1) if a generic assessment of resistance for each habitat type and all pressures is sufficient, and (2) how to best include or reflect biological traits.

The necessity of ground-truthing the various models of the approach and the importance of evaluating the indicator with increasing knowledge of habitat-impact relationships was highlighted. Currently, ground-truthing is suggested to be integrated in the assessments of the benthic indicators under the criterion 6.2 "Condition".

BH3 suitability for the newly suggested criterion "Recoverability"

Recoverability as currently used in BH3, only considers the properties of a (local) community, as a parameter contributing to the sensitivity of the community. However, to be able to assess recoverability of the system (as a criterion), also habitat fragmentation and connectivity could also be considered to assess whether a locally disturbed or destroyed habitat can actually recover. Therefore, BH3 covers major parts of the concept of recoverability. However, habitat heterogeneity and fragmentation, and connectivity are not fully integrated in the BH3 approach. The conceptual approach on how GES boundaries reflect on "recoverability" is the major difference between the concept of the newly suggested criterion "Recoverability" and the BH3 indicator. However, so far GES thresholds have not yet been developed.

Next planned steps in BH3 elaboration

- A manual for BH3, including GES boundaries for further discussions, needs to be developed.
- Improved knowledge of the extent and distribution of seafloor habitats is important for an improved accuracy of the suggested indicator and should be better reflected in the various European activities of seabed mapping.
- The inclusion of biological traits and functions in the underlying modes of sensitivity should be tested in further BH3 developmental steps.

2.2 Session 2 – Structure and function link

Introductory presentation

"Linking structure to function(s) that ensure seafloor integrity" (Silvana Birchenough, vice-chair)

How to prioritize functions under D6 is a key deliverable of the workshop. A state-of-the-art overview of definitions/status of structure and function links was provided. This better allowed workshop participants to understand how structural indicators can be used to measure function(s) that best ensure seafloor integrity is maintained.

Key questions for subgroups:

1) What functions will be feasible to prioritize?

2) Can structural indicators be used to measure function(s), what are other options available?

3) Can "Table 1" (ICES 2014) be strengthened and clarified to provide guidance, if so how?

What functions will be feasible to prioritize?

Functions are necessary to interpret structural changes and give an ecological insight on how to achieve GEnS (ecosystem services). Some suggestions, when assessing functions, as some function could be considered in two categories:

1) Functions common at regional or EU level- (e.g. primary production, secondary production). Some clear functions will be distinguished over large ecosystem assessments. This is the case, for example when looking at the characteristics of large and predominant habitats dominated by zoobenthos, or over specific biogenic reefs areas.
2) Functions specific to (sub) regions. Denitrification for example, is an important function of resilience to eutrophication in Baltic, but is less so in Mediterranean Sea)

Functions that are assessable through an existing, ongoing and operational method should be considered priority functions to assess seafloor integrity. For example, denitrification can be assessed via the bioturbation potential when combining species-abundance data collected by ongoing monitoring programmes, with existing data on sediment reworking traits. Similarly, secondary production can be estimated when combining species-abundance/biomass data with existing taxon-specific production-biomass ratio's.

The feasibility of incorporating indicators for ecosystem functioning in seafloor integrity assessment has to be tested by case studies. This testing process is similar to the process conducted by RSCs and ICES EGs for structural indicators. An example on the bioturbation potential is presented in Annex 6.

Contrary to ICES (2014), the workshop considered connectivity not to be a function but an important ecosystem attribute that is deemed to be relevant to support several functions. Connectivity hence is important to be assessed in relation to functions such as spawning grounds and feeding grounds.

Can structural indicators be used to measure function(s), what are other options available?

Structural indicators do not measure function themselves, but the underlying metrics can be used to calculate indicators for function (e.g. secondary production, bioturbation, biodiffusion, habitat formation). These function indicators are not operational at the moment, but the approaches are well developed and can be adapted. Some functions will need further longer term elaboration (or modelization, with local ground-truthing).

Making use of the same basic metrics (e.g. species abundance/biomass data), the same monitoring required for structural indicators can be used to assess the functional indicators.

Can "Table 1" be strengthened and clarified to provide guidance, if so how? There is a need to consider common and dedicated functions across different scales and (predominant and special) habitat types. Table 1 was further elaborated from the previous ICES

workshop to illustrate that there are functions that can be already identified across different seafloor attributes, habitat types and across scales (e.g. local and broad). More information will be needed in this table to provide dedicated guidance on what is operational or will need further development.

"Table 1" (ICES 2014) was also discussed with regards to sensitivity of functions and how these functions will be affected by different types of human activities (e.g. fishing, dredging, etc.). Depending on the scales and level of assessments (e.g. EU, regional and subregional), there are some available tools that can be used to represent dedicated functions (e.g. Biological Traits approach-BTA; habitat modelling, etc.). There is some published literature and research looking at some of these questions that could help to support further discussions on this topic. The group agreed that there is further work needed to answer this question at present.

The issues associated with structure and functions have clear links with D1 (and other descriptors e.g. D4 (trophic, productivity) as well as D5 for eutrophication issues). Structure and functions issues will need further elaboration from this table to ensure that these methods to measure processes to understand functions are fully operational and can directly complement to work well developed under structure indicators.

Table 1. An example of main benthic functions and potential seafloor attributes, indicators and scales that may help to provide linkages to structure and function (Table modified from ICES, 2014). The two columns "Seafloor attribute" and "Indicator or function" were kept from the previous report. Due to the shortage of time, they were not revised here, however, it was concluded, that these need a major revision.

Function		Seafloor attribute	Indicator of function	Scale	Operational
Provision of food	**Primary production**	Species/size composition Throphodynamics Life-history traits	Remote sensing on benthic productivity (intertidal zone) in situ subtidal	Local	
	Secondary production	Bioengineers Throphodynamics Life-history traits	Abundance/production of grazers filter feeders, deposit feeders detritivores, meiofauna **Secondary production** P/B rations Growth rates	Large	
	Provision of feeding grounds/food	Substrate Bioengineers Species/size composition	Seasonal occurrence/abundance of mobile organisms	Local	
Habitat structure	**Provision of spawning areas**	Bioengineers Oxygen Habitat environmental heterogeneity and regional connectivity	Occurrence/density of fish and other mobile organisms	Local	
	Sediment reworking	Bioengineers	**Bioturbation potential ,** different reworking abilities	Large	
	Sediment stabilization	substrate/bioengineers	Abundance/composition of bioengineer specie	Large	
	Provision of 3-D structure/ Permanent	Bioengineers (Kelp) Seasonal/permanent	Area extent of 3-D structure Area extent of 3-D structure	Large	

2.3 Session 3 – Scouting and prioritizing indicators for function

Introductory presentation

"Possible D6 indicators?" (Fernando Tempera, vice-chair)

A suite of benthic habitat indicators was compiled for the workshop from various sources (Member States, Regional Seas Conventions, and projects such as DEVOTES). An overview of these indicators was presented (Annex 5). This stimulated discussions on the most pragmatic approach, with an aim of producing a minimum set of operational indicators for seafloor integrity. Furthermore, it allowed workshop participants to become aware of the options available to link existing indicators with assessing GES for existing and newly suggested D6 criteria.

Key questions for subgroups:

1) Which indicator sets address the priority functions selected?

2) From those, which are operational or tangible per MSFD (sub-)region?

3) What could be a minimum set of indicators to assess seafloor integrity?

Background

A list of indicators potentially useful to assess the D6 criteria was compiled from MSFD Initial Assessments (Annex 5). This list was selected from different sources, namely: EU Directives, Regional Seas Conventions, Common Fisheries Policy and the project DEVOTES indicator catalogue. The table summarizes the high diversity of metrics considered relevant (>400 indicators) and where Member States have made use of them or proposed their use under marine-related legal instruments. A selection of functions (taken from WKGMSFDD6 in September 2014) potentially covered by each metric are also indicated, linking the list to the new proposed function-based framework.

The information in the table is instrumental to extract sub-selections of indicators covering a certain function. The habitat provisioning function (in the form of spawning area, feeding area or 3D structure) was exploited as a demonstration case. Forty-three (43) indicators were highlighted, of which 2/3 are considered operational. Most of these represent macrophyte indicators, suggesting that special habitats may be better covered than predominant habitats.

Endorsing specific functional and structural indicators will require a formal analysis using indicator suitability criteria (e.g. SMART, indicator criteria from the RSC). For those eventually selected indicators, there will be a need for methodologies (data requirements, formulation, spatial application, etc.) to be specified.

Functional indicators

It is also worth noting that most indicators listed do not straightforwardly address functions. Instead they are related to community composition (including species lists and richness and diversity metrics) or to structural aspects, such as the extent and pattern of biogenic structures. Because the compositional, structural, and functional aspects of natural systems are interdependent, some of the existing compositional or structural indicators may be used as proxies in an initial phase of function-based assessments. Secondary production functions, for instance, can be straightforwardly derived from basic benthic assessment parameters like abundance and biomass.

However, in a more advanced phase, or where compositional/structural metrics are insufficient proxies to function, it might be feasible to measure some functions directly,

which will involve measuring ecological processes directly (e.g. nutrient cycling, bioturbation, genetically based connectivity).

Raw information

As an alternative to analysing the indicator list, a more fundamental perspective of defining raw data requirements was followed by the workshop participants. Participants considered that species composition provides a basis to envisage the development/validation of relevant indicators because the main functions of the seafloor are inherent to species composition, abundance, biomass, and size classes.

Indicators focus

By using biological traits catalogues, the raw data considered above can be subsequently translated to the Functionality and Recoverability indicators endorsed by the newly suggested D6 framework (ICES 2014). In this perspective, two categories of indicators need to be distinguished:

i. Indicators informing on the species effects on their environment.

This category is to be based on species effect traits directly connected to the functions the organisms provide in the ecosystem. Among these effects are several functions (i.e. services) that the seafloor ensures for the marine ecosystem, such as sediment mixing, habitat creation, nutrient cycling, biomass production for higher trophic levels. Although some functions are beneficial only to the seafloor (e.g. habitat creation for seafloor species only), they are indirectly part of other functions beneficial to other marine ecosystem compartments (e.g. bentho-pelagic coupled processes, habitat creation enhancing biomass production which enhances energy flow at a foodweb level).

ii. Indicators informing on the species sensitivity, resilience and resistance to pressures.

This category is to encompass life-history traits as structural community components. Benthic communities can occur in naturally stressed/disturbed environments as well as stable ones. Environmental contexts need to be taken into account when selecting indicators. For instance, in a habitat stressed by a pressure that mimics a natural stress, assessing a taxon that is sensitive to natural stress is more relevant than assessing a resilient taxa.

The most critical seafloor functions will be highlighted by combinations of traits characterizing a feature's contribution to seafloor functioning and sensitivity/recoverability (Table 2).

Table 2. Indicator characteristics for identifying critical functional units of the seafloor.

Indicator	Functional contribution (effect traits)	Sensitivity to pressure (life–history traits)	Recoverability after pressure	Indicator relevance
Indicator 1	High	High	High	Low
Indicator 2	High	High	Low	High
Indicator 3	High	Low	High	Low
Indicator 4	High	Low	Low	Low
Indicator 5	Low	High	High	Low
Indicator 6	Low	High	Low	Low
Indicator 7	Low	Low	High	Low
Indicator 8	Low	Low	Low	Low

For simplicity an example considering three selected inherent indicator characteristics (functional contribution, sensitivity and recoverability) are independent from each other. However, they cannot *a priori* be considered independent when assessing the relevance of a synthetic indicator (e.g. group of species aggregated by trait) to a pressure. For instance, sensitivity and recoverability can perfectly match, compounding a single synthetic trait, but this type of synergies is not always the case. Where low recoverability is related to a strong temporal component, cases like that of indicator type 4, this will be highly relevant to long-term assessment and of little relevance in the short term.

Examples of seafloor functions can be captured by a single feature or by both features (effect functional traits and life-history (structural) species traits) (Table 3).

Table 3. Examples of the role of effect and structural species traits in capturing seafloor functions.

Seafloor process	Seafloor functions	Bioturbation typology (Effect traits)	Life-hisory typology (life-history traits)
Sediment reworking	Organic matter decomposition	+	+
	Nutrient recycling	+	
	Habitat creation (below sediment 3D structures)	+	
Biodiffusion	Nutrient recycling	+	
	Habitat creation (O2 concentration enhancement)	+	
Production	Primary productivity (food for higher trophic levels)		+
	Secondary productivity (food for higher trophic levels)		+
Biogenic reef formation	Habitat creation (above sediment 3D structures)	+	+
	Spawning grounds and/or nusery	+	+

Indicator calibration

When calibrating a responsive metric in a spatial context, it is also essential that confounding factors are eliminated (i.e. quantitatively removed from the measurements) prior to assessing the pressure effects (e.g. impact). The anthropogenic signal needs to be extracted from the data by removing the underlying environmental signal (e.g. natural biogeographical gradients). For instance, finding a comparatively low biomass site does not necessarily indicate a low habitat condition compared to a high biomass site. Both cases can represent natural conditions, with the low biomass representing a naturally stressed site vs. a naturally productive site.

Relative metrics (e.g. ratios, normalized scores, percentages, anomalies) capture the functional identity of habitats independently of production gradients. Using this approach, quantitative aspects are masked so that only functional aspects are considered.

In addition, potential differences in an indicator's sensitivity to pressure in different spatial contexts must also be assessed. This can be quantified by measuring the variation of the indicator's responsiveness along a pressure gradient in a context where natural conditions are considered to be homogeneous. Where no continuous pressure gradient can be found within a defined location, naturally analogue sites subject to a range of pressure levels in discrete locations may represent a useful alternative.

2.4 Session 4 – Linking indicator options to criteria options

Introductory presentation

"Methodological standards to measure progress towards GES: a D3 fishy example" (Mark Dickey-Collas, ICES)

An assessment of the seafloor under the MSFD will require alignment of operational indicators by MSFD ecoregion for each criteria option. A clear example of what an MSFD tailored assessment could look like (illustrated by D3) helped providing direction for D6 workshop participants.

Key questions for subgroups:

1) Minimum set of indicators under each criterion, new and old?
2) What is the status of these indicators in the MSFD ecoregions?
3) What are the long-term and short-term options?

Background

An assessment of the seafloor under the MSFD will require alignment of operational indicators by MSFD ecoregion for each criteria option.

This session aimed at finding the possible examples of the operational (or near operational) indicators best suiting the four criteria being considered. Subsequently, there was also a need to identify possible gaps and ways forward on the operationalization of a minimum set of indicators (considering issues of good coverage) under the proposed criteria (over short- and long-term perspective). During this exercise four criteria were considered, i.e. both existing criteria and both newly suggested criteria. A general desire is to have a short list of common indicators allowing to cover all criteria and allowing interregional comparison. It should however be acknowledged that most of the indicators developed so far have been based either on existing D6 criteria or criteria from other descriptors (D1, D4, D7). It is hence likely that the choice of indicators available may not fully cover newly proposed criteria.

Minimum set of indicators under each criterion, new and old?

There is not a simple way to determine a minimum set of indicators, which will cover the priority aspects of the existing and newly suggested criteria, but some considerations are considered relevant.

There is a conceptual overlap in the existing criterion "Condition" and the newly suggested criterion "Function" by utilizing same data characterizing status and condition of populations.

Table 4. Example of spread of existing indicators under existing and newly proposed criteria (example illustrated using OSPAR common indicators)

Existing criteria		Newly suggested criteria	
6.1. Physical damage	6.2. Benthic conditions	6.1. Functionality	6.2. Recoverabilty
BH3 pressure layer and habitat	Typical species (BH1) Abundance Biomass Areal extent Multimetric indices (BH2) Size spectra as a proxy for biomass. Relative dominance of key groups Groups associated with desired state Groups associated with degraded state	Trait-based analysis: state/condition[1] of the set of organisms comprising those functional groups that are key to the characteristic functioning of the habitat, as a proxy for function. Examples of such key traits: Habitat formation Bioturbation Biodeposition in nutrient cycling Relative dominance of key groups Groups associated with desired state Groups associated with degraded state	"BH3+" (sensitivity layer added, compared to the BH3 under 6.1 physical damage) Extinction threshold (metapopulation analysis)

[1] **State/condition of the groups could be assessed as abundance; biomass; age/size spectra of key species as a proxy for biomass; areal extent of habitat or habitat-forming species.**

Priority should be given to indicators responding to a pressure along a full pressure gradient, not only at extreme conditions. An indicator response to management measures indeed is very important. For example, many multimetric indices often do not react to management and pressures from human activities in intermediate situations. In such case, using state indicators (reflecting cumulative pressures) can be combined with pressure indicators (reflecting the distribution and intensity of a particular pressure). The lack of time-series is an issue, particularly, when developing good pressure-state relationships. Therefore, often other suitable methods (e.g. modelling) should be applied.

An alternative approach is illustrated by a German example, i.e. the combination of three types of indicators to be considered under the D6:

- physical damage, measuring pressures;
- special habitats (listed in the Habitat's directive), measuring extent, condition and function;
- predominant habitats, measuring condition and function.

What is the status of these indicators in the MSFD ecoregions?

A variety of indicators is being developed by Member States under Regional Seas Conventions (RSC) and projects covering different structural properties of the seafloor. The process in RSCs has resulted in a selection of common indicators to be operationalized in nearest future. However, in most cases the full operationalization has been delayed,

mainly due to shortcomings in development of all needed indicator properties (e.g. design/concept, established pressure relationships, monitoring program/strategy, assessment system including GES boundaries, data arrangements). The relevance to the new approach (assessing of *Functionality* and *Recoverability*) still need to be established in most of the cases.

What are the long-term and short-term options?

Further development of the concept needs consideration of activities achievable at short term and at longer term:

Short term

- Operationalize existing indicators (e.g. BH3)
- Process existing data on species composition, abundance and biomass to assess functionality, through for example biological trait analyses, bioturbation potential etc.
- Production and application of single pressure layers.

Short and long-term

- Develop a list of special functions tied to habitats and key functions of habitats and develop indicators to describe these - some are currently available, some should be still developed (e.g. remineraliztion)
- Describe functions – pragmatic approach specific for a given habitat type. In some cases the development of a pure function indicator can be very relevant.
- Development of concepts of combining pressure with sensitivity.
- Describing co-occurring pressures.
- Newly suggested criteria – developing from existing structural indicators or using the same parameters put in a functional framework of interpretation (e.g. species abundance data combined with biological traits analysis)

2.5 Session 5 – GES boundaries

Introductory presentation

"*DEVOTES and seafloor integrity research*" (Angel Borja, AZTI)

Information and case studies of recent outcomes of DEVOTES FP7 programme: methods and proposed criteria for testing indicators.

"*Methods and options applied in OSPAR and Barcelona conventions to set baseline and GES boundaries*" (Laurent Guérin, vice-chair)

Guiding principles for setting GES have been defined and agreed upon by some RSCs. Statistical principles to compute datasets to EcoQuality standards are described for benthic multimetric indices. This presentation aimed at facilitating achieving a common understanding among workshop participants on methods and options available to set baselines and GES for benthic habitats and seafloor integrity.

Key questions for subgroups:

1) Have baseline and targets been set for any previously identified "top D6 indicators", to measure progress towards GES? What are good examples of operational/implemented GES indicators?
2) Do general principles and options fit to all of these indicators (/types)? And if not, why and what are the alternatives?
3) How to amend D6 manual and EC Decision to reconcile and combine theoretical long-term common approach, as requested by MSFD, vs. short term and further gradual operational implementation?

Initial data and knowledge required before setting GES (e.g. issues associated with scale assessments and data requirements)

The scientific feasibility to set (ecologically meaningful) GES boundaries will very much depend on data availability. At present, most of the actually operational indicators developed under the RSCs or published in scientific literature, mainly describes what (meta)data are needed and the methodology necessary to compute EcoQuality values.

Additional tools such as habitat maps are available at biologically relevant levels (e.g. EUNIS 3 at a subregional resolution: e.g. MESH, EUSEAMAP, EMODNET) to EUNIS 5 for some areas and habitat types. Wide scale (subregional) assessments are mostly based on habitat maps and ground-truthing datasets, which are often collected over decades, with a limited reproducible short-term capability (<10 years). The subregional assessment should be stratified by habitat types, i.e. predominant and special habitats.

An example under the OSPAR "BH3-Physical damage" indicator, has considered the scale of the analysis as the the total area of each predominant or special habitat in the marine waters within a bioregion. Special habitats (*sensu* D7 and Habitat Directive, e.g. spawning and feeding areas) should be considered during assessments, but at present some of the available data to support these types of analysis are scarce. When there is a lack of datasets, particularly over a finer scale assessments, (e.g. outside the scope of EUNIS 3 level) there is opportunity to use models (e.g. of distribution, and potentially reference states) helping to ground-truth maps and supporting the validation process.

Several fine spatial- or temporal-scale time-series (point based information) are available for some habitats defined at EUNIS level 5. However, these datasets are quiet scarce at the subregional scale. For the OSPAR "BH1-typical species" and "BH2-Benthic habitat community condition" indicators, the relevant scale of the analysis is the community level (EUNIS level 5-6). To support the analysis of these indicators, there is a need to analyse associated environmental datasets (e.g. depth, temperature, grain size, organic matter content, oxygen, etc.), to provide context, these datasets are often available. Furthermore, associated pressure data, at a relevant scale, however are often scarce.

Environmental datasets are very important parameters for interpreting biological information and may often be a proxy to relate to a pressure type.

