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MARINE STRATEGY FRAMEWORK DIRECTIVE

Task Group 1 Report

Biological diversity

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PREFACE

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

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

A Task Group was established for each of the qualitative Descriptors. Each Task Group consisted of selected experts providing experience related to the four marine regions (the Baltic Sea, the North-east Atlantic, the Mediterranean Sea and the Black Sea) and an appropriate scope of relevant scientific expertise. Observers from the Regional Seas Conventions were also invited to each Task Group to help ensure the inclusion of relevant work by those Conventions. A Management Group consisting of the Chairs of the Task Groups including those from DG SANCO and IFREMER and a Steering Group from JRC and ICES joined by those in the JRC responsible for the technical/scientific work for the Task Groups coordinated by JRC, coordinated the work. The conclusions in the reports of the Task Groups and Management Group are not necessarily those of the coordinating organisations.

Readers of this report are urged to also read the report of the above mentioned Management Group since it provides the proper context for the individual Task Group reports as well as a discussion of a number of important overarching issues.

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1. Definition of key terms

Descriptor 1: "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions". See Sections 0 and 2.1.

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

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

Habitats and species are key attributes of biological diversity; the term 'habitats' in the Descriptor is interpreted as including their associated communities of species (see Section 3.3.2). Aspects of **quality, occurrence, distribution and abundance** form the basis of the criteria upon which to assess GES.

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

The **scope** of Descriptor 1, according to Annex III (Table 1) of the Directive, encompasses angiosperms, macro-algae, invertebrates, phytoplankton, zooplankton, fish, mammals, reptiles and birds. Microbes, pelagic cephalopods and the range of marine habitat types that occur within the jurisdictional area of the Directive are also considered to fall within the scope. Descriptor 1 shall be applied to the geographic area defined by Art. 3.1 of the Directive, but areas beyond the jurisdictional limits of the Directive may need to be considered for migratory species. Vagrant species are excluded; non-indigenous species are treated under Descriptor 2, and as a pressure for Descriptor 1. The elements of biological diversity treated under Descriptor 1 may be considered with those of the other descriptors when assessing overall **ecosystem function**.

A pragmatic approach to selection of key elements of biodiversity for assessment is adopted throughout.

2. GES in relation to the descriptor "Biological diversity"

Good Environmental Status for Descriptor 1 will be achieved given no further loss of the diversity of genes, species and habitats/communities at ecologically relevant scales and when deteriorated components, where intrinsic environmental conditions allow, are restored to target levels. See Section 2.2.

3. The assessment of biological diversity at different temporal and spatial scales

Spatial and temporal scales. GES is assessed at the scale of Region (for the Baltic Sea and Black Sea) or the Subregions defined for the Atlantic and Mediterranean Seas. See Section 4.6.

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

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

4. Key attributes of the Descriptor

Attributes of biological diversity. The recommended levels of ecological organisation for assessment are as follows. See Section 4.3.

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

Biodiversity components. TG1 recommends appropriate treatment of the biodiversity components from Annex III (Table 1) of the Directive. See Section 4.4.

- The predominant seabed and water column types;
- Special habitat types (under Community legislation or international conventions);
- Habitats in particular areas (e.g. in pressured or protected areas);
- Biological communities associated with the predominant seabed and water column habitats;
- Fish, marine mammals, reptiles, birds;
- Other species (under Community legislation or international conventions);
- Non-indigenous, exotic species and genetically distinct forms of native species.

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

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

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

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

Predominant habitat types are provisionally listed as:

Ecological zone/realm	Habitat
Seabed habitats	Littoral rock and biogenic reef Littoral sediment Shallow sublittoral rock and biogenic reef Shallow sublittoral sediment Shelf sublittoral rock and biogenic reef Shelf sublittoral sediment Bathyal rock and biogenic reef Bathyal sediment Abyssal rock and biogenic reef Abyssal sediment
Pelagic habitats	Low salinity water (Baltic) Reduced salinity water (Baltic, Black Sea) Estuarine water Coastal water Shelf water Oceanic water
Ice habitats	Ice-associated habitats

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

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

Criteria for assessing the relevant attributes and components of biological diversity are summarised as follows**.** This table outlines the main **classes of indicator**; within each class, specific indicators appropriate to the assessment area, biodiversity component and pressures need to be selected. See Sections 4.5 and 4.7.5 for pragmatic guidance.

Attribute	Criteria	Indicator classes
Species state (includes sub-species and populations where they need to be assessed separately; apply criteria to each recognised sub-species/population)	Species distribution	• Distributional range • Distributional pattern
	Population size	• Population biomass • Population abundance (number)
	Population condition	• Population demography e.g.: ○ body size or age class structure ○ sex ratio ○ fecundity rates ○ survival/mortality rates • Population genetic structure • Population health (sub-lethal condition, e.g. disease prevalence; parasite loading; pollutant contamination) • Inter and intra-specific relationships (e.g. competition, predator-prey relationships)
	Habitat distribution, extent and condition	• Habitat distributional range • Habitat distributional pattern • Habitat extent • Physical condition • Hydrological condition • Chemical condition
Habitat/community state	Habitat distribution	• Habitat distributional range • Habitat distributional pattern
	Habitat extent	• Areal extent of habitat • Habitat volume
	Habitat condition	• Physical condition (structure and associated physical characteristics, incl. structuring species) • Hydrological condition (incl. water movement, temperature, salinity, clarity) • Chemical condition (incl. oxygen, nutrient and organic levels)
	Community condition	• Species composition • Relative population abundance • Community biomass • Functional traits
Landscape state (where assessed as 'Listed' habitats)	Landscape distribution and extent	• Landscape distributional range • Areal extent of landscape
	Landscape structure	• Habitat composition and relative proportions
	Landscape condition	• As for habitat condition and community condition, as appropriate
Ecosystem state	Ecosystem structure	• Composition and relative proportions of the ecosystem components