Some case studies (e.g. Dauvin, 2007) highlighted that using historical (e.g. decades) data as a reference state to assess community condition, may not be relevant to community structure based indicators. This is due to the natural long-term variability/evolution of environment (e.g. global change) and communities. Furthermore, time-series (e.g. reference and assessment sites) are needed to disentangle the potential "background noise" of e.g. global change from finer scale anthropogenic pressure effects.

A geographical network of comparable time-series (cf. Water Framework Directive) would help to address this at wider scale (subregional). Time-series are further needed to estimate recoverability at all biological and spatial scales, i.e. the time needed to recover as an intrinsic capacity of the community. Recoverability has to be estimated by quantifying the change of the condition, as pressure decreases.

Options to assess GES (from data to EcoQuality value; Figure 3)

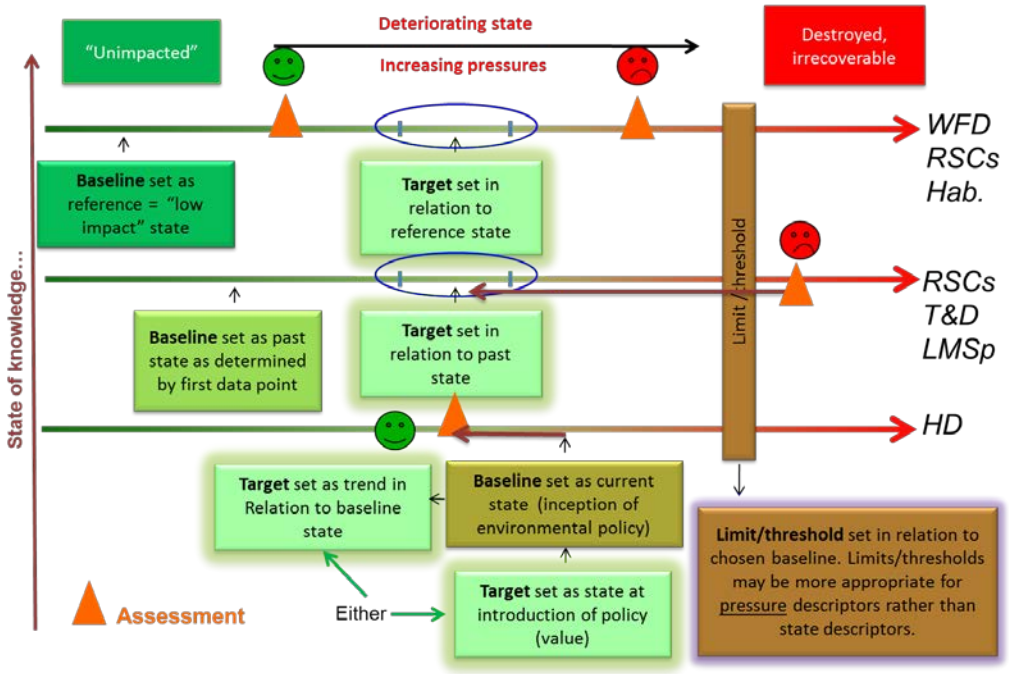

Figure 3. A conceptual baseline and Good environmental status (GES) methods and options for implementation of biodiversity indicators with the view to support management uses (e.g. distance to or reached GES). Figure taken from OSPAR, 2011).

At short term (actually operational, or operational by 2016), a combination of (nested) options is recommended:

i) The biological quality of a habitat and its community needs to be assessed at fine scale (biological and geographical) whereas total impact needs to be assessed across the entire extent of the habitat. The assessment of impact intensity should be based and quantified on pressure (spatial and temporal gradient of intensity) vs. condition (structure and functions) relationship. To objectively calibrate a state indicator for GES (i.e. acceptable level of pressure or guaranteeing resilience) there is a need for understand this system. A reference area (lower impact or minimal impact) often exists at this scale for several pressure types (e.g. for physical damage, but less obvious for eutrophication in Baltic Sea). This type of baseline, is more robust and should be favoured, in accordance to the RSC' guidance. The target (e.g. GES) should thus be an acceptable deviation from this baseline;

ii) Habitat, pressure layers and sampled data at finer scale will help to assess the total extent of impacts for each habitat type at a suitable bioregion scale. Reference areas (lower impacts or minimal impacts) may often be less clearly (or incompletely) defined at this scale. In a preliminary approach, OSPAR BH3 indicator aims to compute an index to estimate spatial extend (footprints) of considered pressure. For condition, a

wide scale ground-truthing, a pragmatic approach (used in HELCOM), can used a percentage of "best state stations", helping to serve as a baseline. However, available data and the sampling design (and notably its repeatability) influence strongly the robustness of these approaches.

Quantitative GES principles (e.g. value or threshold) still have to be further defined for both approaches (OSPAR and HELCOM). At short term, a target (towards achieving GES) could be a positive trend (diminution of intensity and extend of impact) from actual state.

Functional aspects

GES process (data to EcoQuality values) should incorporate at each step available information on main functions (cf. session 2) supporting ecosystem functioning. This gives complements on ecological meaning. At short term, functional information could be partially extrapolated from structural indicators and data (e.g. species composition and functional traits of species or community). Both structure and functions information has to be considered for setting ecologically coherent and meaningful GES for habitats.

Quality assurance and transparency of GES setting methods:

For any selected options, there must be a clear understanding of "how" and "what" is assessed by each used indicator and by GES (e.g. intrinsic sensitivity, state/impact/pressure relationship, scale, etc.). Even if complex (e.g. multivariate statistics), the process from data to EcoQuality values have to be clearly described, with its potential (area and criteria assessed, according to available relevant data) and limits (quantified level of uncertainty, according to method and/or unavailable relevant data). In some cases the use of expert judgements has to be used during each step (e.g. as an adopted stepwise approach to be later on fully analysed and checked by experts). Threshold values and decision trees could help to support as some of these decision stages and help to communicate assessment results to ensure transparency.

3 Specific recommendations from Theme Sessions 1–5

Theme session 1 recommendations

- The concept of recoverability as currently used in BH3, only considers the properties of a (local) community, as a parameter contributing to the sensitivity of the community. However, to be able to assess recoverability of the system (as a criterion), habitat fragmentation and connectivity should also be considered to assess whether a locally disturbed or destroyed habitat can actually recover.
- The development of BH3 so far, reflects physical damage, but has the potential to integrate physico-chemical disturbances (e. g. anoxic seafloors in the Baltic Sea).

Theme session 2 recommendations

- Structure and function were discussed at the workshop. The overall view was that these two aspects are complementary as these provide answers of the species present and their role in the seafloor. Structure and functions are needed for understanding seafloor integrity;
- There are some well-developed methods available that can be used to illustrate certain functions. Some additional work will have to be undertaken to ensure that methods are standardized, scales and type of datasets are fit for purpose of these assessments, if these indicators will be adopted as operational indicators by MSs;
- The same information collected for structural indicators in benthic monitoring (e.g. abundance and biomass) can be used to calculate some key mediated faunal processes for understanding some of the functional indicators;
- There is a need to provide further guidance in relation to what functions (e.g. common and specific ones), over which scales and habitats types (e.g. common and predominant), could be considered as common and specific functions in seabed systems;
- Measuring benthic function (e.g. secondary production) could be done, depending on the aims and level of resources, but there are already existing algorithms that could allow to calculate secondary production from existing structural datasets (see Brey 2001);
- There are short-term indicators that may be available for function and there will be a need to develop further indicators (e.g. over long-term) to allow an accurate understanding of seafloor systems.

Theme Session 3 recommendations

- The indicator list (Annex 5) is not to be considered finalized. Further work will be required would include:
    - Reducing/simplifying the list of indicator by discarding: (i) non-operational indicators, (ii) indicators that have had limited usage throughout the regions and Member States, (iii) indicators that do not relate to specific functions;
    - Positively identifying the responsiveness of each indicator to specific pressures;

  - Refining the list of functions potentially conveyed by each indicator (see also recommendation in TS2);
  - Analysing the list to identify gaps in indicators addressing certain functions (see TS2);
  - Focusing on a selection of indicators relevant/used in multiple legal instruments, exploiting monitoring and assessment synergies.
- It was considered that the provision of information on a number of functions (e.g. whether common or specific over certain habitat types) is required, therefore, basic information including: species composition, abundance per species and spatial extent of habitat or relevant biological (habitat-forming species) coverages;
- Having biomass per species and age-size spectra, which are less commonly available, would facilitate building indicators of a broader variety of functions, but can also be relevant to selected species (e.g. targeted by fisheries, long-lived);
- Where these data are not already available or being monitored, collating them will require either fieldwork or the use of remote sensing techniques (if reliable information on abundance and biomass estimates can be extracted from these methods);
- Use relevant structural and functional features of benthic habitats by selecting the best compromise between functional contribution, sensitivity and recoverability. Prior to indicator selection, it is important to understand the fundamental ecological features of assessed zones to disentangle human pressures from natural variability;
- Selected metrics selected need to be estimated in a manner that makes them independent from natural gradients.

Theme Session 4 recommendations:

- Operationalize the existing indicators in short-term perspective to allow robust seabed assessments;
- Newly proposed indicators for assessing recoverability should be clarified and guidance should be developed (short term and long term).

Theme Session 5 recommendations:

- At short term, GES objectives could be based on demonstrating positive trends or on achieving target values, but should always guarantee recoverability at all relevant scales, and assumes no further deterioration from existing status;
- When no sufficient information is available to asses quantitatively GES (e.g. no sufficient or relevant pressure information), precautionary principle should be applied to guarantee recoverability (reduce pressure to the minimum known, per habitat type, to have reversible impacts);
- Based on the current MSFD guidance, if the first cycle of assessment and reporting is limited by available data and knowledge (both on extend and intensity of impacts). There will be a need for a significant progress to improve knowledge, at short and longer terms, which will have to be planned for and demonstrated by MSs;

- Even if incomplete, the first MSFD cycle of subregional assessment of benthic habitats will help to increase knowledge, and to identify knowledge gaps to be filled as a new priorities;
- An integrated process still has to be further conceptually developed, tested and implemented to assess seafloor integrity at Descriptor 6 level (e.g. how to integrate indicators and criteria information, and inter-Descriptor cross-cutting issues, through nested relevant scales?);
- International research programmes including new case studies, on available data or new data acquired by relevant sampling designs, would be necessary to progress significantly for the next MSFD reporting cycle.

4 Workshop conclusions and recommendations

The workshop concluded that (1) functional attributes are to be considered within seafloor integrity, (2) the inclusion of functional attributes do not necessarily necessitate the collection of new monitoring data (3) there is no consensus on the synonymy between the existing criteria "Physical damage" and "Condition" vs. newly proposed criterion "Recoverability", and (4) cumulative pressure effects have to receive better attention.

Functional attributes and seafloor integrity

Based on the current understanding and implementation of the indicators under the existing criteria "Benthic condition" and "Physical damage", both criteria are considered targeting structural attributes of seafloor integrity and pressure-effect relationships. Seafloor functioning is explicitly mentioned by the Directive, but seems to have been only poorly addressed in the current implementation cycle. The workshop concluded that there is added value in including functioning in seafloor integrity assessment, for which obviously the current Commission Decision does not appropriately accommodate.

Functional attributes and data needs

The workshop identified several processes that can be measured to inform seafloor functioning (e.g. secondary production, bioturbation potential) that can be derived from already collected data on structural assets of the seafloor (e.g. species-abundance data) in combination with existing biological trait data (e.g. sediment reworking mode, P/B ratio). The inclusion of these indicators should hence be considered as a complementary perspective of (existing) data interpretation rather than an extra work load in data collection. While monitoring data may be available, major progress is yet to be made at the level of setting thresholds for GES.

Existing criteria "Physical damage" and "Condition" vs. newly proposed criterion "Recoverability"

The workshop identified that while there may be parallels between the current interpretation and implementation of the existing criterion 1 "Physical damage", and the newly suggested criterion "Recoverability", there is no scientific consensus on their synonymy. The conclusion of merging existing criteria "Physical damage" and "Condition" into the newly suggested criterion "Recoverability" as suggested by ICES (2014), was hence not unanimously supported by the workshop.

Single pressure vs. cumulative pressure effects

The workshop further concluded that the currently considered pressures are predominantly targeting single pressures, while multiple pressures (cf. cumulative effects) are considered important yet generally lacking from the current implementation. Given the importance of cumulative pressures assessment, these are to be explicitly considered in the assessment of seafloor integrity.

The workshop therefore proposes to adopt a concept including three criteria themes (i.e. pressure, state and impact) when revising the Commission Decision (Figure 4). This concept has close links with the existing and newly suggested criteria (Annex 7) and allows incorporating existing and newly suggested criteria. The criteria themes should be considered precedents for criteria specification, but the workshop lacked

time to consolidate the criteria themes into solid criteria. The main boxes represent pressures on and state of the seafloor. Within pressures, single pressures should be considered as well as finally the cumulative effects of multiple pressures. State includes structural aspects of the benthic habitats/communities as well as the functions provided. The large horizontal boxes indicate that all of these aspects can be assessed locally focusing on intensity as well as considering spatial distribution (including the variation in intensity), taking into account the sources of pressure and the way they produce these pressures, under specific conditions. By overlaying the spatial distributions of the intensities of pressures with that of structures and/or functions, an assessment of the impact of the pressures can be obtained (such as demonstrated by the example of the OSPAR Common Indicator BH3).

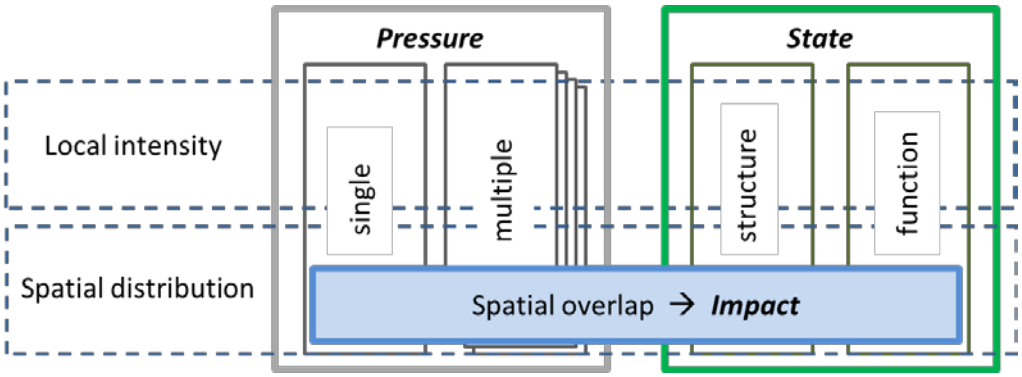

Figure 4. Conceptual diagram, illustrating the link and interactions between newly proposed criteria themes "Pressure", "State" and "Impact" with indication of specific aspects to be considered (i.e. single and cumulative pressure effects, structural and functional state attributes) and spatial scale of assessment (i.e. local and spatial distribution).

Further recommendations on the operationalization of the proposed concept

The workshop identified further steps to be taken in operationalization of the proposed concept. Both short-term (2016) and long-term (2018) actions were distinguished that could be best addressed by a series of expert workshops, that incudes relevant scientific and operational expertise from all MSFD ecoregions together with key stakeholders, projects, and RSCs.

Short-term actions, "proof of concept" (2015-2016)

Develop and test methodical standards for assessing human pressures on benthic habitats within and between MSFD regions. This coordinated development can be achieved using a series of dedicated workshops and intercessional work to support regional indicator development, in particular under the proposed criteria themes (1) pressure (2) state, and (3) impact. Using regional specific indicators under each criterion, assessment methods can be established to measure progress towards ecoregion targets relating to three criteria themes that best reflect seafloor integrity. This would include:

- Address cross cutting issues from a D6 perspective, including the resolution of seabed (habitat) types and assessment scales to be used;
- Consolidate the list of key functions to be addressed across and within MSFD ecoregions;

- Distinguish those requiring the collection of additional information from those for which ongoing monitoring programmes already deliver the required data (i.e. low hanging fruit);
- Identify the necessary set of criteria together with scientific suggestions on the critical values of good and bad as GES boundaries;
- Identify and select the minimum set of indicators (including scientific thresholds) that allow an accurate and practical assessment for each criterion to be carried out in MSFD ecoregions (taking into account regional specificity).

The overarching aim in the short term is to produce guiding principles that ensures alignment between GES boundaries for seafloor integrity to avoid giving conflicting results between regions, methods, and regional specific indicator species.

Long-term actions, "implementation across MSFD ecoregions" (2017-2018)

Develop common and complementary approach between D1, D4 and D6 for exploring regional specific pressure state relationships. This work should include:

- Harmonize the setting of GES boundaries between different descriptors and their criteria;
- Define the list of habitats to be assessed (e.g. habitats of conservation interest, predominant habitats subject to widespread pressures, etc.);
- Address issues of scale by defining e.g. at what EUNIS hierarchical level habitats are going to be addressed;
- Define local/regional approach to an MSFD assessment, which includes the aggregation rules required.

The overarching aim in the long-term actions is to better align cross-descriptor and other relevant legislation in the setting GES boundaries for the benthos. This will avoid duplication of work under different legislation, as well as avoid giving conflicting results between regions, methods, and regional specific indicator species.

5 MS Comments/ Response

Comments related to the reluctance to adopt the newly suggested criteria

Member States responded on the D6 manual provided by ICES in September 2014 with various amendments on the suggested substitution of the two criteria (physical damage, condition) proposed by the Com Dec (2010) with two new criteria (functionality, recoverability). However, a substantial number of amendments can be summarized in two classes of reluctance against this suggestion: those that rejected the suggestion because of principal conceptual reservations and those that denied the applicability because of practical issues.

The workshop analysed and discussed first of all the conceptual differences between the four criteria as equally valuable concepts and identified "functionality" and "condition" as complementary concepts from a scientific point of view. However, the old criterion "physical damage" and actual instruments for its implementation seem to have the ability to be an important tool for the assessment of seabed integrity whereas the new criterion "recoverability" seems not to have this quality.

The workshop demonstrated that the metrics collected for structure indicators can be used to assess several function indicators did not discuss practicalities such as existing tangible monitoring strategies and assessment schemes for each criterion. The need of the Member States on feasible monitoring programs was highlighted but can only be addressed in future steps.

Responses to other comments

	Comment/input to D6 Manual	Response to comments
1	I would have thought that it was difficult enough to monitor change in the condition of benthic communities and changes due to physical damage. Surely considering functionality and recoverability, although laudable, simply makes a difficult task near impossible? This approach seems to fit with the current OSPAR work developing their BH3 indicator as it is based on the sensitivity of habitats (resilience and resistance). Further consideration is needed. ICES should liaise with the OSPAR COBAM group to check.	The workshop suggested that BH3 indicator developed in OSPAR area is an appropriate indicator to address criterion 6.1 "Physical damage". Recoverability as currently used in BH3, only considers the properties of a (local) community in itself, as a parameter contributing to the sensitivity of the community. However, to be able to assess recoverability of the system (as a criterion), there will need to be further consideration of habitat fragmentation and connectivity. These attributes, will have to be considered to assess whether a locally disturbed or destroyed habitat can actually recover. The BH3 indicators, hence covers major parts of the concept of recoverability. For further explanation see Chapter 3 Session 1 of the report.
2	Thresholds would be a better word than tipping point. Setting reference points is very challenging because of large data gaps. Also, it is not clear if this is referring to particular biotopes/biotope types or benthic ecosystems. While this seems perfectly correct, are we sure we have the evidence on which to base such decisions? Do we really know enough, and have we the data, to do this?	There have been a lot of developments in RSC and MSs which utilize different approaches for setting GES boundaries or reference conditions. These include the development of basic habitat maps or establishing dataseries. A multitude of approaches can be used here. For detailed discussion see Chapter 3 session 5.
3	Generally we do not know enough to do this and nor do we have the data. Regarding connectivity other aspects are also key, such the degree and period of time of the impacts, if habitat loss has occurred (no recovery is possible) etc. Also, to establish a principle of connectivity to guide indicator work is not an easy task, and it will depend upon the habitat type and species, so connectivity might aid recovery of some components but not others	Connectivity is an important part of the recoverability potential. The currently developed BH3 indicator partly covers some of these issues. However, habitat heterogeneity, fragmentation and connectivity are not fully integrated in the BH3 approach. Further efforts are needed to bring these aspects into an operational level.
4	Re pressure indicators: Need to reflect that this may be the only indicator we can cost-effectively measure for some habitats	The workshop agrees with that statement. Some aspects of pressure are captured in indicators reflecting the "footprint" on the seafloor, the work developed under the BH3 (under the OSPAR work).
5	ISSUES FOR FURTHER DISCUSSION: Scientific guidance will be required in prioritizing functions to be assessed under each criteria, as well as choosing indicators and establishing GES boundaries for seafloor integrity (with reference points and targets), both in revisions the Decision 2010/477/EC and in its implementation by RSCs and Member Countries.	Ecosystem functions and processes will only be addressed in as much as they show sensitivity to the existing pressures. The issue on how to prioritize functions, will depend on where more than one site/area are affected. The overall issue is considered to be important, but it was not possible this issue in its entirety at the current meeting.