Attribute	Criteria	Indicator classes
	Ecosystem processes and functions	• Interactions between the structural components of the ecosystem • Services provided by biological diversity within ecosystems

5. How are the criteria aggregated to assess GES for the descriptor?

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

6. Monitoring and research needs

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

Assessment and monitoring programme. A pragmatic risk-based and synergistic approach is recommended. See section 4.7. The following main questions are addressed:

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

Preparatory tasks:

Task 1: Collate environmental data to support assessment;

Task 2: Identify biodiversity components present in region or subregion;

Task 3: Define ecologically-relevant assessment areas;

Task 4: Define reference state (condition);

Task 5: Define targets.

Monitoring phases:

Phase 1: Prioritising where to monitor in relation to the location and types of human activities and their associated pressures on and risks to biodiversity;

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

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

Phase 4: Collecting the evidence (monitoring) needed to support the assessment of state and trends;

Phase 5: Assessment of the evidence to draw conclusions the proximity to GES, direction and rate of change and progress towards (or away from) GES. Reporting of assessments.

Phase 6: Developing a Programme of Measures to define appropriate remedial actions;

Phase 7: Adaptive management, adjusting the spatial and temporal intensity of a) the monitoring programme and b) the programme of measures.

Issues requiring further research and development are grouped within the following categories. See Section 5:

- Integrating research and monitoring;
- Harmonisation of assessments and reporting;
- Management tools for biological diversity.

1 Introduction

1.1 Background

Biological diversity is the variety of life on the planet, within and among species and across ecosystems. It plays a vital role in defining and regulating the environmental conditions in which we live and survive. It provides many different services ranging from food, clean water and fuel to the provision of medicines. In recognising this, the European Union has launched the Marine Strategy Framework Directive (MSFD)[1] as part of it Integrated European Maritime Policy.

The aim of the Directive (adopted in June 2008) is to protect more effectively the marine environment across Europe. It aims to achieve 'good environmental status' of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The Directive constitutes the vital environmental component of the Union's Maritime Policy, designed to achieve the full economic potential of oceans and seas in harmony with the protection of the marine environment.

The Directive establishes European Marine Regions on the basis of geographical and environmental criteria. Each Member State, in cooperation with other Member States and non-EU countries within a marine region, is required to develop a marine strategy or strategies for its marine waters. These strategies are to contain a detailed assessment of the state of the environment, a definition of 'good environmental status' at regional level and the establishment of clear environmental targets and monitoring programmes[2].

Good environmental status (GES) is defined in the Directive (Art. 3.5) as follows:

> 'good environmental status' means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations, i.e.:
>
> > (a) the structure, functions and processes of the constituent marine ecosystems, together with the associated physiographic, geographic, geological and climatic factors, allow those ecosystems to function fully and to maintain their resilience to human-induced environmental change. Marine species and habitats are protected, human-induced decline of biodiversity is prevented and diverse biological components function in balance;
> >
> > (b) hydro-morphological, physical and chemical properties of the ecosystems, including those properties which result from human activities in the area concerned, support the ecosystems as described above. Anthropogenic inputs of substances and energy, including noise, into the marine environment do not cause pollution effects;

The Directive requires a set of 'criteria and methodological standards' to be established for the assessment of GES (Art. 9.3). These are to ensure consistency and to allow comparison between marine subregions of the extent to which GES is being achieved by Member States.

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[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008L0056:EN:NOT. Hereafter referred to simply as the 'Directive'.

[2] http://ec.europa.eu/environment/water/marine/index_en.htm

GES has to be determined at the level of the marine region or subregion, on the basis of the eleven qualitative descriptors provided in Annex I of the Directive and the environmental factors and pressures given in Tables 1 and 2 respectively of Annex III (Art. 9.1).

Lastly, each Member State must draw up a programme of measures in order to achieve GES. Prior to any new measure an impact assessment which contains a detailed cost-benefit analysis of the proposed measures is required.

This report focuses on providing guidance on the interpretation of Descriptor 1 "Biological biodiversity" for future use in implementation of the Directive:

1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

The other Descriptors are as follows:

2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6. Sea floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

1.2. Task Group 1 tasks and approaches

The European Commission tasked the Joint Research Centre (JRC) and the International Council for the Exploration of the Sea (ICES) in 2009 to lead the development of suitable criteria and methodological standards for 8 of the 11 Descriptors[3]. The work was scheduled with a view to the guidance being

[3] D7 Hydrography has had limited consideration to date; D9 Contaminants in seafood was led by DG-SANCO; D10 Litter was led by France.

available for adoption in July 2010, according to the timetable laid out in the Directive. JRC and ICES established an expert scientific Task Group for each descriptor, with responsibilities outlined in the Guidance/ Terms of Reference for the task groups 'criteria and methodological standards for the Good Environmental Status (GES) descriptors' (Annex 2). The Task Groups worked under the guidance of an ICES/JRC Management Group and a Steering Group.