	Comment/input to D6 Manual	Response to comments
6	It is true that the seafloor, as well as the water column show a natural high dynamics both in space and time, due to natural processes (tide, waves, etc.). It cannot be considered as a disturbance, but as a natural range of variation. Source of pressures may modify this water and sediment dynamic.	It is absolutely true that natural variability of physical forcing cannot be treated as pressure. Scaling of pressure and especially quantification of impact should be done on detailed information. There are several indicators (available and under development) that are incorporating these aspects.
7	Attributes quoted in fig 1 were only partially considered in the comdec2010/477 for D6, but O2, heterogeneity, contaminants have been taken in account in D5, D7, D4(?).	There are obvious links with other Descriptors when dealing with describing the status of Seafloor integrity. The participants of the workshop were given the opportunity to feedback issues associated with Cross-cutting issues, as these full issues were not discussed at the workshop. Some of these aspects should be incorporated under the new concept of combing "pressure", "state" and "impact" as proposed in Chapter 5.
8	Recommendations: The physical aspect of GES is a main link between human activities/occupations and alteration of ecosystem, and is, together with considering the natural variation of hydrodynamics and sediment dynamics, an essential tool to understand the alteration processes and to allow weighing the real impact of human activities, and adapting programme of measures towards balanced environmental and economic targets. Whichever descriptor will embed it, integration of physical indices (typology and intensity of pressures, index of bottom mobility) must not be neglected.	The workshop agreed that physical context (hydrodynamics and morphodynamics nearby the seafloor) should be taken into account under pressure assessments. As far as local intensity and spatial distribution are concerned (see figure 4). This issue appears to be upstream of the BH3 development, which is currently being tackled by several MSs. Therefore, a networking on this specific topic may prove useful.
9	General comment: As already announced on WG GES we have principal reservations against deleting the original indicators “6.1 physical damage” and “6.2 condition of benthic community” of the COM Dec 2010 and to foster instead two new indicators named “functionality” and “recoverability”.	During the workshop the current approach to D6 has been strengthened. The overall conceptual integration of the three components has been considered relevant to a seafloor integrity assessment. These are: structurally based state information, knowledge of benthic sensitivity and a quantification of relevant pressures. So there is no intention to dismiss the original 6.1 and 6.2 criteria, but to develop a new concept combing the information on pressure, state (including structure and function) through impact on seafloor. For clarification see Chapter 5 and overall schematics.

	Comment/input to D6 Manual	Response to comments
10	General comment: Since the relevant 2010 COM Decision many activities were started nationally and under the Regional Sea Conventions, e. g. OSPAR and HELCOM, to further develop "physical damage" and "condition of benthic community". Firstly neglecting the work so far undertaken on these indicators and secondly introducing two practically new concepts, rather than scientifically new concepts, should only be done for very strong reasons and after intensive discussion with the appropriate bodies or groups. Both of these prerequisites are not given to date. On the ICES D6 meeting on "seafloor integrity" in September 2014 the relevant working group representatives of the regional conventions or national working groups have neither been invited nor present.	Workshop discussed this topic and general statement. There is no intention to neglect the existing and previous efforts. There is a clear need to improve the developments of indicators and make them operational under the existing criteria. Instead these new concepts were proposed, which incorporates some of the existing aspects as well as adding new features these new additions will improve the current understanding of seafloor integrity. See Chapter 5 and figures in it for illustration of the concept.
11	General comments: We disagree with some of the results of the D6 group, e. g. that the original indicators are per-se risk comprising in the ability to assess seafloor integrity. We agree that functionality and recoverability should be reflected in the final indicators for seafloor integrity, but they have to be in cooperated into already existing monitoring concepts and assessment programmes.	At the workshop discussion on the topic and general statements were undertaken. There is no intention to neglect the existing and previous indicators efforts and developments under the existing criteria. Instead the new concepts were proposed which incorporates already developed aspects and indicators and adds features not considered under existing criteria. These new attributes will considerably improve the understanding of seafloor integrity. See Chapter 5 and Figures for illustration of this concept.
12	General comment: We disagree with the result that the two newly proposed indicators can be based on existing monitoring. To date, none of the indicator examples in table 1 (p. 9 of the D6 manual) for measuring seafloor functioning is part of an official monitoring programme in Germany, nor is it known to be measured in that way in any other Member State. Many of the examples given have scientific measure procedures, however most of them are currently not transformed in large-scale official areal monitoring for Member States obligations.	Workshop was in general agreement that the newly proposed concept incorporates in most cases the information collected or available under existing monitoring and data collection schemes. Functionality aspects can be addressed in most cases through combing existing structural data with additional existing information e.g. functional traits databases, modelled pressure layers etc.
13	General comment: We would like to point out that the questions (1) how function and recoverability can be directly linked to existing or future anthropogenic pressures, (2) how they reflect the given parameters predominant and sensitive habitats in Annex III Table 1 MSFD and (3) how ecosystem tipping points can be measured practically as a GES threshold; are not explained sufficiently within the manual.	We would therefore like to ask ICES to establish a new working group on D6 in due course. This group will brings together their ideas and the practical work done on D6 indicators of the Com Dec 2010 in the Regional Sea Conventions and in some Member States.

	Comment/input to D6 Manual	Response to comments
14	General comment: While we agree that some of the previous indicators for seafloor integrity were insufficient and difficult to operate with in practice, as the Art. 12 reporting review demonstrates, we believe that the process of the MSFD COM Decision review (similar to D3) has failed. We are not happy with the interpretation of the outcome of the D6 workshop for the following main reasons: • The conclusion to skip all previous indicators does not properly reflect the workshop discussions and conclusions; and • Key standards from other pieces of EU legislation (Habitats Directive) and/or international and RSC norms were omitted to be scrutinized with regard to their value as supporting guidance to the application of the criteria.	Workshop discussed the topic and general statement is that there is no any wish to neglect the existing and previous efforts and developments in operationalization of indicators under existing criteria. Instead the new concept was proposed which incorporates already developed aspects and indicators (national and those developed at RSC) and adds features not considered under existing criteria but considerably improve the understanding of seafloor integrity. See Chapter 5 and figures in it for illustration of the concept. The synergies with other EU legislation was not really discussed at the workshop except that different approaches can be used for assessing different types of habitats (predominant-MSFD or special-HD), see Chapter 3 Session 4.
15	General comment: The suggestion from the ICES core group and the majority of the workshop participants was to delete the current criteria in the D6 part of the COM Decision. However, we had agreed with the chairs of the workshop that at least criteria 6.1 "Physical damage" should be kept in. Instead, at the end of the meeting the core group decided that the two criteria in the COM Decision should be taken out and instead of them two new criteria should be filled in: "Recoverability" and "Functionality". Reference is made to the original D6 workshop text which reads "There is not full certainty in some experts that all changes captured in the original 6.1 would be captured in assessments used in the new 6.1 and 6.2.	During the workshop new concept, combing the previous, existing and new approach was proposed which allows to keep all the indicators developed under existing framework and add the missing parts of the information needed to fully address the seafloor integrity. For schematic presentation see Chapter 5 and figures in it.

	Comment/input to D6 Manual	Response to comments
16	Criteria 6.1. "Physical damage" should be kept in the Decision: the criteria will help assess the spatial extent and intensity of physical pressures and the spatial extent and sensitivity of benthic habitats. This will account for the pressures on different substrate types causing physical damage or loss to seafloor habitats and the proportion of habitat area permanently or temporarily affected by anthropogenic use. Among the substrate types, biogenic substrata, which are the most sensitive to physical disturbance, provide a range of functions (which are part of criteria 6.2) that support benthic habitats and communities. A sufficient area of each habitat should not be adversely affected by the following anthropogenic changes (which must be part of the assessment): • Changes in siltation • Abrasion e.g. by bottom gear • Selective extraction • Oxygen depletion • Sealing and Smothering.	In order to determine the cumulative physical impact on a particular habitat, the separate impacts have to be summarized. Most approaches to assess cumulative impacts assume additive effects for lack of knowledge of actual responses of benthic habitats. It is proposed to follow this practice as the physical pressures regarded here are assumed to affect habitat structure and suitability in a similar mode. Furthermore, we would like to caution against the use of "Recoverability" without using proper time-scales in general: the criteria works for sensitive habitats, reefs, deep-sea VMEs etc., However it does not work for a number of key European marine habitats consisting of sand, mud, gravel etc. They may all be recoverable within a certain time frame. The timelines have to be consistent with the politically agreed ones to achieve GES.

	Comment/input to D6 Manual	Response to comments
17	General comment: Linkages with international and RSC norms and standards The referenced JRC statement "There is very low integration between D6 and RSC and this shows a gap in the development of agreed methods for the implementation of D6 on regional level" may only be applicable to the fact that the EU Member States and bodies overseeing MSFD implementation asa well as the RSCs referred to are struggling with the methodology to measure seafloor integrity as this exercise clearly shows once more. The statement, however, ignores that international bodies as well as RSCs and RFMOs have rolled out scientifically corroborated guidance as to which benthic habitats and communities are particularly vulnerable, threatened or declining. Again, detailed reference should be made to • Vulnerable Marine Ecosystems (VMEs) as defined by the respective FAO Guidelines • VME indicator species for certain regions (NE Atlantic) adopted by NEAFC following ICES advice • Benthic habitats / communities included in the OSPAR List of Threatened and/or Declining Species and Habitats (reviewed by ICES) with a view to providing concise guidance for the application of the D6 criteria.	This aspect was not discussed during the workshop but is considered an important topic for future discussions. Future steps shall include the definition of a concise list of habitats to be assessed which may include not only special habitats defined by EU Directives and RSCs as well as predominant habitats that are heavily affected or suffered significant reductions.
18	Figure Criterion 6.1 "within their historical range" As boundary conditions may have changed over time, having caused shift in potential ecosystem functions that can be delivered at a particular location, historical range of natural variation may not be the most suitable frame of reference.	Workshop was on opinion that reference conditions and GES boundaries should be set on the basis of available information and several methods can be utilized here. Setting those reference conditions should take into account the possible local baseline shifts or other processes affecting the quality of target setting.
19	"at many scales" Seafloor properties and benthic life show variations on different scales, introducing "patches". Scale is an important factor in interpreting heterogeneity. Care will be required to considering activities and their effects on seafloor integrity on relevant scales.	This issue was not discussed in detail during the workshop. Future discussions shall include: (i) the definition of the scale (e.g. EUNIS hierarchical level) at which habitats are going to be assessed, (ii) the consideration of scale issues in the intersection between pressure footprint and state information and (iii) the integration of scale-explicit information in the recoverability criteria, namely when extracting connectivity measurements from fragmented patterns.

	Comment/input to D6 Manual	Response to comments
20	General comment: The switch to a different set of criteria (functionality and recoverability) is not supported. Arguments: 1. Former 6.1(physical damage) has been regarded so far as an efficient approach to assess seafloor integrity. At least monitoring human uses and their physical interactions with the seafloor can define hot spot areas and gradients of damage. It can also serve as a basis for assessment while state and impact indicators for D6 are being developed. 2. The newly proposed criteria functionality and recoverability represent core characteristics of seafloor integrity, when used next to, and complementary to, D1. In theory. However, we are not convinced that the example indicators in Table 1 are close to being operational and/or easier to develop than the indicators under the original COM DEC. In addition, we expect that indicators of functionality will be less sensitive to changes in seafloor integrity caused by human action. We do not want (ethics!) a situation where species composition has significantly changed due physical disturbance by human action, while in the same habitat indicators on functioning show no signal. 3. There has been insufficient contribution from the RSC groups (COBAM, CORESET) working on D6 in this advice. participation is of course the responsibility of the MS, but getting these people in has been hampered by the short time available and the overlap with summer holiday period.	Workshop discussed the topic and general statement is that there is no any wish to neglect the existing and previous efforts and developments in operationalization of indicators under existing criteria. Instead new concept was proposed which incorporates already developed aspects and indicators (national and those developed at RSC) and adds features not considered under existing criteria but considerably improve the understanding of seafloor integrity. See Chapter 5 and figures in it for illustration of the concept. Involvement of RSC experts and experiences is strongly urged and most of present proposals take into account the developments in COBAM and CORESET.
21	The statement that these new criteria may not require any additional monitoring is not supported sufficiently in the current advice.	Participants at the workshop were of the opinion that application of new concept (see chapter 5) will not necessarily result in creating a need for additional monitoring effort. Many new proposed aspects can be derived from the existing data collection schemes, helping to add the relevant available supporting information (e.g. functional trait database, modelling of pressure extent or habitat distribution).
22	To my (LE) understanding 6.1 was never developed as a stand alone indicator. It can be very effective in combination with status/impact indicators	Newly proposed concept supports this idea. See Chapter 5 for illustration.

	Comment/input to D6 Manual	Response to comments
23	Indicators such as primary production indeed would contribute to detecting changes in functioning. Primary production has been on the wish list of OSPAR for many years, but never made it into regular monitoring programmes, because of inherent methodological difficulties. We question whether the proposed new indicators are realistic.	Some of these aspects were discussed in Sessions 2-3.
24	The situation that MS have not decided upon a threshold value yet is only a snapshot in a development process. It does not mean that indicators under this criterion would not function (provided we have set a threshold).	Setting of relevant threshold values, reference conditions and GES boundaries for indicators is very important step in operationalization of indicators. The participants at the workshop supported the further work on operationalization of existing and proposed indicators (national and RSC).
25	Key conclusions, second bullet: Finland appreciates that the suggested criteria 6.1 and 6.2 address the state (6.1) and impacts (6.2). Finland, however, considers the suggested criterion 6.2 'Recoverability' to be too theoretically defined and difficult to assess in practice with the monitoring programme. Finland proposes that the expert group reconsiders the 6.2 and defines it closer to the human pressures.	The approach to D6 has been strengthened in its conceptual integration of the three components considered relevant to a seafloor integrity assessment. Human pressures are now a clear component, along structurally based state information and knowledge of benthic sensitivity.
26	The suggested definition of criterion 6.2: Finland considers the definition difficult to assess with the current monitoring programme in the Baltic Sea. The monitoring programme is not in a state where high-resolution (time and space) data can be obtained to estimate 'rapid recoverability'. In addition, Finland is of the opinion that implementing the criterion will require major assumptions in the indicators. While recoverability assessments are highly appreciated, the current scientific knowledge does not yet allow routine assessments of those.	The refined D6 approach establishes now a clear link between pressure and state information, which is based on recoverability. Future steps of the D6 review will address practical methods to establish recoverability, which may be based on species lifetime, dispersal potential, connectivity and fragmentation parameters.
27	There are some aspects of the current criteria that should be left, in particular the use of multimetric indices and Parameters describing the characteristics of the size spectrum of the benthic community as they will provide information on chronic effects. These might be might be captured under the recoverability criterion but we need to ensure they don't disappear.	The refined D6 approach establishes now a clear link between structurally based state information, knowledge of benthic sensitivity and a quantification of relevant pressures. The existing indicators are still used under a stronger conceptual framework.

	Comment/input to D6 Manual	Response to comments
28	It would be good if the effects of Climate Change are also included.	Both the MSFD and the 2010 COM DEC actually allows for the determination of good environmental status that may have to be adapted over time. This will have to be done taking into account the impact of climate change. Future steps of the D6 review will address technical aspects on how to adapt GES under global temperature changes and ocean acidification. This may be reflected in periodically adjusted GES boundaries to reflect shifting natural baselines.
29	ISSUES FOR FURTHER DISCUSSION: Interesting to note that aggregation was not considered to be an issues for D6. Aggregation rules will need to be applied depending on indicator but not prescribed.	This issue was not discuss in detail during the Workshop, but it remains a fundamental topic for discussion in a future workshop.

	Comment/input to D6 Manual	Response to comments
30	General comment: The amendment of the COMDEC 2010/477 for D6 needed to refer also to at least D1 and D7 propositions of revisions, notably to find items that are not any more mentioned in the D6 revision proposition. To be noted that the working group for D6 revision is mainly composed of biologists, with one physical oceanographer during the last workshop ; • The proposed criteria are much more fitted to the title of the D6, and to the TG6 report published in 2010, from the same working group of biologists. It nevertheless implies a deep questioning on the work done following the 2010/477 decision, where "physical perturbations" and their sources were clearly proposed to be considered in 6.1.2. and are now excluded from the review. • The proposition lacks , maybe on purpose, the implicit notion of DPSIR which was clear in the 2010/477 version for D6 • Vinchon *et al*., 2012 have underlined the importance of knowledge of hydrodynamics when defining the GES of seafloor regarding pressures and source of pressures. Last advances in the work integrated a bottom dynamic index to contribute to the GES indicator, to be calibrated by measurements on specific locations under pressures. Such action does not fit anymore in the new concepts for D6. • It is not clear either if the word "pressure" refers to human activities /occupation or to their consequences. Despite the title of criteria, the redaction is focused on functionality and recoverability of ecosystems • There is a big lack of knowledge and data (measures or models) -on intrinsic sensitivity of ecosystems -on impacts by pressures processes (light, smothering, etc…). - on resilience processes The given objectives proposed in the review of D6 are far from being reachable, if they are not accompanied by research programs. It will be necessary if this proposition is kept as such, to have intermediate targets, based on expert advices, or heavy monitoring.	This is a cross-cutting issue that could not be explicitly addressed in the present workshop. However, see some comments provided under 8 and 31 will also be applicable in this case.

	Comment/input to D6 Manual	Response to comments
31	"Abiotic substrate" is mentioned here in both proposed new D6 criteria and further in the text. However, it is not clear on how physical processes on seafloor and pressures such as abrasion, sealing, changes in sedimentations are to be considered. It seems they have been transferred to D7. Which links are planned for D6 and D7?	Physical processes appear to be an important aspect of the workshop discussions. The workshop acknowledged the need to take physical aspect into account in D6 as far as the estimation of the pressure footprint in terms of location, extent and intensity is concerned, as shown in figure 2. This cross cutting issue between D6 and D7 need to be tackled accordingly, but is not on the reach of the workshop.
32	General comment: Linkages with existing relevant EU legal requirements, standards, and limit values While the Manual text describes what the Habitats Directive influences in terms of inter alia the establishment of MPAs (marine Natura 2000-sites) it neglects to provide concrete guidance as to which benthic habitats from Annex I and respective EC Manual further defining the habitat types are concerned and relevant to the application of the criteria, such as : • Reefs • Sandbanks slightly covered with water • Submarine structures with leaking gases • Seagrass beds • Coastal lagoons • Tidal mud flats • Asf.	This issue was not discussed in detail during the workshop. It remains an important issue to be addressed in future.

6 References

Borja A, Elliott M, Andersen JH., Cardoso AC, Carstensen J, Ferreira JG, Heiskanen A-S, Marques JC., Neto JM, Teixeira H, Uusitalo L, Uyarra MC, Zampoukas N, Prins T, Simboura N, Berg T, Papadopoulou N, Reker J, Menchaca I (2015) Report on potential Definition of Good Environmental Status Deliverable 6.2, DEVOTES Project. 62pp.

Dauvin, J.-C. (Ed.) (1997). "Les biocénoses marines et littorales françaises des côtes Atlantique, Manche et Mer du Nord: synthèse, menaces et perspectives". Collection Patrimoines naturels: Série Patrimoine écologique, 28. Muséum national d'Histoire naturelle: Paris. ISBN 2-86515-102-6. 359 pp.

HELCOM, 2012a. "Development of a set of core indicators: Interim report of the HELCOM CORESET project. Part A : Description of the selection process". Balt. Sea Environ. Proc. No. 129A. 101 p.

HELCOM, 2012b. "Development of a set of core indicators: Interim report of the HELCOM CORESET project. Part B : Descriptions of the indicators". Balt. Sea Environ. Proc. No. 129 B. 219 p.

ICES. 2014. Report of the Workshop to review the 2010 Commission Decision on criteria and methodological standards on good environmental status (GES) of marine waters; Descriptor 6, 2-3 September 2014, ICES Headquarters, Denmark. ICES CM 2014/ACOM:61. 37pp.

OSPAR, 2011. "OSPAR's MSFD advice manual on biodiversity. Approaches to determining good environmental status, setting of environmental targets and selecting indicators for MSFD descriptors 1, 2, 4 and 6". Version 05 March 2012. 114p. + annexes.

Rosenberg R, Agrenius S, Hellman B, Nilsson HC, Norling K, 2002. "Recovery of marine benthic habitats and fauna in a Swedish fjord following improved oxygen conditions." Marine Ecology-Progress Series 234:43-53

UNEP/MAP (Barcelone convention), 2014. "Draft Monitoring and Assessment Methodological Guidance". UNEP(DEPI)/MED WG.401/3. Version 8 September 2014. 4th Meeting of the EcAp Coordination Group; Athens, Greece, 9-10 October 2014. 139 pp. + annexes

Annex 1. Agenda

Workshops on guidance for the review of MSFD decision Descriptor 6 – seafloor integrity II

16–19 February 2015

Monday 16 February

13.30, start workshop

"A practical guide to working at ICES" (Lise Cronne, ICES)

Workshop participants will be welcomed and provided a brief introduction to the building and meeting facilities.

"Welcome and aims of D6 follow-up workshop" (Steven Degraer, chair)

To set the scene, specific aims for the workshop (i.e. to provide the scientific basis for operationalising the proposed D6 manual revision) will be presented. In a round table participants will be asked to introduce themselves and briefly say how they hope to contribute to the aims of the workshop. This will help align participant's expectations on how they can best contribute to the specific aims of workshop.

"Process and progress in the revision of D6 seafloor integrity" (Fernando Tempera, vice-chair, and Sebastian Valanko, ICES)

The workshop aims to constructively build on the existing D6 Manual. It is thus essential to be aware of the recent D6 review process, to avoid repetition and to build on that work. This presentation will give a brief overview of the timeline and recent progress made in the review of Decision with regard to D6 seafloor integrity, including new and old criteria options for determining GES.

"Priority need(s) for the D6 manual for next GES meeting, and thereafter?" (David Connor, DG ENV)

The D6 Manual should provide a proposal for revision of the Decision and associated guidance to Member States on how to implement the MSFD for descriptor 6. This presentation will provide insight from the ongoing MSFD process, into the type of guidance that is at present still required in the assessment of the seafloor. Discussions need to focus on what is practical in the short term but can also identify issues which can be addressed after the present review. This will ensure that workshop participants understand what is required as input from them to the D6 manual and thus ensure efficient use of the available time.

14.30, plenary discussion

14.40 – 15.00, coffee break

"Same or different indicators across changing environmental conditions: the Baltic Sea experience" (Georg Martin, vice-chair)

How in practice do we operationalize the D6 manual? This presentation will highlight some institutional and natural realities in the indicators development process (data, methods, baselines, targets). An awareness of some operational

challenges will facilitate work in linking criteria (new, old, combination) to operational indicators and in the setting short (2016) and long-term (2018) goals for the D6 Manual.

"Indicators based on community indices: their use is assessing pressure-state relationships of benthic habitat" (Laurent Guérin, vice-chair)

Using regionally accepted approaches can help facilitate the operationalization of some assessment tools. An overview of possible multi-metric index indicators will be presented, in particular for the assessment of pressure-state relationships for benthic habitats. This will enable workshop participants to better evaluate the extent to which different options may already be operational in a regional context.

15.30 – 15.55, plenary discussion

16.00, recap of aims of workshop, common understanding of work to be achieved on Tuesday (Steven Degraer, Chair)

16.30 – 18.00, drinks and snacks ("*beer kitty*"-system)

TUESDAY 17 FEBRUARY

09.00, start

Session 1 - **Regional-scale impact assessments**

"Regional-scale impact indicators for assessing benthic habitats" (Jochen Krause, vice-chair)

It has been suggested that indicators to assess progress towards GES under criteria "6.1 – physical damage" and "6.2 – recoverability" will need to consider how pressure(s) and sensitivity of benthic habitats can be combined to evaluate impact across a large regional scale. A worked example of this will be presented from the HELCOM and OSPAR approach.

9.15-10.00, sub-group work on specific questions

10.00 – 10.30, plenary reporting

10.30 – 10.45, coffee break

Session 2 - **Structure and function link**

"Linking structure to function(s) that ensure seafloor integrity" (Silvana Birchenough, vice-chair)

How to prioritize functions under D6 is a key deliverable of the workshop. Thus a state of the art overview of definitions/status of structure and function links will be provided. This will better enable workshop participants to understand how structural indicators can be used to measure function(s) that best ensure seafloor integrity is maintained.

11.00-11.45, sub-group work on specific questions

11.45 – 12.15, plenary reporting

12.15 – 13.15, lunch

Session 3 – **Indicators**

"Possible D6 indicators?" (Fernando Tempera, vice-chair)

A suite of benthic habitat indicators have been compiled for the workshop from various sources (Member States, Regional Seas Conventions, and projects such as DEVOTES). An overview of these indicators will be presented. This will stimulate discussions on the most pragmatic approach, with an aim of producing a minimum set of operational indicators for seafloor integrity. Furthermore, it will allow workshop participants to become aware of the options available to link existing indicators with assessing GES for new and old D6 criteria.

13.30-14.15, sub-group work on specific questions

14.15 – 14.45, plenary reporting

14.45 – 15.00, coffee break

Session 4 – **Linking indicator options to criteria options**

"Methodological standards to measure progress towards GES: a D3 fishy example" (Mark Dickey-Collas, ICES)

An assessment of the seafloor under the MSFD will require alignment of operational indicators by MSFD ecoregion for each criteria option. A clear example of what an MSFD tailored assessment could look like (illustrated by D3) will help provide direction for D6 workshop participants.

15.15-16.00, sub-group work on specific questions

16.00 – 16.30, plenary reporting

Session 5 - GES boundaries

"Methods and options applied in OSPAR and Barcelona conventions to set baseline and GES boundaries" (Laurent Guérin)

Guiding principles for setting GES have been agreed upon by some Regional Sea conventions. This presentation will facilitate achieving a common understanding amongst workshop participants on some methods and options available for setting GES for benthic habitats / seafloor integrity.

16.45-17.30, sub-group work on specific questions

17.30 – 18.00, plenary reporting: towards a consensus/approaches on D6 GES

19.30, Drinks - Ørsted Ølbar (Nørre Farimagsgade 13)

20.30, Dinner - Höst Restaurant (Nørre Farimagsgade 41)

Wednesday 18 February

9.00, start

"Progress towards achieving the aims of workshop" (Steven Degraer, chair)

An overview will be presented on common understanding after previous day's sessions 1-5 with reference to aims of the workshop in revising the D6 Manual. This will set out the drafting tasks required by workshop participants, towards providing clarity and operational solutions for the D6 Manual. Similarly, identifying both short-term (2016) and in the long term (2018) steps for the MSFD D6 revision process.

9.15 – 12.00, sub-group work/drafting on specific tasks from sessions 1-5 from previous day

12.00 – 12.30, plenary reporting

12.30 – 13.30, lunch

13.30 – 14.30, sub-group work on scientific comments for revision of D6 manual

14.30 -15.00, coffee break

15.00 – 15.15, plenary reporting, and allocation of tasks

15.15 – 17.30, sub-group work/drafting on specific tasks from sessions 1-5 from previous day + scientific comments

17.30 – 18.00, plenary

19.00 -> dinner and drinks (to be organized amongst participants)

THURSDAY 17 FEBRUARY

9.00, start

"Recommendations from D6 workshop on cross-cutting issues" (Mark Dickey-Collas, ICES)

> The workshop has specifically been asked to consider and deliver comments on cross-cutting issues. This includes, thought on how seafloor integrity (D6) is linked to the pressure and state goals under other descriptors (e.g. D1, D4, D5). Within this context, consideration will be needed on both how cross-cutting issues could help simplified/strengthen, as well as the potential pitfalls that could jeopardize seafloor integrity.

9.15-10.15, sub-group work on specific questions

10.15 – 10.30, coffee break

10.30 – 12.00, reporting and plenary discussion on outstanding issues

12.00 - wrap-up of workshop, end

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Annex 3. Terms of References

2015/2/ACOM61 The **Workshop on guidance for the review of MSFD decision descriptor 6 – seafloor integrity II** (WKGMSFDD6-II), chaired by Steven Degraer, Belgium, with vice-chairs Silvana Birchenough, UK, Laurent Guérin, France, Georg Martin, Estonia, Jochen Krause, Germany, and Fernando Tempera, JRC, will meet in Copenhagen, Denmark, 16-19 February 2015 to:

a) Provide further input to the MSFD review D6 manual following on from the initial ICES/JRC workshop and template (see scientific justification below).

b) Consolidate and address relevant scientific comments and requests for clarification received from WG GES and DG ENV on the earlier version of the MSFD review D6 manual.

c) Comment on implications for the MSFD review D6 manual in light of the DGENV cross-cutting workshop (held in January 2015).

WKGMSFDD6-II will report by 27 February 2015 for the attention of ACOM.

Supporting information

Priority	This workshop is part of an advice process to respond to an MoU request to ICES from DGENV to review the descriptors for the MSFD 2010/477 Decision
Scientific justification	The 2010 Decision of the MSFD raised many challenges. Many of these are concerned with the scientific interpretation of the ideas and concepts of the Decision. This workshop will focus on the scientific challenges for D6- seafloor integrity with a view to clarify the text and make the Decision more understandable. Recent relevant ICES Advice should be taken into account in the review. The workshop should address matters that arose from the previous workshop, namely: How do we prioritize functions to be assessed under the criterion? How do we determine GES boundaries for seafloor integrity? How can the suggested revision be tangibly implemented?
Resource requirements	None
Participants	Experts with expertise in MSFD implementations or scientific issues regarding the descriptor are encouraged to participate. Each country can send 1–2 participants. If nominations exceed the meeting space available ICES reserves the right to reject participants. This will be done based on the experts' relevant qualifications for the Workshop and geographical coverage. National participants join the workshop at national expense. The Workshop will be open to stakeholders, dependent on availability of space. The WK will be open to secretariat members of RSCs. The vice chairs are nominated to provide a geographic and expertise spread of relevant researchers.
Secretariat facilities	Secretariat support and meeting room
Financial	No financial implications.
Linkages to advisory committees	Direct link to ACOM.
Linkages to other committees or groups	Direct link to the CSGMSFD
Linkages to other organizations	Links to DGENV and the EU GES/MSCG

Annex 4. Background paper

WKGMSFDD6-II: ICES workshop on guidance for the review of MSFD decision descriptor 6 – seafloor integrity II (MSFD review D6 manual)

GOOD ENVIRONMENTAL STATUS (GES) FOR MSFD D6 (SEAFLOOR INTEGRITY) WILL BE ACHIEVED WHEN SEAFLOOR 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.

What is expected of workshop in the ICES process?

Previously (autumn 2014) ICES has addressed D6 seafloor integrity issues of methods and bounds for setting GES. However, the MSFD GES meeting has highlighted that more detail will be required on how to link higher level criteria to specific indicators that countries can implement in practice in national monitoring and assessment programmes. ICES has specifically been asked to:

1. Provide **further input** to the MSFD review D6 manual following on from the initial ICES/JRC workshop and manual (see Annex 1).
   - How do we prioritize functions to be assessed under the criterion?
   - How do we determine GES boundaries for seafloor integrity?
   - How can the suggested revision be tangibly implemented?

2. Consolidate and **address relevant scientific comments** and requests for clarification received from WG GES and DG ENV on the earlier version of the MSFD review D6 manual.
   - These have already been consolidated by ICES secretariat (Annex 2)

3. Comment on implications for the MSFD review D6 manual in light of the DGENV **cross-cutting workshop** (21-22 January).
   - What is the status of different seafloor indicators across MSFD ecoregions?
   - How can indicators be used in aggregating information for assessment purposes across space (region, subregions) and time (measure progress towards GES)? What are some underlying pitfalls and best practice rules that ensure comparability/harmonization between regions?
   - What is practically possible to asses across MSFD ecoregions for the seafloor in the short term (2016) and in the long term (2018)? What are the steps to be taken?
   - In describing state, how can seabed (D6, D1) goals be combined with that of other "status" descriptors of the ecosystem (D1 water column, birds, mammals, reptiles; D1/D3 Fish)?

What is expected of participants prior to workshop?

1. Understanding of the scope and specific aims of the workshop (see above).
2. Working understanding of the MSFD review D6 manual and report.

D6 manual (ICES technical advice for D6 manual to GES workshop): http://ices.dk/sites/pub/Publication%20Reports/Advice/2014/Special%20Requests/EU_Annex_%20I_D6_Manual_Milieu.pdf

D6 report (ICES WKGMSFDD6 Report 2014): http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2014/WKGMSFDD6/WKGMSFDD6%20Final%20Report%202014.pdf

3. Initial thoughts/material from respective MSFD ecoregion that can be used in the workshop to achieving the overall goals of work at hand.

Process and time line for D6 MSFD review process:

The EU has asked ICES to address the above issues before the end of March 2015 (see Annex 1). A five person expert group (one chair with four co-chairs), together with an ICES and JRC secretariat member, has been assembled to prepare a four day workshop (16-19 February).

In order to most effectively communicate the revised D6 manual should strive to be: 1) Simpler, 2) Clearer, 3) Introducing minimum standards (to be enhanced by regions and MS, if necessary), 4) Self-explanatory, 5) Coherent with other EU legislation, 6) Coherent with regional assessment methods (where EU methods do not exist), and 7) Include a clear and minimum list of elements and/or parameters per descriptor. Invited workshop participants will thus explore standardized methodologies for assessment of the seafloor (i.e. D6 seafloor integrity) that ensure comparability and replicability between regions so as to be able to measure progress towards GES across all MSFD marine regions (Baltic Sea, Northeast Atlantic Ocean, Mediterranean Sea and Black Sea). This work will specifically contribute towards revising the existing D6 manual so as to better highlight how higher level criteria (GES targets) can be linked to specific indicators (setting targets and limits) that countries can implement in practice in national monitoring and assessment programmes (Figure 1).

The workshop, together with chairs, will contribute towards revising the existing manual and will also produce a short workshop report (due 27 February), which will be reviewed by three external experts (due 7 March). The report, revised manual and review will feed into an ICES advice drafting process (ADG, 10-12 March 2015) that will finalize the advice for ACOMs approval (18 March) and publication (20 March).

The revised D6 manual (i.e. the advice product) will contribute to the MSFD WG GES meeting (22-23 April) as one of 13 background documents. Prior to the MSFD WG GES meeting the following documents will be made available, i) common understanding ii) cross-cutting, and iii-xiii) revised descriptor 1-11 manuals.

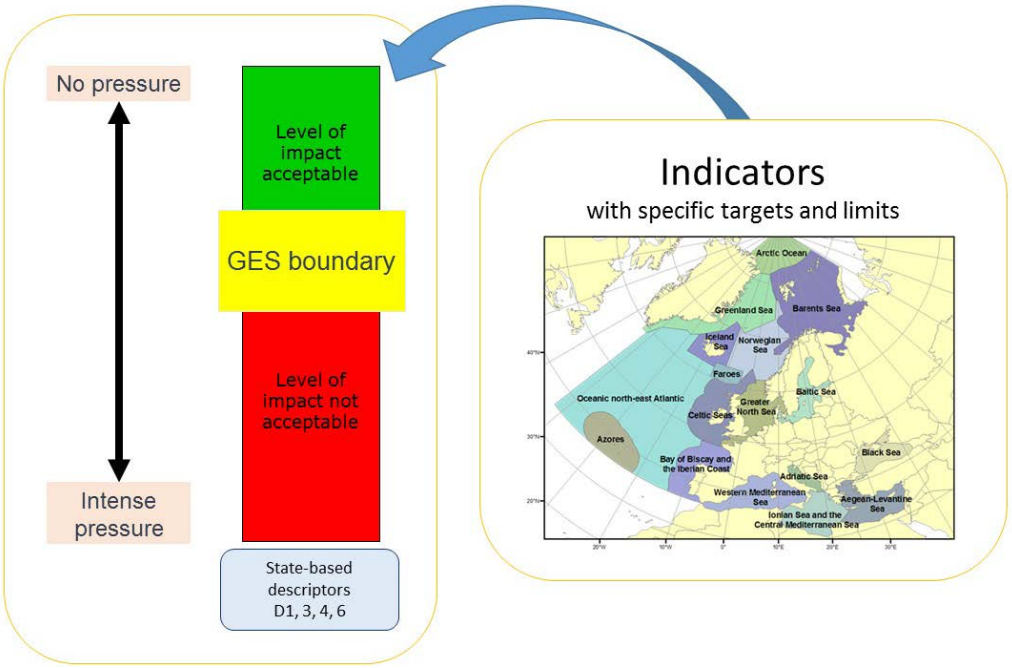


Figure 1. Conceptualized aims of the MSFD 2010/477 Decision.

Annex 5. Availability of seafloor integrity monitoring parameters for D6 indicators under different legal instruments (Zampoukas *et al.*, 2012, updated by F. Tempera and H. Teixeira in January 2015)

Table 1

Hierarchical organization of metrics: Descriptor (D) > Criteria (C) > Indicator Set (IS) > Indicator Subset (ISS) > Metric (M). Under each Indicator Subset (ISS), metrics are first aggregated by aspect addressed in black text (substrate, abundance, biomass, body length, area extent, depth limit, species composition, multimetric index) and on a second level by feature addressed in grey text (e.g., particular "taxonomic" group like macrophytes or invertebrates, particular habitats, particular pressure).

Functions: F1 - Primary productivity, F2 – Secondary production, F3 - Provision of spawning area, F4 - Provision of feeding ground, F5 - Production of food, F6 - Energy flow/Changes in functional traits, F7 - Sediment reworking, F8 - Sediment stabilization, F9 - Provision of emergent 3D structure, F10 – Connectivity

MSFD Monit. - MSFD Monitoring parameters required (Craglia et al., 2010); **WFD** - Water Framework Directive; **HD** - Habitats Directive requirements; **Common Fisheries Policy (CFP) indicator status:** pDCF – ICES proposal for the Data Collection Framework. **DEVOTES indicator status**: Op – operation demonstrated in at least a report or scientific paper; uDev - under development; Concep - conceptual. **OSPAR indicator status:** Co – Common; Ca – Candidate**. HELCOM indicator status:** Co – Core; pCo – Pre-Core; Ca – Candidate**.**

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
C 6.1. Physical damage, having regard to substrate characteristics												
IS 6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate		F4, F7, F8, F9										
ISS 6.1.1.1 Type of relevant biogenic substrate												
Substrate characteristics	Habitat characteristics (predominant, special, protected and endangered)		X									
	Seabed Substrata Composition		X									
	Seabed substrate				X							
	Seabed topography	F9	X									
	Seabed quantity				X							
	Seabed structure		X		X							
	Specific structure of natural habitat types of community interest					X						
Species composition	BH1 Typical species composition								X (Ca)			X
	Richness of the bioengineering species	F9		FR								
of macrophytes	WFD RSL - Macroalgae - Rocky Shore Reduced Species List				X			Op				
	RSL - Rocky Intertidal Macroalgae - Reduced Species List							Op				
	Macrophyte species reduction (reduced species list)							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
of invertebrates	Benthic invertebrate fauna composition				X							
	Invertebrate bottom fauna species composition and its annual/seasonal variability		X									
	Species richness of corals	F9						X				
Multimetric indices	BQI - Benthic Quality Index							Op				
	M-AMBI - Multivariate AZTI Marine Biotic Index							Op				
	WFD MarBIT - Marine Biotic Index Tool				X			Op				
for macrophytes	WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos	F1, F9			X			Op				
	WFD BALCOSIS - Macrophyte index	F1, F9			X			Op				
	WFD HPI - German Macroalgae index	F1, F9			X			Op				
	WFD German Eelgrass index (intertidal)	F1, F8, F9			X			Op				
	CymoSkew	F1, F8, F9						Op				
for ecosystems	WFD AETV - German Estuary Typology Procedure				X			Op				
	WFD German Saltmarsh index				X			Op				
6.1.1.2 Abundance of relevant biogenic substrate												
Abundance	Abundance of bioengineering species	F9		FR				Op				
	Abundance of coral colonies alive	F9						uDev				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Abundance ratio of bleached coral colonies							Op				
	Abundance (per unit of surface) of structuring/engineering species (per habitat)							Op				
	Density of biogenic reef-forming species (type, abundance, biomass and areal extent of relevant biogenic substratum)	F9						uDev				
Multimetric indices	M-AMBI - Multivariate AZTI Marine Biotic Index							Op				
	EEI - Ecological Evaluation Index							Op				
	BQI - Benthic Quality Index							Op				
for macrophytes	WFD BALCOSIS - Macrophyte index	F1, F9			X			Op				
	WFD ELBO - German Macrophyte index	F1, F9			X			Op				
	WFD Polish Assessment system for coastal and transitional waters using macrophytes	F1, F9			X			Op				
	WFD HPI - German Macroalgae index	F1, F9			X			Op				
	MarMAT - Marine Macroalgae Assessment Tool	F1, F9						Op				
	WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast	F1, F9			X			uDev				

MSFD Descriptor 6 - seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	WFD Swedish Assessment of Biological Quality Elements in coastal and transitional waters - macrovegetation	F1, F9			X			Op				
	WFD Valencian Region Method using Posidonia oceanica	F1, F8, F9			X							
	POSWARE	F1, F8, F9						Op				
	WFD German Eelgrass index (intertidal)	F1, F8, F9			X			Op				
	WFD British Seagrass index	F1, F8, F9			X			Op				
for ecosystems	WFD AETV - German Estuary Typology Procedure				X			Op				
	WFD German Saltmarsh index				X			Op				
	CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities							Op				
6.1.1.3 Biomass of relevant biogenic substrate												
Biomass	Biomass (per unit of surface) of structuring/engineering species (per habitat)			FR				Op				
	Biomass of macrophytes							uDev				
Multimetric indices	POSWARE	F1, F8, F9						Op				
	WFD Valencian Region Method using Posidonia oceanica	F1, F8, F9			X							
	EPI - Estonian Phytobenthos Index	F1, F9						Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	WFD Polish Assessment system for coastal and transitional waters using macrophytes	F1, F9			X			Op				
	WFD Romanian Assessment system for coastal waters using macrophytes	F1, F9			X			uDev				
6.1.1.4 Areal extent of relevant biogenic substrate												
Areal extent	Extent of benthic biotopes			UK						X (pCo)		
	Ratio of area of selected habitats							Op				
	Areal extent of selected habitats							Op				
	Area covered by natural habitat types of community interest					X						
of physical habitats	Areal extent of intertidal rock							uDev				
	Areal extent of subtidal rock							uDev				
	Areal extent of littoral chalk habitat							uDev				
	Areal extent of intertidal sea caves							uDev				
of biogenic habitats	Ratio of area of biogenic/vulnerable habitat							Op				
	Areal extent of biogenic/vulnerable habitats			ES				Op				
	Spatial extent/area of biogenic structure (marine angiosperms, maerl-type biogenic sediments)							X				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Areal extent of subtidal biogenic structures (type, abundance, biomass and areal extent of relevant biogenic substrata)							uDev				
	Areal extent of selected habitats affected by physical damage							uDev				
of macrophytes	Cumulative coverage of macrophytes	F1, F9				X11 70				X (Ca)		
	Abundance of macroalgae (total cover)	F1, F9				X11 70		Op				
	Areal extent of macroalgae	F1, F9				X11 70		uDev				
	Areal extent of marine angiosperms	F1, F8, F9				X11 10		Op				
	Areal extent of Posidonia oceanica meadows	F1, F8, F9				X11 10		Op				
	Areal extent of eelgrass	F1, F8, F9				X11 10		Op				
	Areal extent of maerl-type biogenic sediments	F1, F9						Op				
of invertebrates	Areal extent of blue mussels	F9						uDev				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
Depth limits	Depth limit of macroalgae	F1, F9						uDev				
	Depth limit of attached perennial macroalgae	F1, F9						uDev				
	Depth limit of Fucus spp.	F1, F9						Op				
	Depth limit of Fucus vesiculosus	F1, F9						Op				
	Depth limit of Furcellaria lumbricalis	F1, F9						Op				
	Depth limit of eelgrass	F1, F8, F9						Op				
	Depth limit of Ruppia spp.	F1, F8, F9						uDev				
	Depth limit of charophytes	F1, F8, F9						Op				
	Depth limit of spermatophytes	F1, F8, F9						Op				
	Lower depth limit of macrophytes species	F1, F9								X (pCo)		
Distributional range	Natural range of natural habitat types of community interest					X						
	Potential / observed distribution range of selected coastal and marine habitats (SPA protocol)											X
	Distribution pattern of selected coastal and marine habitats (SPA protocol)											X
	Distribution and pattern of benthic biotopes									X (pCo)		
	Distributional range of horse mussel banks	F9						uDev				
	Distributional range of Haploops communities	F7						uDev				