Task Group 1 on Biological Diversity (TG1) has set out to develop scientifically sound guidance in relation to the objectives laid out in Descriptor 1, the definition of GES and the scope of the Directive. In undertaking its work TG1 fully recognised the ambitious nature of the Descriptor, as written, and the potentially conflicting requirement to achieve sustainable use of the marine environment. It was also fully aware of the need to prepare guidance which is realistic, achievable and of direct relevance to those aspects of the marine environment which can be effectively managed (i.e. the pressures from human activities). It has consequently aimed to provide a framework for assessment of biodiversity which reduces the potentially enormous scope of what might be assessed down to a more manageable task, established on a risk-based approach wherever possible. It is also recognised that the available date, assessment systems and monitoring programmes to fully meet the requirements of the Directive are not yet established in all regions and for all aspects of biodiversity. A pragmatic approach, using available evidence and expert scientific judgement can be used initially and improved through time to develop more robust evidence-based assessments for this challenging Descriptor.

In summary, this report dealing with Descriptor 1: Biological Diversity aims to provide the following:

a. An initial interpretation of the descriptor in terms of Good Environmental Status (GES);
b. An overview and basic understanding of the key concepts of biological diversity;
c. An outline of assessment strategies, covering attributes, criteria, targets and indicators;
d. Pragmatic guidance on devising a monitoring strategy.

The report has been prepared by Task Group 1 (TG1) comprising the members and observers (from the regional seas conventions) shown in Table 1-1.

Table 1-1. Members of Task Group 1 on biological diversity, and observers from the regional seas conventions (alphabetical order).

Name	Affiliation	Country	E-mail	Region	Expertise
Members					
Alexei Birkun (non-participant)	BREMA	Ukraine	alexeibirkun@home.cris.net	Black Sea	Mammals
Sabine Cochrane (chair from May 2009)	Akvaplan-NIVA, Polar Environmental Centre	Norway	sc@akvaplan.niva.no	Arctic, Atlantic	Benthic (sediment)
David Connor	Joint Nature Conservation Committee	UK	david.connor@jncc.gov.uk	Atlantic	Benthic
Jan Ekebom	Metsähallitus Natural Heritage Services	Finland	Jan.ekebom@metsa.fi	Baltic	Benthic, pelagic

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Ian Mitchell	Joint Nature Conservation Committee	UK	Ian.Mitchell@jncc.gov.uk	Atlantic	Birds
Snejana Moncheva	Institute of Oceanology	Bulgaria	snejanam@abv.bg	Black Sea	Pelagic, benthic
Per Nilsson	University of Gothenburg	Sweden	Per.Nilsson@marecol.gu.se	Baltic, Atlantic	Pelagic, fish
Kari Nygaard (chair up to May 2009)	Norwegian Institute of Water Research	Norway	kari.nygaard@nilu.no	Atlantic	Pelagic, benthic (rock)
Johnny Reker	Agency for Spatial and Environmental Planning	Denmark	jyr@blst.dk	Baltic, Atlantic	Benthic, general
Ricardo Serrão Santos	University of the Azores/IMAR	Portugal	ricardo@uac.pt	Atlantic	Fish, deep sea
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1.3 Glossary of terms

A number of key terms are used in a specific way in this report. Table 1-2 provides an overview of these, with a cross-reference to the relevant section where the term is further discussed.

Table 1-2. Glossary of terms.

Term	Definition used in this report
Assessment area	See Ecological assessment area
Attribute (of biological diversity)	For Descriptor 1, four attributes of biological diversity are defined: species state, habitat/community state, landscape state and ecosystem state. See Section 4.3.
Baseline (state)	The value of state at a specific point in time, against which subsequent values of state are compared. The degree of change in state from a baseline is sometimes used in the absence of a known reference (see below), to assess whether the desired target state has been achieved. See Section 3.3.6.
Biodiversity	Abbreviation of Biological Diversity
Biodiversity component	A particular example of an attribute of biological diversity (e.g. a specified species, species group, population or habitat type). A standardised set of components is recommended for use to assess biodiversity for Descriptor 1. See Section 4.4. Shorthand: Component
Biological diversity	The variability among living organisms, as defined by the Convention of Biological Diversity (1992). See Section 3.2.
Biotope	The combination of an abiotic habitat and its associated community of species. It can be defined at a variety of scales (with related corresponding degrees of similarity) and should be a regularly occurring association to justify its inclusion within a classification (typology) system (MESH 2008).
Community	An assemblage of species (i.e. a group of different species that occur together at a given location), dependent on each other, and constituting an organized system through which energy, nutrients, and water are cycled (MESH 2008). A community is associated with a particular habitat type, with the two components together technically termed a biotope. Other equivalent terms in common use: associations, biocenoses.
Component	See Biodiversity component. Ecosystem component refers to wider ecostystem aspects, such as abiotic features.
Criteria	Properties relating to the attributes of biological diversity. See Section 4.5.
Degradation (in state)	Deviation from reference conditions as a result of impacts from pressures. Note: Degradation does not always mean a decline in the abundance of all species or the extent of communities; some individual biodiversity components may increase in response to pressures, but usually do so at the expense of others. See Section 3.3.
Ecological assessment area	A defined geographical area used to make assessments of biodiversity for Descriptor 1. May equate to a Marine Region, Subregion or subdivision as defined in Art. 4. See Section 4.6.1.