MSFD Descriptor 6 - seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
Multimetric indices	CFR - Multimetric CFR index (Quality of Rocky Bottoms)	F1, F9						Op				
for macrophytes	WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos	F1, F9			X			Op				
	WFD HPI - German Macroalgae index	F1, F9			X			Op				
	MarMAT - Marine Macroalgae Assessment Tool	F1, F9						Op				
	WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast	F1, F9			X			uDev				
	WFD Swedish Assessment of Biological Quality Elements in coastal and transitional waters - macrovegetation	F1, F9			X			Op				
	POSWARE	F1, F8, F9						Op				
	WFD Dutch Eelgrass index	F1, F8, F9			X			Op				
	WFD German Eelgrass index (intertidal)	F1, F8, F9			X			Op				
	WFD British Seagrass index	F1, F8, F9			X			Op				
	WFD Valencian Region Method using Posidonia oceanica	F1, F8, F9			X							
for ecosystems	WFD German Saltmarsh index				X			Op				
	CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types		Recoverability?										
Substrate characteristics	Seabed structure		X									
	Seabed substrata composition		X									
	Seabed topography		X									
	Seabed substrate encountered during operation of mobile bottom gears						pDCF					
	Substrate condition							Op				
Species composition	Macrophyte species reduction (reduced species list)	F1, F9						Op				
	Species richness of corals	F9						uDev				
	Species diversity (Simpson) of benthic invertebrates							uDev				
	Species diversity (Shannon index) of benthic invertebrates							Op				
Abundance	Abundance (per unit of surface) of structuring/engineering species (per habitat)	F9						Op				
	Abundance of bioengineering species	F9						Op				
	Density of biogenic reef-forming species (type, abundance, biomass and areal extent of relevant biogenic substratum)	F9						uDev				
of macrophytes	Macroalgae abundance	F1, F9			X							

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Macroalgae cover	F1, F9			X							
	Angiosperms abundance	F1, F8, F9			X							
	Angiosperms cover	F1, F8, F9			X							
of invertebrates	Benthic invertebrate fauna abundance				X							
	Abundance ratio of bleached coral colonies							Op				
Biomass	Macroalgae biomass	F1, F9	X									
	Biomass ratio of opportunistic macroalgae	F6						Op				
	Angiosperms biomass and its annual/seasonal variability	F1, F9	X									
Areal extent	Areal extent of selected habitats affected by physical damage (≈6.1.2 definition)			LT, SI				uDev				
	BH3 Physical damage of predominant and special habitats			SI					X (pCo)			
	BH4 Area of habitat loss			SI				uDev	X (Ca)	X (Ca)		
	Areal extent of human affected area			ES				uDev				
	Ratio of area potentially affected by changes in the seafloor topography	F9						Op				
	Areal extent of dead Posidonia oceanica meadows	F1, F8, F9						Op				
of substrate extract'n	Area affected by extraction											
	Ratio of area potentially affected by selective extraction of substrate							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions				
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Ratio of area affected by harbor dredging activities							Op				
	Areal extent of abrasion			SI								
of dumping	Ratio of area affected by dredging disposal							Op				
	Ratio of area potentially affected by discharge of materials							Op				
	Spatial extent of area affected by dumping							X				
	Ratio of area affected by artificial beaches or beach nourishment							Op				
	Spatial extent of area affected by major construction			SI				X				
	Length of coastline subject to physical disturbance due to the influence of manmade structures (Length of manmade coastline, Total surface area reclaimed, Length of sandy coastline influenced by manmade structures)											X
	Ratio of area affected by port infrastructure							Op				
	Ratio of area affected by human highly-modified coast							Op				
	Ratio of area affected by anchorage							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Ratio of area affected by cables and pipelines							Op				
	Ratio of area affected by aquaculture							Op				
of sedimentation	Ratio of area potentially affected by changes in the sedimentation rate							Op				
	Spatial extent affected by smothering		X									
	Spatial extent affected by sealing		X									
of fisheries	Ratio of area affected by each type of fishing gear							Op				
	Spatial extent of area affected by trawling							X				
	Total area fished by year (if discriminating métier that actually disturbs the seafloor)						X					
	Proportion of surface area fished by year (if discriminating métier that actually disturbs the seafloor)						X					
	Cumulative proportion of surface area not impacted by mobile bottom gears over a specific period (allowing recovery)	F7, F8, F9					X					
	Proportion of surface area not impacted by mobile bottom gears at a specific level of confidence						X					
aggregat'n of fishing	Proportion of surface area fished by specific proportion of effort						X					

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Proportion of surface area fished at specific intensity (e.g., more than once a year)						X					
of oxygen depletion	Areal extent of oxygen depletion							uDev				
	Areal extent of hypoxia (spatial and temporal)							Concep				
	Areal extent of hypoxic zones							uDev				
	Areal extent of anoxic bottoms							Concep				
Depth limit	Depth distribution of selected macrozoobenthos species							uDev				
Impacting activities	Cumulative effect of human activities			FI				uDev				
	Cumulative impact on benthic biotopes									X (pCo)		
	Cumulative impacts on benthic habitats			SE, DK, FR				uDev				
	Dredging and dumping of dredge materials									X (Ca)		
	Number of dredging permits and the amount dredged related to them			FI				uDev				
	Deposition of fine-grained sediments in sand-eel areas from construction works in the marine environment							uDev				
	Impacts of anthropogenic physical disturbance on the sea-pen community							uDev				

MSFD Descriptor 6 - seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Accumulation of contaminants in sediment							Op				
	Abrasion by benthic impacting fishing gears (otter trawl, rapido trawl and hydraulic dredge) on biogenic substrates			IT, SI								
	Sealing (determined by coastal defense structures, offshore structures, pipes, etc.) on biogenic substrates			IT								
	Impacts of anthropogenic removal of target species							uDev				
	Impacts of anthropogenic removal of non-target species							uDev				
	Impacts of anthropogenic sediment penetration and/or disturbance below the seabed surface							uDev				
	Impacts of anthropogenic shallow abrasion/penetration damage to seabed surface							uDev				
Multimetric indices	Index describing recovery of underwater deposition sites			FI				Concep				
	Index for the seafloor geological stability (physical integrity)							Concep				
for macrophytes	WFD Polish Assessment system for coastal and transitional waters using macrophytes				X			Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory		Regional Sea Conventions		
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	MAB - Macroalgal Bloom Assessment (opportunistic macroalgae)	F6			X			Op				
6.2. Condition of benthic community										X(pCo)		X
6.2.1 Presence of particularly sensitive and/or tolerant species		F1, F2										
Presence of species	Presence of particularly sensitive and/or tolerant species (different species list for MS)							Op		X(pCo)		
	Macroalgae - Presence of sensitive taxa	F1, F9			X							
	Angiosperms - Presence of sensitive taxa	F1, F9			X							
	Benthic bycatch of mobile bottom gears						pDCF					
Species composition	Benthos species composition										X	
	Species richness of selected habitats							Op				
	Average number of species per bottom sample											
of macrophytes	Macroalgae species composition	F1, F9	X									
	Macroalgae species composition	F1, F9			X							
	RSL - Rocky Intertidal Macroalgae - Reduced Species List (RSL)	F1, F9						Op				
	WFD RSL - Macroalgae - Rocky Shore Reduced Species List	F1, F9			X			Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Macrophyte species reduction (reduced species list)	F1, F9						Op				
	Angiosperms species composition and its annual/seasonal variability	F1, F8, F9	X									
	Angiosperms composition	F1, F8, F9			X							
of invertebrates	Invertebrate bottom fauna species composition and its annual/seasonal variability		X									
	Benthic invertebrate fauna composition				X							
	Species richness of benthic invertebrates							Op				
	Morphological diversity of sponges	F9						uDev				
Abundance	Benthos population abundance										X	
	Abundance (per unit of surface) of structuring/engineering species (per habitat)	F9						Op				
of macrophytes	Abundance and composition of intertidal macroalgae	F1, F9						Op				
	Abundance of macroalgae (total cover)	F1, F9						Op				
of invertebrates	Abundance of selected benthic invertebrate species							uDev				
of fish	Abundance of functional groups of fish	F6						Op				
	Abundance ratio of plankton functional groups (in terms of life form)	F6						uDev				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
Biomass	Benthos population biomass	F2									X	
	Biomass (per unit of surface) of structuring/engineering species (per habitat)	F9						Op				
	Biomass of engineering species	F9						Op				
of macrophytes	Biomass ratio of opportunistic macroalgae	F6						Op				
of invertebrates	Biomass of selected benthic invertebrate species							uDev				
	Invertebrate bottom fauna biomass and its annual/seasonal variability		X									
Body size	Body length distribution of Cladophora							uDev				
Area extent	Extent of selected benthic biotopes (key)											X
of macrophytes	Areal extent of intertidal opportunistic green algae	F6						Op				
	Areal extent of selected macroalgae species	F1, F9						Op				
	Areal extent of alterated Posidonia oceanica meadows	F1, F8, F9						Op				
	Areal extent of eelgrass	F1, F8, F9						Op				
Depth limit	Depth limit of attached perennial macroalgae	F1, F9						uDev				
	Depth distribution of Cystoseira sp.	F1, F9						uDev				
	Depth limit of Fucus spp.	F1, F9						Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Depth limit of Fucus vesiculosus	F1, F9						Op				
	Depth limit of Furcellaria lumbricalis	F1, F9						Op				
	Depth distribution of Phyllophora sp.	F1, F9						uDev				
	Depth limit of eelgrass	F1, F8, F9						Op				
	Depth limit of spermatophytes	F1, F8, F9						Op				
	Depth limit of charophytes	F1, F8, F9						Op				
Condition	Condition of the habitat's typical species and communities											X
Multimetric indices	BENTIX							Op				
	M-AMBI - Multivariate AZTI Marine Biotic Index							Op				
	BAT - Benthic Assessment Tool							Op				
	BBI - Brackish water benthic index			FI				Op				
	BTA - Biological Traits Analysis	F6						Concep				
	EEI - Ecological Evaluation Index							Op				
	WFD MarBIT - Marine Biotic Index Tool				X			Op				
	MEDOCC							Op				
	ITI - Trophic index	F6						Op				
for macrophytes	WFD BALCOSIS - Macrophyte index	F1, F9			X			Op				

MSFD Descriptor 6 – seafloor integrity		EU Directives					Inventory	Regional Sea Conventions			
Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
WFD ELBO - German Macrophyte index	F1, F9			X			Op				
WFD Romanian Assessment system for coastal waters using macrophytes	F1, F9			X			uDev				
WFD Polish Assessment system for coastal and transitional waters using macrophytes	F1, F9			X			Op				
WFD Swedish Assessment of Biological Quality Elements in coastal and transitional waters - macrovegetation	F1, F9			X			Op				
MAB - Macroalgal Bloom Assessment (Opportunistic macroalgae)	F1, F6, F9						Op				
MarMAT - Marine Macroalgae Assessment Tool	F1, F9						Op				
WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast	F1, F9			X			uDev				
WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos	F1, F9			X			Op				
EPI - Estonian Phytobenthos Index	F1, F9						Op				
POMI - Posidonia oceanica Multivariate Index	F1, F8, F9						Op				X?
WFD Valencian Region Method using Posidonia oceanica	F1, F8, F9			X			X				
POSWARE	F1, F8, F9						Op				X?
CymoSkew	F1, F8, F9						Op				X?

MSFD Descriptor 6 - seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	WFD Dutch Eelgrass index	F1, F8, F9			X			Op				
	WFD German Eelgrass index (intertidal)	F1, F8, F9			X			Op				
	WFD British Seagrass index	F1, F8, F9			X			Op				
for invertebrates	WFD ZKI - Estonian multimetric macrozoobenthos community index				X			Op				
	BOPA - Benthic Opportunistic Annelida Amphipoda Index	F6						Op				X
for ecosystems	WFD AETV - German Estuary Typology Procedure				X			Op				
	WFD German Saltmarsh index				X			Op				
	CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities							Op				
for quality	IQI - Infaunal Quality Index							Op				
	DKI - Danish Quality Index							Op				
	NQI - Norwegian Quality Index							Op				
	BEQI - Benthic Ecosystem Quality Index							Op				
	BQI - Benthic Quality Index							Op				
	CFR - Multimetric CFR index (Quality of Rocky Bottoms)							Op				
	Quality of benthic biotopes									X		

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
6.2.2 Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species		F6										
Species composition	BH1 Typical species composition								X (Ca)			
of macrophytes	Macro-algae species composition	F1, F9	X	CY	X							
	WFD RSL - Macroalgae - Rocky Shore Reduced Species List	F1, F9			X			Op				
	RSL - Rocky Intertidal Macroalgae - Reduced Species List	F1, F9						Op				
	Macrophyte species reduction (reduced species list)	F1, F9						Op				
	Angiosperms composition	F1, F8, F9			X							
	Angiosperms species composition and its annual/seasonal variability	F1, F8, F9	X	CY								
of invertebrates	Species richness of benthic invertebrates							Op	X (pCo)			
	Benthic Invertebrate Fauna Composition				X							
	Benthic Invertebrate Fauna Diversity				X							
	Invertebrate bottom fauna species composition and its annual/seasonal variability		X	CY								
Diversity indices	Species diversity (Shannon index) of macroalgae	F1, F9						Op				
	Species diversity of benthic communities							Op	X (pCo)			

MSFD Descriptor 6 - seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Species diversity (Shannon index) of benthic invertebrates							Op				
	Species diversity (Simpson) of benthic invertebrates							uDev				
	TSI - Taxonomic Spread Index							Op				
	Evenness of sandeel banks							uDev				
Abundance	Abundance ratio of opportunistic/sensitive species	F6		EL				Op	X (pCo)			
	Abundance of opportunistic macroalgae	F1, F6, F9						Op				
	Abundance ratio of opportunistic green macroalgae	F1, F6, F9						uDev				
	Abundance of perennial seaweeds	F1, F9						Op				
	Abundance of shade-adapted, slow growing calcareous species							Op				
Biomass	Biomass ratio of opportunistic macroalgae	F1, F6, F9						Op				
	Biomass ratio of opportunistic/perennial macroalgae	F1, F6, F9						uDev				
	Biomass ratio of opportunistic/sensitive species	F6						Op				
Functions	Necessary functions of natural habitat types of community interest					X						
Multimetric indices	BENTIX							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	MEDOCC							Op				
	ITI - Trophic index							Op				
	EEI - Ecological Evaluation Index							Op				
for macrophytes	WFD BALCOSIS - Macrophyte index	F1, F9			X			Op				
	WFD ELBO - German Macrophyte index	F1, F9			X			Op				
	WFD Polish Assessment system for coastal and transitional waters using macrophytes	F1, F9			X			Op				
	WFD Romanian Assessment system for coastal waters using macrophytes	F1, F9			X			uDev				
	WFD HPI - German Macroalgae index	F1, F9			X			Op				
	Surface area/biomass ratio of selected macroalgae species	F1, F9						Op				
	MarMAT - Marine Macroalgae Assessment Tool	F1, F9						Op				
	WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast	F1, F9			X			uDev				
	Benthic flora Cheney's ratio index	F1, F6, F9						uDev				
	EPI - Estonian Phytobenthos Index	F1, F9						Op				
	WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos	F1, F9			X			Op				
	Index of phytocoenoses ecological activity (S/Wph)	F1, F9						Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	POMI - Posidonia oceanica Multivariate Index	F1, F8, F9						Op				
	WFD British Seagrass index	F1, F8, F9			X			Op				
	WFD German Eelgrass index (intertidal)	F1, F8, F9			X			Op				
for invertebrates	Zoobenthos Community Index (ZKI)							X				
	Index for functional groups of benthic invertebrates							uDev				
	WFD ZKI - Estonian multimetric macrozoobenthos community index				X			Op				
	BOPA - Benthic Opportunistic Annelida Amphipoda Index	F6						Op				
	WFD Lithuanian Assessment system for transitional and coastal waters using macrozoobenthos				X			uDev				
for communities	BH2 Multimetric indices – Condition of habitat-defining communities								X (Co)			
	State of benthic communities							Op				
	State of hard-bottom communities									X (Ca)		
	State of soft-bottom macrofauna communities		LV							X (Co) FI, PL, LV, SE, DE, DK?		
	BBI - Brackish water benthic index							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	WFD MarBIT - Marine Biotic Index Tool				X			Op				
	CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities							Op				
	MarClim - Intertidal community indicator (Condition of typical species/communities)							uDev				
	AMBI - AZTI Marine Biotic Index							Op				
	M-AMBI - Multivariate AZTI Marine Biotic Index							Op				
	BAT - Benthic Assessment Tool							Op				
for ecosystems	WFD AETV - German Estuary Typology Procedure				X			Op				
	WFD British Saltmarsh classification tool				X			uDev				
	WFD German Saltmarsh index				X			Op				
	CFR - Multimetric CFR index (Quality of Rocky Bottoms)							Op				
for quality	BQI - Benthic Quality Index			LT, LV				Op				
	BEQI - Benthic Ecosystem Quality Index							Op				
	IQI - Infaunal Quality Index							Op				
	DKI - Danish Quality Index							Op				
	NQI - Norwegian Quality Index							Op				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Seabed geological stability (physical integrity) index	F7, F8		FI								
6.2.3 Proportion of biomass or number of individuals in the macrobenthos above some specified length/size		F1, F2										
6.2.3.1 Proportion of biomass of individuals in the macrobenthos above some specified length/size												
Biomass	Biomass ratio									X		
	Biomass/size spectrum of benthic invertebrates							Concep				
Species composition	Species composition							Op				
Multimetric indices	BTA - Biological Traits Analysis	F6						Concep				
6.2.3.2 Proportion of number of individuals in the macrobenthos above some specified length/size												
Abundance	Population structure of long-lived macrozoobenthic species	F5, F7, F8						Concep		X(pCo)		
	Abundance ratio of cumulative proportions of size classes >80mm of Mytilus galloprovincialis	F5, F9										
Body size	Body length distribution of bivalve or other sensitive/indicator species	F6						uDev				
	Body length distribution of bivalves	F6						Concep				

MSFD Descriptor 6 – seafloor integrity			EU Directives					Inventory	Regional Sea Conventions			
	Detailed metrics (in MSFD a.k.a. methodological standards)	Function (see legend)	MSFD Req	MSFD Art. 9 IA	WFD	HD	CFP	DEVOTES	OSPAR	HELCOM	Black Sea Conv.	Barc. Conv.
	Body length distribution of selected (long-living) benthic invertebrate species	F7, F8						uDev				
Species composition	Species composition	F6, F7, F8						Op				
Multimetric indices	CymoSkew	F1, F8						Op				
	BTA - Biological Traits Analysis	F6						Concep				
6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community		F1, F2, F6, F9*										
Abundance	Abundance ratio of benthic invertebrates above a specified length	F2						Op				
Size spectrum	BH5 Size frequency distribution of bivalve or other sensitive indicator species	F6							X (Ca)			
	Population structure (size distribution) of long-lived macrozoobenthic species	F6						Concep		X		
	Median colony/body size of conspicuous ecologically significant species (e.g., Buccinum undatum, Mytilus edulis, Flustra foliacea, Haliclona oculata and Alcyonium digitatum)	F6, F9						X				
	Population structure and size distribution of invertebrate animals	F6						uDev				
	Biomass/size spectrum of benthic invertebrates	F6						Concep				

Table 2

Hierarchical organization of metrics: Descriptor (D) > Criteria (C) > Indicator Set (IS) > Indicator Subset (ISS) > Metric (M). Under each Indicator Subset (ISS), metrics are first aggregated by aspect addressed in black text (substrate, abundance, biomass, body length, area extent, depth limit, species composition, multimetric index) and on a second level by feature addressed in grey text (e.g., particular "taxonomic" group like macrophytes or invertebrates, particular habitats, particular pressure).

Functions: F1 - Primary productivity, F2 – Secondary production, F3 - Provision of spawning area, F4 - Provision of feeding ground, F5 - Production of food, F6 - Energy flow/Changes in functional traits, F7 - Sediment reworking, F8 - Sediment stabilization, F9 - Provision of emergent 3D structure, F10 – Connectivity

MSFD Monit. - MSFD Monitoring parameters required (Craglia et al., 2010); **WFD** - Water Framework Directive; **HD** - Habitats Directive requirements; **Common Fisheries Policy (CFP) indicator status:** pDCF – ICES proposal for the Data Collection Framework. **DEVOTES indicator status**: Op – operation demonstrated in at least a report or scientific paper; uDev - under development; Concep - conceptual. **OSPAR indicator status:** Co – Common; Ca – Candidate**. HELCOM indicator status:** Co – Core; pCo – Pre-Core; Ca – Candidate**.**

*** if size spectrum is life history trait; **Source references at the end**

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/I b**	**M ac**	**WM ed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
C 6.1. Physical damage, having regard to substrate characteristics		State				EE											Coreset II inventory of indicators used at national level
IS 6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate		State															
ISS 6.1.1.1 Type of relevant biogenic substrate		State															
Habitat characteristics (predominant, special, protected and endangered)		State		X													Zampoukas *et al.*, 2012
Seabed Substrata Composition		State		X													Zampoukas *et al.*, 2012
Seabed substrate		State															Zampoukas *et al.*, 2012
Seabed topography		State	F9	X													Zampoukas *et al.*, 2012
Seabed quantity		State															Zampoukas *et al.*, 2012
Seabed structure		State		X													Zampoukas *et al.*, 2012
Specific structure of natural habitat types of community interest		State															Zampoukas *et al.*,, 2012

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
BH1 Typical species composition		State					UK, BE, NL, DE	UK	ES	X						uDev	OSPAR 2014
Species accumulation or rarefaction curves (zoobenthos)		State				X										proposed	MARMONI (Baltic)
Indicator of macroalgal community structure (MCS)		State				LV, EE										Op	MARMONI (Baltic)
Number of perennial algal species		State				X										proposed	MARMONI (Baltic)
Number of species (all taxa)		State				X										In use	MARMONI (Baltic)
Ratio of annual and perennial species (phytobenthos)		State				X										In use	MARMONI (Baltic)
Richness of the bioengineering species		State	F9		FR												MSFD National Initial Assessment Reports
WFD RSL - Macroalgae - Rocky Shore Reduced Species List		State														Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
BMI - Beachwrack Macrovegetation Index		State				EE										Op	MARMONI (Baltic)
RSL - Rocky Intertidal Macroalgae - Reduced Species List		State														Op	DEVOTES
Macrophyte species reduction (reduced species list)		State														Op	DEVOTES
Benthic invertebrate fauna composition		State															DEVOTES
Invertebrate bottom fauna species composition and its annual/seasonal variability		State		X													DEVOTES
Species richness of corals		State	F9														DEVOTES
BQI - Benthic Quality Index		State				SE										Op	DEVOTES
Habitat diversity index of phytobenthic zone (FDI)		State				EE										Op	Coreset II inventory of indicators used at national level/MARMONI (Baltic)
Hard bottom index (KPI)		State				EE										proposed	HELCOM CORESET
M-AMBI - Multivariate AZTI Marine Biotic Index		State							ES							Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD MarBIT - Marine Biotic Index Tool		State														Op	DEVOTES
WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos		State	F1, F9				DE									Op	DEVOTES
WFD BALCOSIS - Macrophyte index		State	F1, F9			DE										Op	DEVOTES
WFD HPI - German Macroalgae index		State	F1, F9			DE	DE									Op	DEVOTES
WFD German Eelgrass index (intertidal)		State	F1, F8, F9			DE	DE									Op	DEVOTES
CymoSkew		State	F1, F8, F9													Op	DEVOTES
WFD AETV - German Estuary Typology Procedure		State				DE	DE									Op	DEVOTES
WFD German Saltmarsh index		State				DE	DE									Op	DEVOTES
6.1.1.2 Abundance of relevant biogenic substrate		State															
Abundance of bioengineering species		State	F9		FR											Op	MSFD National Initial Assessment Reports
Abundance of coral colonies alive		State	F9													uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions												
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Abundance of eelgrass	1.6	State				EE										proposed	HELCOM CORESET
Abundance ratio of bleached coral colonies		State														Op	DEVOTES
Abundance (per unit of surface) of structuring/engineering species (per habitat)		State														Op	DEVOTES
Density of biogenic reef-forming species		State	F9													uDev	DEVOTES
M-AMBI - Multivariate AZTI Marine Biotic Index		State							ES							Op	DEVOTES
WFD MarBIT - Marine Biotic Index Tool		State														Op	DEVOTES
EEI - Ecological Evaluation Index		State														Op	DEVOTES
BQI - Benthic Quality Index		State				SE										Op	DEVOTES
WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos		State	F1, F9				DE									Op	DEVOTES
WFD BALCOSIS - Macrophyte index		State	F1, F9			DE										Op	DEVOTES
WFD ELBO - German Macrophyte index		State	F1, F9			DE										Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD Polish Assessment system for coastal and transitional waters using macrophytes		State	F1, F9			PL										Op	DEVOTES
WFD HPI - German Macroalgae index		State	F1, F9			DE	DE									Op	DEVOTES
MarMAT - Marine Macroalgae Assessment Tool		State	F1, F9													Op	DEVOTES
WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast		State	F1, F9				FR		FR							uDev	DEVOTES
WFD Swedish Assessment of Biological Quality Elements in coastal and transitional waters - macrovegetation		State	F1, F9			SE										Op	DEVOTES
WFD Valencian Region Method using Posidonia oceanica		State	F1, F8, F9								ES						DEVOTES
POSWARE		State	F1, F8, F9													Op	DEVOTES
WFD German Eelgrass index (intertidal)		State	F1, F8, F9			DE	DE									Op	DEVOTES
WFD British Seagrass index		State	F1, F8, F9				UK	UK								Op	DEVOTES
WFD AETV - German Estuary Typology Procedure		State				DE	DE									Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD German Saltmarsh index		State				DE	DE									Op	DEVOTES
CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities		State														Op	DEVOTES
6.1.1.3 Biomass of relevant biogenic substrate		State															
Biomass (per unit of surface) of structuring/engineering species (per habitat)		State			FR											Op	MSFD National Initial Assessment Reports
Biomass of macrophytes		State														uDev	DEVOTES
Biomass ratio of opportunistic macroalgae		State	F6													Op	DEVOTES
POSWARE		State	F1, F8, F9													Op	DEVOTES
WFD Valencian Region Method using Posidonia oceanica		State	F1, F8, F9								ES						DEVOTES
EPI - Estonian Phytobenthos Index		State	F1, F9			EE										Op	DEVOTES
WFD Polish Assessment system for coastal and transitional waters using macrophytes		State	F1, F9			PL										Op	DEVOTES
WFD Romanian Assessment system for coastal waters using macrophytes		State	F1, F9												RO	uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
6.1.1.4 Areal extent of relevant biogenic substrate		State															
Extent of benthic biotopes		State			UK												MSFD National Initial Assessment Reports
Ratio of area of selected habitats		State														Op	DEVOTES
Areal extent of selected habitats		State														Op	DEVOTES
Area covered by natural habitat types of community interest		State															Zampoukas *et al.*, 2012
Areal extent of intertidal rock		State														uDev	DEVOTES
Areal extent of subtidal rock		State														uDev	DEVOTES
Areal extent of littoral chalk habitat		State														uDev	DEVOTES
Areal extent of intertidal sea caves		State														uDev	DEVOTES
Ratio of area of biogenic/vulnerable habitat		State														Op	DEVOTES
Areal extent of biogenic/vulnerable habitats		State			ES											Op	MSFD National Initial Assessment Reports
Spatial extent/area of biogenic structure (marine angiosperms, maerl-type biogenic sediments)		State														X	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Areal extent of subtidal biogenic structures		State														uDev	DEVOTES
Areal extent of selected habitats affected by physical damage		State														uDev	DEVOTES
Cumulative coverage of macrophytes		State	F1, F9														Zampoukas *et al.*, 2012
Abundance of macroalgae (total cover)		State	F1, F9													Op	DEVOTES
Areal extent of macroalgae (cumulative/total cover)		State	F1, F9			X										In use	MARMONI (Baltic)
Cummulative cover of perennial macroalgae		State				LV										Op	MARMONI (Baltic)
Cumulative cover of submerged vascular plants		State				X										Op	MARMONI (Baltic)
Areal extent of marine angiosperms		State	F1, F8, F9													Op	DEVOTES
Areal extent of Posidonia oceanica meadows		State	F1, F8, F9													Op	DEVOTES
Areal extent of eelgrass		State	F1, F8, F9			EE										Op	DEVOTES
Areal extent of Fucus vesiculosus		State				EE											Coreset II inventory of indicators used at national level

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/I b**	**M ac**	**WM ed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Cover of Fucus vesiculosus		State				EE											Coreset II inventory of indicators used at national level
Areal extent of Furcellaria lumbricalis		State				EE											
Areal extent of maerl-type biogenic sediments		State	F1, F9													Op	DEVOTES
Areal extent of blue mussels		State	F9													uDev	DEVOTES
Depth limit of macroalgae		State	F1, F9													uDev	DEVOTES
Depth limit of attached perennial macroalgae		State	F1, F9													uDev	DEVOTES
Depth distribution of vegetation		State				X										In use	MARMONI inventory
Depth distribution of selected perennial macroalgae		State				EE, LV, FI, SE										Op	MARMONI inventory
Depth distribution of macroalgae		State				X										in use	MARMONI inventory
Depth distribution of Fucus vesiculosus		State				X										in use	MARMONI inventory
Depth limit of Fucus spp.		State	F1, F9													Op	DEVOTES
Depth limit of Fucus vesiculosus		State	F1, F9													Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions												
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Depth limit of Furcellaria lumbricalis		State	F1, F9													Op	DEVOTES
Depth limit of eelgrass		State	F1, F8, F9													Op	DEVOTES
Depth limit of Ruppia spp.		State	F1, F8, F9													uDev	DEVOTES
Depth limit of charophytes		State	F1, F8, F9													Op	DEVOTES
Depth limit of spermatophytes		State	F1, F8, F9													Op	DEVOTES
Maximum depth distribution of Macoma balthica		State				EE											Coreset II inventory of indicators used at national level
Lower depth limit of macrophytes species		State	F1, F9														
Lower growth limit of perennial phytobenthos		State				X										In use	MARMONI (Baltic)
Natural range of natural habitat types of community interest		State															Zampoukas *et al.*, 2012
Potential / observed distribution range of selected coastal and marine habitats (SPA protocol)		State									X	X	X	X			UNEP/MAP
Distribution pattern of selected coastal and marine habitats (SPA protocol)		State									X	X	X	X			UNEP/MAP

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/I b**	**M ac**	**WM ed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Distribution range of Chara connivens	1.1.	State				EE											Coreset II inventory of indicators used at national level
Distribution range of Fucus vesiculosus	1.1.	State				EE											Coreset II inventory of indicators used at national level
Distribution range of loose Furcellaria lumbricalis	1.1.	State				EE											Coreset II inventory of indicators used at national level
Distributional range of eelgrass		State				EE											
Distributional range of Furcellaria lumbricalis		State				EE											
Distribution and pattern of benthic biotopes		State				DE, EE, FI, PL, SE											
Distributional range of horse mussel banks		State	F9													uDev	DEVOTES
Occurrence of horse mussel beds	1.4.	State				DK											Coreset II inventory of indicators used at national level
Distributional range of Haploops communities		State	F7													uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Occurrence of Haploops (tube dwelling crustaceans) communities	1.4.	State				DK											Coreset II inventory of indicators used at national level
CFR - Multimetric CFR index (Quality of Rocky Bottoms)		State	F1, F9													Op	DEVOTES
WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos		State	F1, F9				DE									Op	DEVOTES
WFD HPI - German Macroalgae index		State	F1, F9			DE	DE									Op	DEVOTES
MarMAT - Marine Macroalgae Assessment Tool		State	F1, F9													Op	DEVOTES
WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast		State	F1, F9				FR		FR							uDev	DEVOTES
WFD Swedish Assessment of Biological Quality Elements in coastal and transitional waters - macrovegetation		State	F1, F9			SE										Op	DEVOTES
POSWARE		State	F1, F8, F9													Op	DEVOTES
WFD Dutch Eelgrass index		State	F1, F8, F9				NL									Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity		Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD German Eelgrass index (intertidal)		State	F1, F8, F9			DE	DE									Op	DEVOTES
WFD British Seagrass index		State	F1, F8, F9				UK	UK								Op	DEVOTES
WFD Valencian Region Method using Posidonia oceanica		State	F1, F8, F9								ES						DEVOTES
WFD German Saltmarsh index		State				DE	DE									Op	DEVOTES
CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities		State														Op	DEVOTES
6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types		Pressure				EE											Coreset II inventory of indicators used at national level
Seabed structure		State		X													Zampoukas *et al.*, 2012
Seabed substrata composition		State		X													Zampoukas *et al.*, 2012
Seabed topography		State		X													Zampoukas *et al.*, 2012
Seabed substrate encountered during operation of mobile bottom gears		State															Data Collection Framework
Substrate condition		State														Op	DEVOTES
Macrophyte species reduction (reduced species list)		Pressure	F1, F9													Op	DEVOTES
Species richness of corals		State	F9													uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Species diversity (Simpson) of benthic invertebrates		State														uDev	DEVOTES
Species diversity (Shannon index) of benthic invertebrates		State														Op	DEVOTES
Abundance (per unit of surface) of structuring/engineering species (per habitat)		State	F9													Op	DEVOTES
Abundance of bioengineering species		State	F9													Op	DEVOTES
Density of biogenic reef-forming species		State	F9													uDev	DEVOTES
Macroalgae abundance		State	F1, F9														Zampoukas *et al.*, 2012
Macroalgae cover		State	F1, F9														Zampoukas *et al.*, 2012
Angiosperms abundance		State	F1, F8, F9														Zampoukas *et al.*, 2012
Angiosperms cover		State	F1, F8, F9														Zampoukas *et al.*, 2012
Benthic invertebrate fauna abundance		State															Zampoukas *et al.*, 2012
Abundance ratio of bleached coral colonies		State														Op	DEVOTES
Macroalgae biomass		State	F1, F9	X													Zampoukas *et al.*, 2012
Angiosperms biomass and its annual/seasonal variability		State	F1, F9	X													Zampoukas *et al.*, 2012

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Areal extent of selected habitats affected by physical damage (≈6.1.2 definition)		Pressure			LT, SI		UK, BE, DE	UK	ES	X						uDev	OSPAR 2014; Initial assessment
BH3 Physical damage of predominant and special habitats		Pressure			SI	DE	UK, DE	X	X	X						uDev	OSPAR 2014; Initial assessment
Benthic bycatch of mobile bottom gears	1.4.	Pressure				X	DK									uDev	Coreset II inventory of indicators used at national level
BH4 Area of habitat loss		Pressure			SI	DE	UK, BE, DE	UK	ES	X						uDev	OSPAR 2014; Initial assessment
Areal extent of human affected area		Pressure			ES											uDev	MSFD National Initial Assessment Reports
Ratio of area potentially affected by changes in the seafloor topography		Pressure	F9													Op	DEVOTES
Areal extent of dead Posidonia oceanica meadows		Pressure	F1, F8, F9													Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Area affected by extraction		Pressure															
Ratio of area potentially affected by selective extraction of substrate		Pressure														Op	DEVOTES
Ratio of area affected by harbor dredging activities		Pressure														Op	DEVOTES
Areal extent of abrasion		Pressure			SI												MSFD National Initial Assessment Reports
Ratio of area affected by dredging disposal		Pressure														Op	DEVOTES
Ratio of area potentially affected by discharge of materials		Pressure														Op	DEVOTES
Spatial extent affected by dumping		Pressure				DK										X	Coreset II inventory of indicators used at national level
Ratio of area affected by artificial beaches or beach nourishment		Pressure														Op	DEVOTES
Spatial extent affected by major construction		Pressure			SI	DK										X	Coreset II inventory of indicators used at national level

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions												
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Length of coastline subject to physical disturbance due to the influence of manmade structures (Length of manmade coastline, Total surface area reclaimed, Length of sandy coastline influenced by manmade structures)											X	X	X	X			UNEP/MAP
Ratio of area affected by port infrastructure		Pressure														Op	DEVOTES
Ratio of area affected by human highly-modified coast		Pressure														Op	DEVOTES
Ratio of area affected by anchorage		Pressure														Op	DEVOTES
Ratio of area affected by cables and pipelines		Pressure														Op	DEVOTES
Ratio of area affected by aquaculture		Pressure														Op	DEVOTES
Ratio of area potentially affected by changes in the sedimentation rate		Pressure														Op	DEVOTES
Spatial extent affected by smothering		Pressure		X													Zampoukas *et al.*, 2012
Spatial extent affected by sealing		Pressure		X													Zampoukas *et al.*, 2012
Spatial and temporal distribution of human activities [shipping, interventions, plans, accidents (oil, nuclear, chemicals...), military, munitions]		Pressure				DE											Coreset II inventory of indicators used at national level

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Extent of seabed impacted by raw material extraction		Pressure				DK											Coreset II inventory of indicators used at national level
Ratio of area affected by each type of fishing gear		Pressure														Op	DEVOTES
Spatial extent of area affected by trawling		Pressure															Data Collection Framework
Total area fished by year (if discriminating métier that actually disturbs the seafloor)		Pressure															Data Collection Framework
Proportion of surface area fished by year (if discriminating métier that actually disturbs the seafloor)		Pressure															Data Collection Framework
Cumulative proportion of surface area not impacted by mobile bottom gears over a specific period (allowing recovery)		Pressure	F7, F8, F9														Data Collection Framework
Proportion of surface area not impacted by mobile bottom gears at a specific level of confidence		Pressure															Data Collection Framework
Proportion of surface area fished by specific proportion of effort		Pressure															Data Collection Framework
Proportion of surface area fished at specific intensity (e.g., more than once a year)		Pressure															Data Collection Framework

MSFD Descriptor 6 – Seafloor Integrity		Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/I b**	**M ac**	**WM ed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Areal extent of oxygen depletion		Pressure														uDev	DEVOTES
Areal extent of hypoxia (spatial and temporal)		Pressure														Concep	DEVOTES
Areal extent of hypoxic zones		Pressure														uDev	DEVOTES
Areal extent of anoxic bottoms		Pressure														Concep	DEVOTES
Depth distribution of selected macrozoobenthos species		State														uDev	DEVOTES
Cumulative impact of human activities		Pressure			FI	X										uDev	Coreset II inventory of indicators used at national level
Cumulative impact on benthic biotopes		Pressure					X	X	X	X							OSPAR 2014
Cumulative impacts on benthic habitats		Pressure			SE, DK, FR											uDev	MSFD National Initial Assessment Reports
Dredging and dumping of dredge materials		Pressure					X	X	X	X							OSPAR 2014
Number of dredging permits and the amount dredged related to them		Pressure			FI	X										uDev	Coreset II inventory of indicators used at national level

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Deposition of fine-grained sediments in sand-eel areas from construction works in the marine environment	1.6	Pressure				DK										uDev	Coreset II inventory of indicators used at national level
Impacts of anthropogenic physical disturbance on the sea-pen community		Pressure				X										uDev	Coreset II inventory of indicators used at national level
Accumulation of contaminants in sediment		Pressure														Op	DEVOTES
Abrasion by benthic impacting fishing gears (otter trawl, rapido trawl and hydraulic dredge) on biogenic substrates		Pressure			IT, SI												MSFD National Initial Assessment Reports
Sealing (determined by coastal defense structures, offshore structures, pipes, etc.) on biogenic substrates		Pressure			IT												MSFD National Initial Assessment Reports
Impacts of anthropogenic removal of target species		Pressure														uDev	DEVOTES
Impacts of anthropogenic removal of non-target species		Pressure														uDev	DEVOTES
Impacts of anthropogenic sediment penetration and/or disturbance below the seabed surface		Pressure														uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity		Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/I b**	**M ac**	**WM ed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Impacts of anthropogenic shallow abrasion/penetration damage to seabed surface		Pressure														uDev	DEVOTES
Index describing recovery of underwater deposition/dumping sites to natural state		Recoverability			FI	X										Concep	Coreset II inventory of indicators used at national level
Seafloor exploitation index		Pressure				FI, EE										Op	MARMONI (Baltic)
Index for the seafloor geological stability (physical integrity)		Pressure				FI										Concep	Coreset II inventory of indicators used at national level
WFD Polish Assessment system for coastal and transitional waters using macrophytes		State				PL										Op	DEVOTES
MAB - Macroalgal Bloom Assessment (opportunistic macroalgae)		Pressure	F6													Op	DEVOTES
6.2. Condition of benthic community		State				DE											
6.2.1 Presence of particularly sensitive and/or tolerant species		State															
Presence of particularly sensitive and/or tolerant species (different species list for MS)		State				DK										Op	HELCOM
Macroalgae - Presence of sensitive taxa		State	F1, F9														Zampoukas *et al.*, 2012