Term	Definition used in this report
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (MarBEF Marine Biodiversity Wiki).
Ecotype (of species groups)	An ecologically-relevant set of species, applied here to the following (highly) mobile species groups: birds, reptiles, marine mammals, fish and cephalopods. Each ecotype represents a predominant ecological niche (e.g. offshore surface-feeding birds, demersal fish) within the species group. See Section 0.
Good Environmental Status	Definition provided in Art. 3.5 of the Directive and defined in terms of 11 descriptors in Annex I of the Directive. See Section 1.1, 2.2 and Phase 5.1.
Habitat	The physical and environmental conditions (e.g. the seabed substratum and associated hydrological and chemical conditions) that support a particular biological community or communities (adapted from Connor et al. 1997) or a species. Habitat is often used to include the associated community, for instance in the EUNIS classification and the Habitats Directive (Foster-Smith, Connor & Davies 2007), and in this sense is synonymous with our definition of 'biotope'. For Descriptor 1, we use the abiotic definition of 'habitat' given here and use 'community' when referring to biotic components. Where the combination with community is being discussed, this is referred to as habitat/community (as shorthand for habitat and its associated community or communities of species), rather than the more technical term biotope. EUNIS has multiple scales (levels) of definition for habitat types. The lower levels (levels 5-6) are more narrowly defined with specific communities, whilst the upper levels (levels 2-4) are more broadly defined and thus include multiple communities.
Human activity	Human social or economic actions or endeavours that may create pressures on the marine environment e.g. fishing, energy production (adapted from Robinson et al. 2008b).
Impact	The consequences of a pressure, e.g. benthic invertebrate mortality resulting from physical disturbance by bottom trawling (adapted from Robinson et al. 2008b).
Indicator (of biological diversity)	Provides a measure for a particular criterion of biodiversity in relation to a particular component or multiple components. The assessment of state provided by an indicator allows inferences to be made on the state of a wider set of components, and/or the prevailing environmental conditions. Indicators are often used to assess the impact of pressures on biological diversity and/or environmental conditions. See Phase 3.
Landscape (marine)	Topographic features, generally large in size, (e.g. estuaries, fjords, seamounts, deep-sea canyons) which comprise combinations of particular (seabed) habitats/communities and also often certain mobile species (e.g. anadromous fish in estuaries, bentho-pelagic fish on seamounts), due to the physical and hydrological characteristics of the feature.
Limit (state)	The value of state that, if violated, is taken as *prima facie* evidence that there is an unacceptable risk of serious or irreversible harm. GES is achieved at 'target' values of state that are above such a 'limit' (see below). See Section 3.3.6.

Term	Definition used in this report
Listed features (species or habitat types)	Species or habitat types which are listed (for protection) under Community legislation or international conventions. Table 1 of Annex III to the Directive refers to these habitat types as 'special'. See Section 4.4.4.
Mobile species	Refers to those species, such as species of bird, turtle, marine mammal, fish and pelagic cephalopods, which are generally large and highly/actively mobile and thus not associated with specific communities. Assessed separately (individually or as ecostypes) from habitats/communities (benthic or plankton). See Section 4.4.1.
Non-indigenous species	Species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. See guidance on Descriptor 2. See Section 2.3.2.
Population	A group of individuals of one species, which live in a particular area and are much more likely to breed with one another than with individuals from another such group of the same species[4]. The relationship between 'stock' used in fisheries assessments and populations is not always clear.
Predominant habitat type	Broadly-defined habitat types of the water column and seabed, referred to in Table 1 of Annex III to the Directive. See Section 0.
Pressure	The mechanism (physical, chemical or biological) through which an activity has an effect on any part of the ecosystem, e.g. physical disturbance to the seabed (adapted from Robinson et al. 2008b). See Section 3.3.4.
Quality target	The state (condition) of a biodiversity component, measured at a local scale, which will meet the objective of achieving GES, i.e. it defines the level of deviation away from reference conditions (caused by impacts from pressures) beyond which GES will not be met for that component locality. The target is expressed in relation to a specific criterion (e.g. population or community condition) and may be measured by a particular indicator. The target is measured relative to a reference (or baseline) state. Quality targets may also be set for desired levels of a pressure or activity, or compliance with a management measure, as other means of assessing progress towards achieving GES. See also Quantity target and Target. See Task 5.
Quantity target	The value set for the proportion of the biodiversity component which should be at or above the specified quality target condition in the assessment area in order to achieve GES. Quantity targets are also set for criteria which have a spatial component (e.g. species distribution, habitat extent). Quantity targets are also set in relation to a reference (or baseline) state. Quantity targets may also be set for desired levels of a pressure or activity, as other means of assessing progress towards achieving GES. See also Quality target and Target. See Task 5.
Reference (state)	The value or range of values of state at which impacts from anthropogenic pressures are absent or negligable (cf. OSPAR 2001). Values used to define the reference state are directly linked to the criteria used for assessment. They will vary in relation to prevailing physiographic and geographic conditions and may vary over time in relation to changing climatic conditions (a 'rolling' reference state). See Section 3.3.6.

[4] symposia.cbc.amnh.org/archives/seascapes/glossary.html (accessed January 2010).