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Angiosperms - Presence of sensitive taxa		State	F1, F9														Zampoukas *et al.*, 2012
Benthic bycatch of mobile bottom gears		Pressure					DK									uDev	Data Collection Framework; Coreset II inventory of indicators used at national level
Benthos species composition		State													X		Black Sea Convention
Species richness of selected habitats		State														Op	DEVOTES
Average number of species per bottom sample (or Mean species index value per bottom sample)		State				DK											Coreset II inventory of indicators used at national level
Macroalgae species composition		State	F1, F9	X													Zampoukas *et al.*, 2012
Macroalgae species composition		State	F1, F9														Zampoukas *et al.*, 2012
RSL - Rocky Intertidal Macroalgae - Reduced Species List (RSL)		State	F1, F9													Op	DEVOTES
WFD RSL - Macroalgae - Rocky Shore Reduced Species List		State	F1, F9													Op	DEVOTES
Macrophyte species reduction (reduced species list)		State	F1, F9													Op	DEVOTES
Angiosperms species composition and its annual/seasonal variability		State	F1, F8, F9	X													Zampoukas *et al.*, 2012
Angiosperms composition		State	F1, F8, F9														Zampoukas *et al.*, 2012

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Invertebrate bottom fauna species composition and its annual/seasonal variability		State		X													Zampoukas *et al.*, 2012
Benthic invertebrate fauna composition		State															Zampoukas *et al.*,2012
Species richness of benthic invertebrates		State				FI										Op	DEVOTES
Morphological diversity of sponges		State	F9													uDev	DEVOTES
Benthos population abundance		State													X		Black Sea Convention
Abundance (per unit of surface) of structuring/engineering species (per habitat)		State	F9													Op	DEVOTES
Abundance and composition of intertidal macroalgae		State	F1, F9													Op	DEVOTES
Abundance of macroalgae (total cover)		State	F1, F9													Op	DEVOTES
Abundance of selected benthic invertebrate species		State														uDev	DEVOTES
Abundance of functional groups of fish		State	F6													Op	DEVOTES
Abundance ratio of plankton functional groups (in terms of life form)		State	F6													uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions												
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Benthos population biomass		State	F2												X		Black Sea Convention
Biomass (per unit of surface) of structuring/engineering species (per habitat)		State	F9													Op	DEVOTES
Biomass of benthic fauna		State				DK										In use	Coreset II inventory of indicators used at national level
Biomass of engineering species		State	F9													Op	DEVOTES
Biomass ratio of opportunistic macroalgae		State	F6													Op	DEVOTES
Biomass of selected benthic invertebrate species		State														uDev	DEVOTES
Invertebrate bottom fauna biomass and its annual/seasonal variability		State		X													Zampoukas *et al.*, 2012
Body length distribution of Cladophora		State														uDev	DEVOTES
Extent of selected benthic biotopes		State									X	X	X	X			UNEP/MAP
Areal extent of intertidal opportunistic green algae		State	F6													Op	DEVOTES
Areal extent of selected macroalgae species		State	F1, F9													Op	DEVOTES
Areal extent of alterated Posidonia oceanica meadows		State	F1, F8, F9													Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/I b**	**M ac**	**WM ed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Areal extent of eelgrass		State	F1, F8, F9			EE										Op	DEVOTES
Depth limit of attached perennial macroalgae		State	F1, F9													uDev	DEVOTES
Depth distribution of Cystoseira sp.		State	F1, F9													uDev	DEVOTES
Depth limit of Fucus spp.		State	F1, F9													Op	DEVOTES
Depth limit of Fucus vesiculosus		State	F1, F9													Op	DEVOTES
Depth limit of Furcellaria lumbricalis		State	F1, F9													Op	DEVOTES
Depth distribution of Phyllophora sp.		State	F1, F9													uDev	DEVOTES
Depth limit of eelgrass		State	F1, F8, F9													Op	DEVOTES
Depth limit of spermatophytes		State	F1, F8, F9													Op	DEVOTES
Depth limit of charophytes		State	F1, F8, F9													Op	DEVOTES
Condition of the habitat's typical species and communities		State									X	X		X	X		UNEP/MAP
Benthic community condition of bladderwrack habitat	1.6	State				EE											Coreset II inventory of indicators used at national level

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Benthic community condition of charophyte habitat	1.6	State				EE											Coreset II inventory of indicators used at national level
Benthic community condition of eelgrass habitat	1.6	State				EE											Coreset II inventory of indicators used at national level
Benthic community condition of Furcellaria lumbricalis habitat	1.6	State				EE											Coreset II inventory of indicators used at national level
Condition of soft sediment habitats – the aRPD approach		State				X										Op	MARMONI (Baltic)
BENTIX		State														Op	DEVOTES
M-AMBI - Multivariate AZTI Marine Biotic Index		State							ES							Op	DEVOTES
BAT - Benthic Assessment Tool		State														Op	DEVOTES
BBI - Brackish water benthic index		State			FI											Op	MSFD National Initial Assessment Reports
BTA - Biological Traits Analysis		State	F6													Concep	DEVOTES
EEI - Ecological Evaluation Index		State														Op	DEVOTES
WFD MarBIT - Marine Biotic Index Tool		State														Op	DEVOTES
MEDOCC		State														Op	DEVOTES
ITI - Trophic index		State	F6													Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD BALCOSIS - Macrophyte index		State	F1, F9			DE										Op	DEVOTES
WFD ELBO - German Macrophyte index		State	F1, F9			DE										Op	DEVOTES
WFD Romanian Assessment system for coastal waters using macrophytes		State	F1, F9												RO	uDev	DEVOTES
WFD Polish Assessment system for coastal and transitional waters using macrophytes		State	F1, F9			PL										Op	DEVOTES
WFD Swedish Assessment of Biological Quality Elements in coastal and transitional waters - macrovegetation		State	F1, F9			SE										Op	DEVOTES
MAB - Macroalgal Bloom Assessment (Opportunistic macroalgae)		State	F1, F6, F9													Op	DEVOTES
MarMAT - Marine Macroalgae Assessment Tool		State	F1, F9													Op	DEVOTES
WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast		State	F1, F9				FR		FR							uDev	DEVOTES
WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos		State	F1, F9				DE									Op	DEVOTES
EPI - Estonian Phytobenthos Index		State	F1, F9			EE										Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions												
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
POMI - Posidonia oceanica Multivariate Index		State	F1, F8, F9													Op	DEVOTES
WFD Valencian Region Method using Posidonia oceanica		State	F1, F8, F9								ES						DEVOTES
POSWARE		State	F1, F8, F9													Op	DEVOTES
CymoSkew		State	F1, F8, F9													Op	DEVOTES
WFD Dutch Eelgrass index		State	F1, F8, F9				NL									Op	DEVOTES
WFD German Eelgrass index (intertidal)		State	F1, F8, F9			DE	DE									Op	DEVOTES
WFD British Seagrass index		State	F1, F8, F9				UK	UK								Op	DEVOTES
WFD ZKI - Estonian multimetric macrozoobenthos community index		State				EE										Op	Coreset II inventory of indicators used at national level
BOPA - Benthic Opportunistic Annelida Amphipoda Index		State	F6								X	X	X	X		Op	DEVOTES, UNEP/MAP
WFD AETV - German Estuary Typology Procedure		State				DE	DE									Op	DEVOTES
WFD German Saltmarsh index		State				DE	DE									Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities		State														Op	DEVOTES
IQI - Infaunal Quality Index		State														Op	DEVOTES
DKI - Danish Quality Index		State				DK										Op	DEVOTES
BEQI - Benthic Ecosystem Quality Index		State														Op	DEVOTES
BQI - Benthic Quality Index		State				SE										Op	DEVOTES
CFR - Multimetric CFR index (Quality of Rocky Bottoms)		State							FR							Op	DEVOTES
Quality of benthic biotopes		State															
Quality of sandeel habitats	1.4.	State				DK											Coreset II inventory of indicators used at national level
6.2.2 Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species		State			PT	FI, PL, LV, SE, DE	FR, NL, UK	UK	FR, ES, PT	ES	FR, ES						OSPAR 2014

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
BH1 Typical species composition		State					UK, BE, NL, DE	UK	ES	X						uDev	OSPAR 2014
Macro-algae species composition		State	F1, F9	X	CY												MSFD National Initial Assessment Reports
WFD RSL - Macroalgae - Rocky Shore Reduced Species List		State	F1, F9													Op	DEVOTES
RSL - Rocky Intertidal Macroalgae - Reduced Species List		State	F1, F9													Op	DEVOTES
Macrophyte species reduction (reduced species list)		State	F1, F9													Op	DEVOTES
Angiosperms composition		State	F1, F8, F9														
Angiosperms species composition and its annual/seasonal variability		State	F1, F8, F9	X	CY												MSFD National Initial Assessment Reports
Species richness of benthic invertebrates		State			PT	FI			PT							Op	DEVOTES
Benthic Invertebrate Fauna Composition		State															

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD							MSFD regions						
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Benthic Invertebrate Fauna Diversity		State															
Invertebrate bottom fauna species composition and its annual/seasonal variability		State		X	CY												MSFD National Initial Assessment Reports
Species diversity (Shannon index) of macroalgae		State	F1, F9													Op	DEVOTES
Species diversity of benthic communities		State			PT	DK			PT							Op	DEVOTES
Species diversity (Shannon index) of benthic invertebrates		State														Op	DEVOTES
Species diversity (Simpson) of benthic invertebrates		State														uDev	DEVOTES
TSI - Taxonomic Spread Index		State														Op	DEVOTES
Evenness of sandeel banks		State														uDev	DEVOTES
Abundance ratio of opportunistic/sensitive species		State	F6		EL											Op	MSFD National Initial Assessment Reports
Abundance of opportunistic macroalgae		State	F1, F6, F9													Op	DEVOTES
Abundance ratio of opportunistic green macroalgae		State	F1, F6, F9													uDev	DEVOTES
Abundance of perennial seaweeds		State	F1, F9													Op	DEVOTES
Abundance of shade-adapted, slow growing calcareous species		State														Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Biomass ratio of opportunistic macroalgae		State	F1, F6, F9													Op	DEVOTES
Biomass ratio of opportunistic/perennial macroalgae		State	F1, F6, F9													uDev	DEVOTES
Biomass ratio of opportunistic/sensitive species		State	F6													Op	DEVOTES
Necessary functions of natural habitat types of community interest		State															
BENTIX		State														Op	DEVOTES
MEDOCC		State														Op	DEVOTES
ITI - Trophic index		State														Op	DEVOTES
EEI - Ecological Evaluation Index		State														Op	DEVOTES
Habitat diversity index of phytobenthic zone (FDI)		State				EE										Op	Coreset II inventory of indicators used at national level/MARMONI (Baltic)
Hard bottom index (KPI)		State				EE											Coreset II inventory of indicators used at national level
WFD BALCOSIS - Macrophyte index		State	F1, F9			DE, DK										Op	DEVOTES
WFD ELBO - German Macrophyte index		State	F1, F9			DE										Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD Polish Assessment system for coastal and transitional waters using macrophytes		State	F1, F9			PL										Op	DEVOTES
WFD Romanian Assessment system for coastal waters using macrophytes		State	F1, F9												RO	uDev	DEVOTES
WFD HPI - German Macroalgae index		State	F1, F9			DE	DE									Op	DEVOTES
Surface area/biomass ratio of selected macroalgae species		State	F1, F9													Op	DEVOTES
MarMAT - Marine Macroalgae Assessment Tool		State	F1, F9													Op	DEVOTES
WFD Quality index of subtidal macroalgae of French Channel and Atlantic coast		State	F1, F9				FR		FR							uDev	DEVOTES
Benthic flora Cheney's ratio index		State	F1, F6, F9													uDev	DEVOTES
EPI - Estonian Phytobenthos Index		State	F1, F9			EE										Op	DEVOTES
WFD SHWAP - Schleswig-Holstein Wadden Sea Assessment of Phytobenthos		State	F1, F9				DE									Op	DEVOTES
Index of phytocoenoses ecological activity (S/Wph)		State	F1, F9													Op	DEVOTES
POMI - Posidonia oceanica Multivariate Index		State	F1, F8, F9													Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD British Seagrass index		State	F1, F8, F9				UK	UK								Op	DEVOTES
WFD German Eelgrass index (intertidal)		State	F1, F8, F9			DE	DE									Op	DEVOTES
Zoobenthos Community Index (ZKI) (macrozoobenthos)		State				FI, SE, EE										In use	HELCOM CORESET; MARMONI (Baltic)
Zoobenthos community stability (the ratio between the mean and the standard deviation)		State				X										proposed	MARMONI (Baltic)
Zoobenthos community wide synchronicity		State				X										proposed	MARMONI (Baltic)
Zoobenthos relative abundance (or biomass) and species-rank curves		State				X										proposed	MARMONI (Baltic)
Index for functional groups of benthic invertebrates		State														uDev	DEVOTES
WFD ZKI - Estonian multimetric macrozoobenthos community index		State				EE										Op	DEVOTES
BOPA - Benthic Opportunistic Annelida Amphipoda Index		State	F6													Op	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
WFD Lithuanian Assessment system for transitional and coastal waters using macrozoobenthos		State				LT										uDev	DEVOTES
BH2 Multimetric indices – Condition of habitat-defining communities		State					BE, DE, DK, FR, SE, UK	FR, UK	ES, FR	X							OSPAR 2014
State of benthic communities		State														Op	DEVOTES
State of hard-bottom communities		State				X										proposed	HELCOM
State of soft-bottom macrofauna communities		State		LV	LV	FI, PL, LV, SE, DE, DK?										proposed	HELCOM CORESET; Initial assessment

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions												
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
State of the predominant species and communities specific to underwater biotopes	1	State				FI											Coreset II inventory of indicators used at national level
BBI - Brackish water benthic index		State														Op	DEVOTES
WFD MarBIT - Marine Biotic Index Tool		State														Op	DEVOTES
CARLIT-BENTHOS - Cartography of littoral and upper-sublittoral rocky-shore communities		State														Op	DEVOTES
MarClim - Intertidal community indicator (Condition of typical species/communities)		State														uDev	DEVOTES
AMBI - AZTI Marine Biotic Index		State							ES							Op	DEVOTES
M-AMBI - Multivariate AZTI Marine Biotic Index		State			ES, PT				ES, PT							Op	MSFD National Initial Assessment Reports
BAT - Benthic Assessment Tool		State														Op	DEVOTES
WFD AETV - German Estuary Typology Procedure		State				DE	DE									Op	DEVOTES
WFD British Saltmarsh classification tool		State					UK	UK								uDev	DEVOTES
WFD German Saltmarsh index		State				DE	DE									Op	DEVOTES
CFR - Multimetric CFR index (Quality of Rocky Bottoms)		State			ES				FR							Op	MSFD National Initial Assessment Reports

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Community heterogeneity (CH)		State				EE										Op	MARMONI (Baltic)
BQI - Benthic Quality Index		State			LT, LV	SE										In use	MARMONI (Baltic)
BEQI - Benthic Ecosystem Quality Index		State														Op	DEVOTES
IQI - Infaunal Quality Index		State														Op	DEVOTES
DKI - Danish Quality Index		State				DK										Op	DEVOTES
Ecosystem structure index based on distribution and abundance indicators	1	State				FI											Coreset II inventory of indicators used at national level
Seabed geological stability (physical integrity) index		State	F7, F8		FI												MSFD National Initial Assessment Reports
6.2.3 Proportion of biomass or number of individuals in the macrobenthos above some specified length/size		State				EE											Coreset II inventory of indicators used at national level
6.2.3.1 Proportion of biomass of individuals in the macrobenthos above some specified length/size		State															
Biomass ratio		State				X											HELCOM
Biomass/size spectrum of benthic invertebrates		State														Concep	DEVOTES
Species composition		State														Op	DEVOTES
BTA - Biological Traits Analysis		State	F6													Concep	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
6.2.3.2 Proportion of number of individuals in the macrobenthos above some specified length/size		State															
Population structure of long-lived macrozoobenthic species		State	F5, F7, F8			X										Concep	HELCOM
Population structure of Macoma balthica		State				LV, FI										Op	MARMONI (Baltic)
Abundance ratio of cumulative proportions of size classes >80mm of Mytilus galloprovincialis		State	F5, F9														MSFD national reports
Body length distribution of bivalve or other sensitive/indicator species		State	F6													uDev	DEVOTES
Body length distribution of bivalves		State	F6													Concep	DEVOTES
Body length distribution of selected (long-living) benthic invertebrate species		State	F7, F8													uDev	DEVOTES
Species composition		State	F6, F7, F8													Op	DEVOTES
CymoSkew		State	F1, F8													Op	DEVOTES
BTA - Biological Traits Analysis		State	F6													Concep	DEVOTES
Number of functional traits (NFT)		State				FI, EE										Op	MARMONI (Baltic)

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Zoobenthos number (diversity) of functional traits		State				X										proposed	MARMONI (Baltic)
6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community		State				EE											Coreset II inventory of indicators used at national level
Abundance ratio of benthic invertebrates above a specified length		State	F2													Op	DEVOTES
Spectral variability index		State				EE										Op	MARMONI (Baltic)
BH5 Size frequency distribution of bivalve or other sensitive indicator species		State	F6				DE	X	X	X							OSPAR 2014
Population structure (size distribution) of long-lived macrozoobenthic species		State	F6			X										Concep	HELCOM
Median colony/body size of conspicuous ecologically significant species (e.g., Buccinum undatum, Mytilus edulis, Flustra foliacea, Haliclona oculata and Alcyonium digitatum)		State	F6, F9														DEVOTES
Population structure and size distribution of invertebrate animals		State	F6													uDev	DEVOTES

MSFD Descriptor 6 – Seafloor Integrity			Function	MSFD		MSFD regions											
Detailed metrics (in MSFD a.k.a. methodological standards)	**other D's**	**State/ Pressure**	**(see legend)**	**Moni. Art. 10**	**Init. Asses. Art. 9**	**Baltic**	**NS**	**CS**	**BoB/Ib**	**Mac**	**WMed**	**CMed**	**Adriat**	**EMed**	**Black**	**Status**	**Source****
Biomass/size spectrum of benthic invertebrates		State	F6													Concep	DEVOTES

Snapshot extract from the table. The full table is available on request to ICES.

MSFD Descriptor 6 – seafloor integrity			Function	MSFD		MSFD regions										
Detailed metrics (in MSFD a.k.a. methodological standards)	other D's	State/ Pressure	(see legend)	Moni. Art. 10	Init. Asses. Art. 9	Baltic	NS	CS	BoB/Ib	Mac	WMed	CMed	Adriat	EMed	Black	Status	Source**
C 6.1. Physical damage, having regard to substrate characteristics		State				EE											Coreset II inventory of indicators used at national level
IS 6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate		State															
ISS 6.1.1.1 Type of relevant biogenic substrate		State															
Habitat characteristics (predominant, special, protected and endangered)		State		X													Zampoukas *et al.*, 2012
Seabed structure		State		X													Zampoukas *et al.*, 2012
Specific structure of natural habitat types of community interest		State															Zampoukas *et al.*, 2012
BH1 Typical species composition		State					UK, BE, NL, DE	UK	ES	X						uDev	OSPAR 2014

Annex 6. Case study: Bioturbation potential in the North Sea.

Bioturbation is the biologically mediated regulation of biogeochemical processes. This is one of the most important aspects of ecosystem function in marine soft sediments (Queiros *et al*., 2013, Birchenough *et al*., 2014; Solan *et al*., 2004). The bioturbation potential of individual communities can be estimated using the BPc index developed by Solan *et al*., (2004), taking account of structural macrobenthic parameters (e.g. abundance and biomass of benthic species) and biological traits information (e.g. mobility and reworking more). A total of 1033 benthic invertebrate species from the Northwest European continental shelf were coded for reworking and mobility as a way to standarize bioturbaiton potential calculation in the region (Queiros *et al*., 2013).

The example provided below aimed to examine spatial patterns in bioturbation over the North Sea, with the view on assessing how these patterns relate to habitat type and environmental forcing.

The infaunal datasets (e.g. abundance and biomass) obtained from this work were used to calculate the Community Biotubation potential (BPc). The calculation of the BPc was based on the methodology proposed by Solan *et al*., (2004), where individual species were coded following the categories proposed by Swift (1993) and Solan *et al.,* (2004a), each taxon (1) was scored on categorical scales that reflect increasing mobility (Mi) from 1 (living in a fixed tube) to 4 (free three-dimensional movement via burrow system), and increasing sediment reworking (Ri) from 1 (epifauna that bioturbate at the sediment–water interface) to 5 (regenerators that excavate holes, transferring sediment at depth to the surface) (Queiros *et al*., 2013) . The bioturbation formula is represented below:

$$\mathrm{BP_c} = \sum_{i=1}^{n} \sqrt{\mathrm{B}i/\mathrm{A}i} \times \mathrm{A}i \times \mathrm{M}i \times \mathrm{R}i$$

Bi and Ai are the biomass and abundance of species/taxon i in a sample. The trait scores were derived from an extensive review of published material and expert knowledge, which is available to allow calculation of this metric (Queirós *et al*., 2013

Approach

This work was done under the ICES Study Group on Climate Related Processes in the North Sea (ICES SGCBNS, 2012). The analysis used the North Sea Benthic Project 2000 (NSBP 2000) data, which provided the most extensive macrofauna dataset on a North Sea wide scale. The bioturbation potential was calculated by adopting the formula proposed by Solan *et al.,* 2004.