Term	Definition used in this report
Region	Refers to one of four specified parts of European waters in Art. 4 of the Directive: Baltic Sea, North-east Atlantic Ocean, Mediterranean Sea, Black Sea.
Risk-based approach (to monitoring)	The risk to biodiversity of being adversely affected by pressures caused by human activities is used to prioritised monitoring requirements. Monitoring is targeted towards those aspects of biodiversity and locations within an assessment area which are considered to be at risk of failing to meet targets set for GES. This is achieved through an avaluation of which pressures from human activities are considered most likely to cause failure to achieve GES targets. Monitoring programmes need to include areas at high risk and reference sites (low or no risk). A risk-based approach is not as useful when causal links between pressures and the state of some species (e.g. top predators) is not clear. See Sections 4.1.1, 4.7.2 and Phases 1 and 2.
Sensitivity	The degree to which a component (e.g. a species or habitat/community) responds to a pressure (Zacharias & Gregr 2005). Sensitivity is itself a function of the component's resistance to a pressure (i.e. how much of the pressure it can withstand) and its inherent resilience (i.e. its recovery potential, once the pressure is removed) (Bax & Williams 2001). A component is deemed to be highly sensitive when it has both low resistance and low resilience (Robinson et al. 2008b). See Section 3.3.4.
Special habitat type	Referred to in Table 1 of Annex III to the Directive in relation to types identified under Community legislation or international conventions. In this report these are referred to as 'Listed' habitat types. See Section 4.4.4.
Species	Many definitions exist, but generally understood as a taxonomic rank referring to a group of animals or plants which are similar in structure, function and descent, which are able to breed among themselves[5]. Note: there is no real consensus amongst taxonomists as to exactly what constitutes a species, particularly for invertebrate taxonomy. Some workers distinguish between sub-species, whereas others consider species to be the lowest recognisable taxonomic unit. Some researchers reject the traditional Linnean system of taxonomic ranks (phylum, class, family, genus etc) and instead refer to named nodes on a phylogenetic "tree of life" (Cantino & de Queiroz, 2010). Some researchers do not accept the species concept at all, instead referring to 'least inclusive taxonomic units', or LITUs (Pleijel & Rouse 2000). TG1 uses species when referring to individual taxa generally recognised as species, and which in themselves are the focus of monitoring or used as indicators (e.g. harbour porpoise *Phocoena phocoena*). For assessments of community structure, for example benthic fauna, the term taxon (plural taxa) is used, because the level of identification in such studies varies between taxa, depending on operator expertise, state of taxonomy and not least of all, condition of specimens. An online list of updated nomenclature, synonyms and 'name-checking' function are available through the European Register of Marine Species (ERMS), a subset of the World Register of Marine Species (WoRMS).

[5] Adapted from animaldiversity.ummz.umich.edu/site/glossary/page/s.html (accessed January 2010).

Term	Definition used in this report
State	The actual (measured or otherwise assessed) environmental condition (e.g. of a species, species group or habitat/community) in a given geographical area. This may range from an unimpacted condition through to a destroyed or irrecoverable condition. The assessment of state can therefore include impacts from pressures. See Section 3.3.6.
Status	A classification of state (e.g. of a species or habitat/community) according to a classification system, using a defined methodology and with distinct differences between the classes. See Section 3.3.6.
Subdivision (of a region or subregion)	Refers to divisions of a Region or Subregion (Art. 4.2) which can be defined by Member States to reflect specificities of a particular area. These must be compatible with the subregions (i.e. nested within). See also Ecological assessment area and Section 3.3.6.
Subregion	Refers to specified divisions of the North-east Atlantic Ocean and Mediterranean Sea Regions (Art. 4.2).
Sustainable use	The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations[6]. See Section 2.1 and Art. 3.5.
Target (state)	The value or range of values of state that should be maintained, or achieved through recovery, in order to achieve GES. The lower boundary of the target range represents the threshold between environmental conditions that will achieve GES and those that will not achieve GES (cf. OSPAR Commission 2001). This lower boundary is not the same as 'limit' used in some assessment systems. For many aspects of assessment, both quality and quantity targets need to be set. See Section 3.3.6.
Taxon (pl. taxa)	A named group of organisms (may be species or more inclusive groups).
Vagrant species	A species that occurs, through natural means (i.e. not introduced through human activities), well outside its normal distributional range. See Section 2.3.2.
Vulnerability	The probability or likelihood that an ecosystem component (e.g. a species or habitat/community) will be exposed to a pressure to which it is sensitive (Robinson et al. 2008a). See Section 3.3.4.

6 www.acil.com.au/glossary.htm (accessed February 2010).

1.4 Abbreviations

Table 1-3 provides a list of abbreviations used in this report.

Table 1-3. Abreviations used in this report.

Abbreviation	Meaning
ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
AMO	Atlantic Multi-decadal Oscillation
Art.	Article in the Directive (MSFD)
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
ATBI	All Taxa Biodiversity Inventories
BALANCE	Baltic Sea Management – Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning (Interreg-funded programme 2005-2007)
BIOMARE	A concerted action to establish the infrastructure and conditions required for marine biodiversity research at an European scale. Funded under the CORDIS programme of the European Union 2000–2002
CBD	Convention on Biological Diversity
CEN	European Committee for Standardisation
CFP	Common Fisheries Policy
CMS	Convention on Migratory Species (Bonn Convention)
D1-D11	Descriptors of GES (Annex I of MSFD)
Directive	When used as a single word in this report, refers to the MSFD
DOC	Dissolved Organic Carbon
EC	European Commission
EcoQOs	Ecological Quality Objectives (e.g. http://www.noordzeeloket.nl/ecoqos/en/ecoqos/)
EEA	European Environment Agency
EEZ	Exclusive Economic Zone
EMODNet	European Marine Observations and Data Network
ERMS	European Register of Marine Species
EU	European Union
EUNIS	European Nature Information System
FCS	Favourable Conservation Status (Habitats Directive)
GES, GEcS	Good Ecological Status (WFD)
GES, GEnS	Good Environmental Status (MSFD)