Since the NSBP 2000 dataset only provides abundance data, the bioturbation potential for this dataset had to be calculated based on mean individual weights of the North Sea macrofauna species. Thus, available abundance and biomass data, provided by the members of the SGCBNS was used to calculate the mean individual weights (MIW). Following a group discussion during the meeting in 2011, the abundance and biomass data were compiled on a seasonal scale to account for seasonal differences in bioturbation potential (see section 5 of ICES SGCBNS, 2012 for details).

Overall, Figure 1 shows the different ranges of BPc calculated across the North Sea. The highest values were observed in central part of the North Sea and in the German Bight. The Northern North Sea area reached moderate BPc values when compared to

the Western and Southern areas. There are some clear coastal spots in the South with higher BPc values. This analysis showed that there are 3 main BPc groups, which are not different from each other in the Northern North Sea area. This example helps to illustrate that the basic structural properties of the benthic communities (e.g. abundance and biomass) can help to calculate the bioturbation potential of macrobenthic communities, which is a key mediated process to help to illustrate aspects on benthic function in the North Sea.

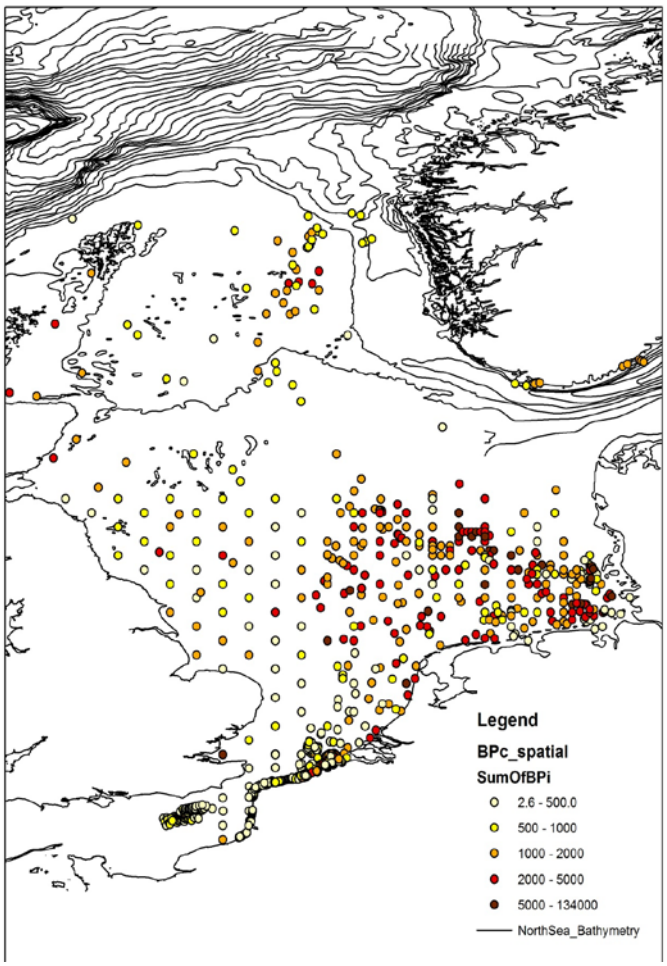


Figure 1. Bioturbation potential calculated with data from the NSBP 2000 (ICES SGCBNS, 2012.)

References

Birchenough, S. N. R., Parker, E. R., McManus, E., and Barry, J. 2012. Combining bioturbation and redox metrics: potential tools for assessing seabed function. Ecol Ind, 12, 8-16.

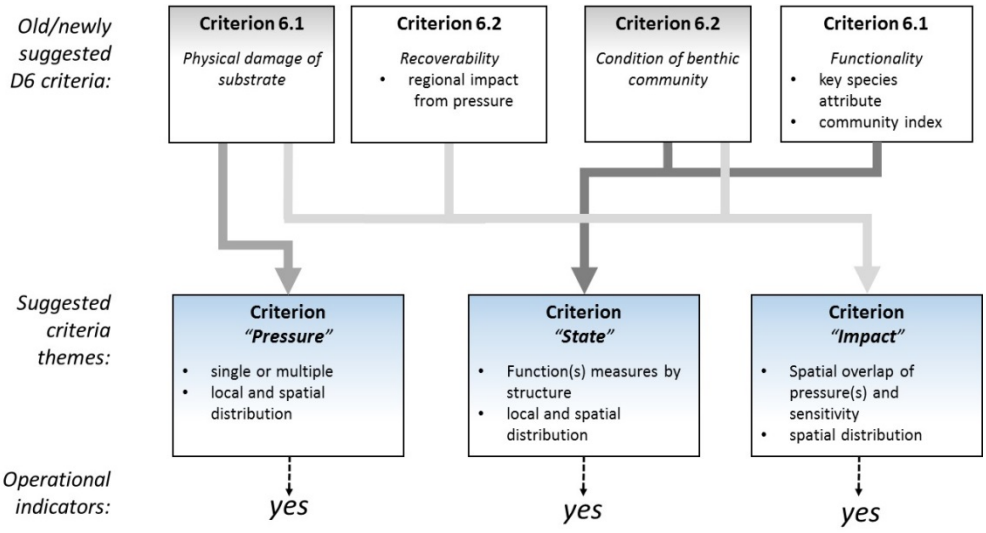
ICES (2012) Report of the Study Group on Climate related Benthic processes in the North Sea (SGCBNS). ICES CM 2012.

ICES (2011) Report of the Study Group on Climate related Benthic processes in the North Sea (SGCBNS). ICES CM 2011/SSGEF:12, by correspondence.

Queirós, A. M., Birchenough, S. N., Bremner, J., Godbold, J. A., Parker, R. E., Romero-Ramirez, A., ... and Widdicombe, S. (2013). A bioturbation classification of European marine infaunal invertebrates. *Ecology and evolution*, *3*(11), 3958-3985.

Solan M, Cardinale BJ, Downing AL, Engelhardt KAM, Ruesink JL, Srivastava DS (2004a) Extinction and ecosystem function in the marine benthos. Science 306: 1177-1180

Annex 7. Link between existing and newly suggested criteria and the proposed criteria themes.



Conceptual diagram illustrating how work under both old (2010) and newly suggested (2014) criteria can be merged for a conceptually stronger assessment and use of existing indicators/data to measure progress towards GES for seafloor integrity.

Annex 8. Overview of methodology for the OSPAR indicator BH3 – Physical damage to seafloor habitats

Identification of human activities and pressures

Human activities affecting the seabed and their impacts are described and assigned to predefined pressures based on specifications by the MSFD: Physical loss (sealing, smothering) and physical damage (selective extraction, abrasion, changes in siltation). Anthropogenic activities considered in the German EEZ of the North Sea are bottom-trawling, permanent offshore installations, aggregate extraction and pipelines. In order to assess the spatial extent of pressures the area affected by each activity is defined. The temporal extent is determined by means of a five-step scale ranging from rare (once per reporting period) to persistent (permanent installation or more than three times per year). Each pressure is visualized separately on a GIS-based map.

Assessment of habitat sensitivity

The MSFD differentiates between 'predominant' (broad-scale habitats based on EUNIS level 3) and 'special habitats' (habitats protected under EU, regional or national legislation).

The method to assess habitat sensitivity is mainly adopted from the MarLIN approach developed by Tyler-Walters *et al*., (2001). The sensitivity of ecosystem components is determined by two aspects: the ability to withstand disturbance or stress (resistance or tolerance) and the ability and time needed to recover from a perturbation and return to the previous state (resilience or recoverability). Resistance and recovery time are categorized in relation to each pressure both for the physical habitat features and the sensitive species. Information on the potential impact of physical disturbance and the response of specific habitats and species is based on evidence as far as available. A decision matrix is used to automate the combination of resistance and recoverability and to obtain sensitivity categories for the physical habitat and the sensitive species. The highest (i.e. most sensitive) rank assigned to either habitat structure or species determines the overall habitat sensitivity.

Physical impacts on benthic habitats

The degree of physical impact on a habitat is a product of its sensitivity and the exposure to a specific pressure. An impact assessment thus requires the linkage of sensitivity information with pressure data. A matrix combining pressure intensity through temporal extent and habitat sensitivity supports the classification in nine categories of physical impact. A percentage value is assigned to each rank which should provide an approximation of the relative impact on the habitat with regard to e.g. habitat structure, species richness, abundance or biomass. Due to the different nature of the pressures 'selective extraction', 'abrasion' and 'changes in siltation', for each of these physical damage pressures a separate impact matrix is provided in order to include a weighting factor in the impact assessment. 'Sealing' and 'smothering' are persistent pressures which are associated with an impact that destroys habitat structures as well as benthic organisms. The habitat is not expected to recover, thus sealing and smothering always result in a very high impact or total loss of habitat (100%).

In order to determine the cumulative physical impact on a particular habitat, the separate impact maps have to be summarized. Most approaches to assess cumulative impacts assume additive effects for lack of knowledge of actual responses of benthic

habitats. It is proposed to follow this practice as the physical pressures regarded here are assumed to affect habitat structure and suitability in a similar mode. This means that percentages for overlapping physical impacts are added up with 100 % (total loss) as maximum value. The cumulative physical impact is calculated from the proportion of area affected (A, [%]) for each habitat and the corresponding degree of impact (I, [%]) as derived from the impact matrices. The cumulative impact (CI, [%]) for each habitat results from the sum of individual values for the relative impact on habitat:

$$CI = \sum I \times A / 100 \ [\%]$$

High values of cumulative impact indicate either pressures with considerable temporal and spatial extent or habitats with high sensitivity towards the occurring pressures. The cumulative impact value may range from 0% which would be a habitat completely without impacts to 100% meaning the total loss of the habitat.

This method provides the advantage of easily comparing the different impacts of the pressures physical loss (reduction in extent) and physical damage (impairment of condition) and results in a single percentage value of physical degradation for each habitat.

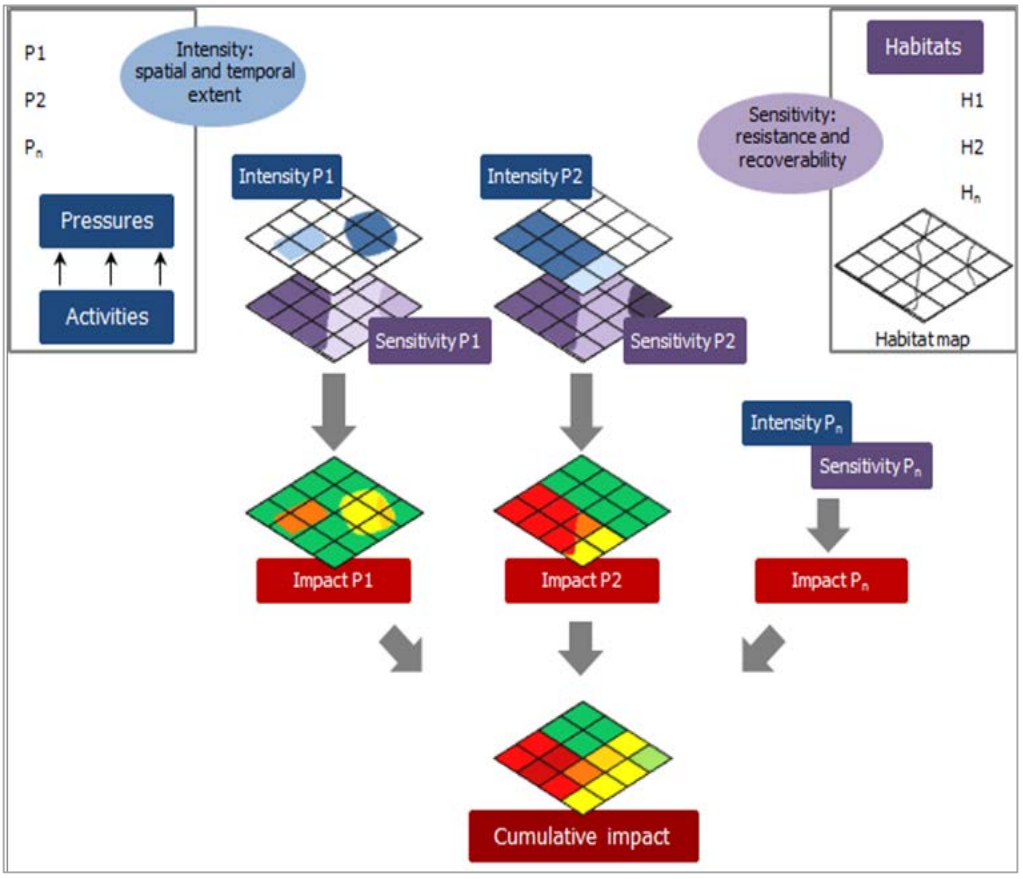


Figure 1: Assessment of cumulative physical impact by combining pressure intensity and habitat sensitivity.

Annex 9. Review Group Technical Minutes

MSFD D 3, 4 and 6 Review Group

2-6 March 2015 (by correspondence)

Reviewers:	Carl O'Brien (chair)
	Eugene Nixon
	Samuli Korpinen
Secretariat:	Michala Ovens
	Mark Dickey-Collas
	Inigo Martinez

This review group worked by correspondence during the week indicated. Two WebEx meetings were held during the review – one on the 2nd March to agree the approach to the review, ensure that all outstanding review documentation would be made available during the week by the ICES' Secretariat and assign tasks to the reviewers; and the second on the 5th March to ensure consistency in approach to the reviews of the three MSFD Descriptors and agree deadlines for completion.

Review introduction

In the context of the revision of the 2010 MSFD Decision, the Commission (DG-ENV) has asked ICES to provide guidance to address the scientific interpretation of the ideas and concepts of the Decision as part of a review process. This was the second set of 'Workshops on guidance for the review of MSFD decision (WKGMSFD II)' for descriptors on commercial fish and shellfish (D3), food webs (D4) and seafloor integrity (D6).

The workshops have contributed towards revising the existing Manuals (together with workshop reports) addressing the relevant scientific comments received from WG GES, DG ENV, MS and stakeholders and commenting on implications for MSFD cross-cutting issues across descriptors.

The reports, revised manuals and this review will underpin the ICES' advisory process and publication by 20th of March. The ICES' Advice (i.e. the revised Manuals) will contribute to the MSFD WG GES meeting (22-23 April 2015) to inform the discussion on the revision of the 2010 Decision process.

ICES' REVIEW OF THE MARINE STRATGEY FRAMEWORK DIRECTIVE DESCRIPTOR 6 – SEAFLOOR INTEGRITY

Good Environmental Status (GES) for Descriptor 6 – Seafloor 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 effected.

In the current COM DEC (2010/477/EU), the assessment of the GES status for the Descriptor 6 is based on two criteria: (6.1) Physical damage, having regard to substrate characteristics and (6.2) Condition of benthic community. The previous ICES D6 workshop in September 2014 proposed two new criteria: (6.1) Functionality and (6.2) Recoverability.

The report (ICES CM 2015\ACOM:48) from the ICES WKGMSFDD6-II has been technically reviewed; together with the EU_Annex_I_D6_Manual_Milieu(1) and proposed amendments.

The ICES' workshop on D6 had the objective to (1) provide further input to the MSFD review D6 manual following on from the initial ICES/JRC workshop and template, (2) consolidate and address relevant scientific comments and requests for clarification received from WG GES and DG ENV on the earlier version of the MSFD D6 review manual, and (3) comment on implications for the MSFD review D6 manual in light of the DG ENV cross-cutting workshop (Terms of Reference, Annex 2 of the report). The workshop background paper further defined the objectives of the workshop (Annex 3 of the workshop report).

The report states that the objectives 1 and 2 of the ToR were addressed during the workshop and the third objective was complemented by a questionnaire after the workshop but the response rate was poor. The objective 2 (MS comments) was covered by a comprehensive summary table in Annex 5, which included workshop responses to the MS comments and references to the text. This part was covered well by the report.

The objective 3 (cross-cutting issues) was partly covered by the report: (1) the workshop discussed the status of existing indicators and also the possibilities to assess D6 in short term (2015-2016) and long-term (2017-2018). The report did not cover the linkages with other descriptors or aggregation of indicators. These were recommended to be addressed in a series of workshops. Even though the indicator analysis seemed to be performed well (with the given time constraints), the results were only partially visible in the report and the conclusions remained a bit abstract. For instance, typical benthic indicators in EU are the benthic community indices (e.g. AMBI, BQI, etc) but their role in the proposed 'criteria themes' were not discussed. Such practical discussion would have responded to many of the MS comments, which mainly included worry that the new criteria cannot be assessed by the operational indicators.

The objective 1 had the widest scope and therefore was also given most attention in the report. The report describes adequately the process to address the objective and the workshop organization (5 thematic sessions) was an effective solution to tackle the objective. The report recommendations (Chapters 3 and 4) are mainly clear and respond to the MS comments and the ToR. The identification of short-term and long-term actions in the implementation are valid and focus on relevant gaps (answering also the objective 3).

A bigger gap in the text is the lack of clarity in the proposal. The report stated that the workshop lacked time to consolidate solid criteria, but the message should nevertheless be clear what is intended to be included (as the MS ask in their comments in Chapter 5). Two issues of non-clarity are below:

(1) Figure 4 (p. 27) aims to give a summary of the 'indications of aspects to be considered'. This figure illustrates the 'criteria themes' which were many times referred to in the text: pressure, impact and state. According to the figure, the state theme would consist of 'structure' and 'function' aspects. If compared with the diagram in Annex 7 (links between old and new criteria), the 'structure' aspect seems to disappear (or be used as a data source for 'function'). As 'structure' is however a term that is explicitly mentioned in the D6 definition and thoroughly discussed in the report, there should be clear and strong argumentation to leave it out of the criteria. See also the specific comment #5 below. The easiest way to correct this would be to correct the Annex 7 (=add structure to the definition of the new state criterion). Another possibility is to

mention that here is a potential cross-cutting issue, where structural aspects of seabed could be assessed by D1 criteria (species composition, presence of certain habitats or taxons, etc.).

(2) The Chapter 4 recommendation concerning the 'Single pressures versus cumulative pressure effects' is not clear. The short paragraph is very important as it presents two of the criteria themes. The recommendation includes only pressure aspects (although the title mentions effects). It is not clear what are the 'multiple pressure assessments' mentioned, as BH3 is a multiple effect indicator. The Chapter 2 and Annex 8 include discussion of BH3 and give a clear message that BH3 estimates effect. However, it is possible to carry out multiple pressure assessments where effects are left out (see HELCOM 2010, Andersen et al. 2013) but this was not discussed in the report. The Annex 7 diagram links the old criterion 6.1 (Physical damage) and the new Pressure criterion (and with a light arrow also the new Impact criterion), but it remains unclear how these two new criteria would differ. Remembering the MS comments to the previous workshop outcome, it is of utmost importance that each new criterion is understandable and has a justification how it can be supported by data and assessment methods. The Chapter 4 recommendation would become clearer if the BH3 indicator is clearly linked to the impact criterion (in text, Figure 4 and Annex 7) and the pressure criterion is better described. Regarding the latter, references to single pressure indicators and multiple pressure methods should be made.

There are also some small issues (e.g. inconsistencies, lack of clarity, gaps) in the text which are noted below:

1) Page 8, the section on impact: the text (in the third last line) states that 'useful state indicators can be beta-diversity…'. This sentence would fit better in the preceding section on 'state'. Instead, one could discuss the possibility to use AMBI-type of indicators as impact indicators, as they include species sensitivity to pressures.

2) P 11, discussion on cumulative effect indicator: the text refers to the OSPAR BH3 and the similar HELCOM indicator, but does mention the recent development in the FP7 project ODEMM, where pressure and effect assessment methodology has been approached from a different angle (e.g. Anthony Knights et al. 2013, 2015). It would be worth to be mentioned in the report is that in the ODEMM method the recovery from pressures is considered as a separate assessment result, because it has specific consequences to management decisions.

3) P. 12, what functions will be feasible to prioritize: the sentence referring to achieving GEnS has 'ecosystem services in parentheses. One gets the feeling that GEnS is an acronym of ecosystem services. Anyway the reference to ecosystem services remains unclear.

4) P. 17, Section 4 – Background: The last sentence states that 'It is hence likely that the choice of indicators available may not fully cover newly proposed criteria'. This is an important conclusion which was not (clearly) visible in Chapter 4 recommendations and mentioned only for 'recoverability' criterion in the Chapter 3 recommendations.

5) P. 26, Chapter 4, 2nd para: In the 2nd line it says that the old criteria Physical damage and Benthic condition both target structural attributes of seafloor integrity. Earlier (p.17, last para) it was said that Condition and the new criterion Functionality are conceptually overlapping. Later (p. 29, 2nd para) Condition and Functionality are said to 'complementary concepts' (meaning again something else). This inconsistency

should be clarified. It has significant consequences to the definition of the criteria (in the report structural criteria are not proposed!).

6) P. 19-, Session 5 discussion on GES boundaries: There are three 'Key questions' in the beginning. The report does not really answer to these questions. But the Chapter 3 recommendations have much clearer answers (p. 24-25); among these recommendations there are however points which could be refined…they are not recommendations but reiterating existing information..

7) As a general note, the report lists the 'criteria themes' to the order state-pressure-impact or pressure-state-impact. A more appropriate order would be pressure-impact-state (reflecting the causality). This concerns at least page 3 (summary), pages 6-8 (the section titles), page 26 (last para), and Fig. 4 legend.