Abbreviation	Meaning
GIS	Geographical Information System
HD	Habitats Directive
HELCOM	Helsinki Commission (Convention on the Protection of the Marine Environment of the Baltic Sea Area)
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	Internation Council for the Exploration of the Sea
ISO	International Standards Organisation
IUCN	International Union for the Conservation of Nature and Natural Resources
JRC	Joint Research Centre
LITU	Least inclusive taxonomic units
LTBR	Long-Term Biodiversity Monitoring
MarBEF	Marine Biodiversity and Ecosystem Functioning. A network of excellence funded by the European Union th Framework Programme and consisting of 94 European marine institutes
MARS	A foundation created by and open to Europe's marine research stations (www.marsnetwork.org).
MESH	Mapping European Seabed Habitats (Interreg-funded programme 2004-2008)
MSFD	Marine Strategy Framework Directive
NAO	North Atlantic Oscillation
NMBAQC	UK National Marine Biological Analytical Quality Control Scheme
OSPAR	OSPAR Commission (Oslo and Paris Convention for the Protection of the marine Environment of the North-East Atlantic)
QSR	OSPAR Quality Status Report
REBENT	Réseau Benthique (French habitat mapping programme)
TG1-11	Task Group (for the ICES/JRC development of criteria & methodological standards for GES)
WFD	Water Framework Directive
WoRMS	World Register of Marine Species
UNCLOS	United Nations Convention on the Law of the Sea
VMS	Vessel Monitoring System

2 Interpretation of the Descriptor

2.1 Key terms

Descriptor 1 is: "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions".

An outline interpretation of each part of the Descriptor is given below.

Biological diversity

The following definition, taken from the Convention on Biological Diversity (CBD, 1992), will be used for this Descriptor: "the variability among living organisms from all sources including, inter alia, [terrestrial,] marine [and other aquatic ecosystems] and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

Maintained

Maintained equates to a) no further loss of the diversity within species (including genetic and non-genetic variability), between species and of habitats/communities and ecosystems at ecologically relevant scales (taking into account natural variation due to changes in intrinsic environmental conditions within ecosystems), b) any deteriorated attributes of biological diversity are restored to and maintained at or above target levels, where intrinsic environmental conditions allow (cf. Art. 1.2a) and c) where the use of the marine environment is sustainable and the level of measurable impacts from human activities does not compromise the following conditions (cf. Art. 3.5):

a. The maintenance of biological diversity is interpreted here in the sense that there should be no further loss of habitat types or species, including distinct sub-species, populations and genetic forms. This should be applied at ecologically relevant scales (refer to ecological assessment areas in Section 4.6.1) for the different biodiversity components. In practical terms, it is recommended that this should equate to no further loss due to anthropogenic influences (other than from climate change) of habitat types or species, including distinct sub-species, populations and genetic forms, from a subregion or appropriate subdivisions where these have been defined (refer to Section 4.4.1 on treatment elements of biological diversity). Achieving this should help maintain population and genetic variation with each region/subregion. Some loss of individuals in populations of a species and local deterioration in or loss of habitats/communities is an ongoing consequence of human use of the marine environment. The scale of such losses needs therefore to be managed so as to not risk their long-term viability in the subregion or its subdivisions, or to risk a component's status falling below the target values set.

b. Where attributes and biodiversity components are assessed as being below target levels set for this Descriptor, there will be a need to restore them in order to achieve the GES targets set for the region/subregion (Art. 1.2a). This is to be achieved through the implementation of a Programme of Measures (Art. 13). Biodiversity is likely to respond to such passive or proactive restoration measures according to both the prevailing environmental conditions and in relation to prevailing biological conditions (for example, the proportions of prey and predators present). As such, restoration should not be considered as returning to a former state, but progressing towards an improved (i.e. less impacted) state which is in line with prevailing environmental and biological conditions. No deterioration in state should be allowed once the required target state has been achieved. Target state is defined as a specified level of deviation from reference state (i.e. unimpacted conditions).

The quality and occurrence of habitats and the distribution and abundance of species

Habitats and species are key attributes of biological diversity; the term 'habitats' in the Descriptor is interpreted as including their associated communities of species (see Sections 4.4.1 and 0). Aspects of quality, occurrence and distribution form the basis of the criteria upon which GES for this Descriptor is assessed (see Section 4.5).

In line with prevailing physiographic, geographic and climatic conditions

The state of biological diversity should be in accordance with intrinsic environmental conditions. The assessment of GES for this Descriptor needs to take full account of the natural driving forces on biological diversity, such that the assessments are made in relation to the state of biological diversity as would be expected under 'prevailing physiographic, geographic and climatic conditions'. This is important in defining the differing regional characteristics of biodiversity and in establishing appropriate targets and indicators to assess GES.

a. ***In line with*** – the state of biological diversity should be in accordance with what would be expected under natural environmental conditions. However, as the Directive clearly encompasses the need for sustainable use of the marine environment, this interpretation needs also to encompass the multiple uses of the environment for human activities, provided the level of measurable impacts from these activities does not compromise the maintenance of biological diversity (Art. 3.5). In this sense, GES for biological diversity, including the targets set for it, needs to accommodate such activities and achieve a balance between sustainable use of the environment and the maintenance of biodiversity. See Section 4.7.2 on defining targets.

b. ***Prevailing*** – biodiversity should be in accordance with the intrinsic physiographic and climatic conditions of the different geographic regions of Europe. 'Prevailing climatic conditions' means the ongoing effects of climate change on biological diversity need to be understood and their changes monitored when assessing the state of biodiversity, but such climate-related changes need to be excluded from the setting of targets and the assessment of whether GES has been met for this Descriptor[7].

c. ***Physiographic*** – biodiversity characteristics are determined by the environment. The natural characteristics of the marine environment play a very strong role in determining which species live in different parts of the sea; this is sometimes termed environmental forcing. Thus the physical, hydrological and chemical characteristics of the water column and seabed (such as water temperature, salinity, depth, water movements, substratum and other factors[8]) all play an important role in characterising marine habitats (both pelagic and benthic) and therefore determining which species live where.

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[7] Changes in water temperature due to climate change can lead to increases in the rate of introduction and spread of non-indigenous species, for example in the eastern Mediterranean Sea (Pancucci-Papadopoulou et al. 2009, Raitsos et al. Submitted). Such changes can be reflected in the assessment for Descriptor 2 and as a pressure in the assessment of Descriptor 1.

[8] This list of factors is very similar to the set of physical, hydrological and chemical factors given in Table 1 of Annex III to the Directive (as required for the initial characterisation of the marine waters).

d. ***Geographic*** – *variation between regions in Europe*. There is a very wide range of biological diversity in Europe's marine environment, ranging from microscopic organisms living in the water and seabed sediments, through to species of invertebrate and seaweed living on the seabed (e.g. sponges, crabs, molluscs, kelp), fish, large mammals such as whales and seals, and seabirds. Across European waters, these species occupy a very wide range of habitats, from the low salinity waters of the Baltic Sea out to the open Atlantic Ocean, from the ice-bound Arctic to the warm Mediterranean Sea and from the top of the intertidal zone down to the deep seabed at 5000 m depth or more.

   Biological diversity thus differs markedly across the regions of Europe. For example, the number of marine species and habitats on the west coast of Ireland is much greater than in the Baltic Sea or the Black Sea. These are natural differences related to the variation in environmental characteristics of each region (such as temperature and salinity regimes, depth of the seas).

e. ***Climatic*** - *continuous natural/climatic change*. Variations in climate (which lead to changes in temperature, water movements and other effects) and ocean processes (e.g. wave and current dynamics), together with interactions between species (e.g. competition for space and food, predator-prey relationships, recruitment processes) provide natural dynamics which mean that the composition and abundance of species is subject to continuous change. The rate of change varies markedly both spatially and temporally.

2.2 What is Good Environmental Status?

Good Environmental Status (GES) with respect to Descriptor 1 will be achieved if there is no further loss of the diversity of genes, species and habitats/communities at ecologically relevant scales and when deteriorated components, where intrinsic environmental conditions allow, are restored to target levels. Target levels are defined by the second phrase in the Descriptor as being such that "the quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions". Some deviation from reference conditions, as a result of human use of the marine environment, is acceptable, providing the terms of the Descriptor are still met.

GES for this Descriptor will be achieved when each of the targets established by the Member States for the attributes and components of biological diversity have been met. These targets should define the proportion of biological diversity that should reach defined quality target levels in the region, subregion and assessment area. Targets are set to reflect the overall goal of the Descriptor and the need to achieve sustainable use of the environment. Further, the targets should be in line with the preamble of the Directive and the definition of GES in Art. 3.5.

GES is to be determined at the level of the Region or Subregion (Art. 3.5). Consequently, for Descriptor 1, this guidance is provided on the basis that Member States will assess GES, in cooperation with other Member States and non-Member States in the same region/subregion, at the scale of the Region (for the Baltic Sea and Black Sea) or the Subregions defined for the Atlantic and Mediterranean Seas.

2.3 Scope and limitations of the Descriptor

2.3.1 Biological scope

This Descriptor refers to the biodiversity associated with the marine waters covered by this Directive. In terms of species, this includes those which are dependent for all or part of their life cycle on the marine environment, including for breeding, feeding, resting and migratory purposes. The following main types of marine species are given in Annex III (Table 1) of the Directive:

a. Angiosperms, macro-algae, invertebrates
b. Phytoplankton, zooplankton
c. Fish
d. Mammals
e. Reptiles
f. Birds[9]

Microbes (viruses and bacteria) and pelagic cephalopods are additional main types of species to the groups listed in Annex III Table 1. Microbes are a major part of both pelagic and benthic communities, forming a hugely diverse component of marine ecosystems with vital roles in productivity and ecosystem functioning (see Section 5.2.4). Certain species of cephalopod (e.g. squid) provide an important component of pelagic communities.

As for habitats, Annex III gives two categories of habitats (predominant habitats and special habitats). All marine habitat types in the water column and on the seabed, within the geographic scope of the Directive, should be considered under Descriptor 1.

2.3.2 Vagrant and non-indigenous species

Species which are vagrants in the marine waters covered by this Directive need not be considered when assessing this Descriptor. Non-indigenous species should be treated as having or potentially having an adverse effect on biological diversity (i.e. as a pressure), when assessing this Descriptor against GES. Their treatment is covered by the Guidance for Descriptor 2. Species which extend their normal range of distribution by natural means, such as may result from changes in water temperature, are not considered to be non-indigenous species.

2.3.3 Geographic scope

In line with the jurisdictional scope of the Directive (Art. 3.1), this Descriptor is taken to apply to biological diversity that occurs within the 'marine waters' as defined by the Directive, including the EEZs of Member States and, for the seabed, on the extended Continental Shelf where this is claimed under UNCLOS.

[9] Annex III of the Directive refers to 'seabirds'; this term is commonly used to distinguish certain types of marine birds (petrels, gannets, cormorants, skuas, gulls, terns and auks) from water-birds (waders, herons, egrets, ducks, geese, swans, divers and grebes). Descriptor 1 encompasses all of these and hence the term 'birds' is used here.

The biological diversity occurring within the geographical limits set by the Directive will often have dependencies beyond these limits, especially as many species move across such boundaries as part of their normal life cycles and are dependant on the physical and oceanographic processes in wider seas to support aspects of their habitat and life cycle. It may therefore be necessary to consider issues beyond the strict jurisdictional limits of the Directive in determining and achieving GES, such as is done under the 1995 agreement on straddling fish stocks (UNCLOS) and the ICCAT Convention.

2.3.4 Issues outside the scope of this report

Environmental targets.

Setting environmental targets is beyond the scope of this report. Threshold target values for defining GES (i.e. the environmental targets required in Art. 5.2aiii) are to be set by Member States, in cooperation with other Member States in the same region or subregion. Guidance on their setting is given in Section 3.3.6.

Ecosystem functioning.

TG1's treatment of ecosystem functioning relies heavily upon first documenting the structural attributes and components of biological diversity within ecosystems. This information is combined with knowledge on the various interactions between components of biological diversity, to form indicators of ecosystem functions and and the services which they provide.

Certain ecosystem functions are more specifically addressed by other Descriptors, notably Descriptor 3 (food-webs) and Descriptor 6 (sea-floor integrity). Table 2-1 provides an initial analysis of the potential coverage of ecosystem functions by the Descriptors (based on guidance in the Task Group reports). From Table 2-1, it appears that collectively the Descriptors potentially provide good coverage of the range of functions. However, undertaking the assessments at a Descriptor level may be quite different to making an assessment of a particular function in relation to the overarching definition of GES. The assessment of these functions (or some of them) should be further considered when the set of Descriptors as a whole are assessed in relation to the definition of GES (Art. 3.5).

*Table 2-1. Relationship between Descriptors and ecosystem functions, based on a list of ecosystem functions taken from Mazik et al. (2010) and an initial analysis of the guidance in each Task Group report. Key to symbols: X: Indicators suggested in the Task Group Guidance for the Descriptor which will monitor some aspect of ecosystem function; *: The state of the Descriptor will influence the state of the ecosystem function, but some possible relationships with ecosystem functions are given. Note: indicators for D7 are not yet available; indications given represent likely scenarios.*

Ecosystem functions	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**
Ecological ecosystem functions											
Primary production	*	*	*	X	X	*		*		*	
Secondary production	*	*	X	X	*	X		*	*	*	*
Trophic complexity	X	X	X	X	*	X		*			*
Nutrient exchange	*	*	*	*	X	X	*	*		*	
Export of detritus and dissolved	*	*	*	*	X	*		*		*	

Ecosystem functions	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
Ecological ecosystem functions											
organic material											
Bioturbation / Grazing - natural disturbance	X	*	X	*	*	X		*		*	
Propagule dispersal	X	*	*	*	*	*	*	*	*	*	*
Delivery of recruiting organisms	X	*	X	X	*	X	*	*	*	*	*
Other	X	X	*	X	X	X		*		*	*
Physico-chemical ecosystem functions	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**
Sedimentation	*				X	X	*			X	
Dispersal of water quality characteristics via movement of water masses	*				*	*	*	*		X	
Tidal flow							*				
Gas exchange	*				X	X	*			*	
Provision of coastal defence	X	*				X		*			
Other	X	*				X		*		*	

2.4 Relationships with other Descriptors

Descriptor 1 has a very broad biological and geographic scope and provides a high level objective for the required state of marine ecosystems (as part of the definition of GES). Because of its very broad scope, it interacts with and is influenced by many other aspects of the marine environment, both natural and anthropogenic, including each of the other GES Descriptors. The relationship between Descriptor 1: Biological diversity and the other GES Descriptors is summarised in Table 2-2. Full wording for each descriptor is given in Section 1.1.

Table 2-2. Interaction between Descriptor 1 (Biological diversity) and the other Descriptors of GES.

Descriptor (D)	Aim of descriptor relevant to D1 (relevant text given)	Generalised interactions with D1
D2 Non-indigenous species	'do not adversely alter the ecosystems'	Competition for habitat and/or food Change in dominant species composition in community
D3 Commercial fish and shellfish	'exhibiting a population age and size distribution that is indicative of a healthy stock'	Impacts on benthic habitats/communities Reductions in populations of target and by-catch species; damage to species.
D4 Food webs	'ensuring the long-term abundance of the species and the retention of their full reproductive capacity'	Ecosystem functioning Links to population size structure of species and relative abundances between species in trophic group

Descriptor (D)	Aim of descriptor relevant to D1 (relevant text given)	Generalised interactions with D1
D5 Eutrophication	'adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms'	May cause increased abundance of plant species (phytoplankton and macroalgae) with consequent effects on other parts of their communities
D6 Sea-floor integrity	'ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.'	Determines structure and composition of seabed habitats, a key factor determining species composition of benthic communities
D7 Hydrographical conditions	'does not adversely affect marine ecosystems.'	Water movement and temperature/salinity regimes play a significant role in determining species composition of habitats/communities; directly influences sediment type. Ocean acidification may weaken calcareous body parts.
D8 Contaminants	'at levels not giving rise to pollution effects.'	Potential ecotoxicological impacts on species. There is a link with D4 for biomagnified compounds. Smothering of species (especially seabirds) by oil spills.
D9 Contaminants in seafood	'do not exceed levels established by Community legislation or other relevant standards'	Potential ecotoxicological impacts on wild fish and shellfish. Link with D4 for biomagnified compounds.
D10 Litter	'do not cause harm to the coastal and marine environment.'	Affects some species (e.g. turtles) if swallowed or entangled in litter (e.g. nets) Potential to smother/damage (through abrasion) benthic species.
D11 Energy	'do not adversely affect the marine environment'	May disturb some species (e.g. cetaceans, fish)

An initial analysis of Descriptors 2-11 above suggests that all have some relevance to D1, as they either refer specifically to marine species (D2, D3, D4, D5, D9), or to adverse effects on marine ecosystems (D2, D5, D6, D7, D10, D11) or to pollution effects (D8)[10]. Reference to marine ecosystems, in D5, D7 and D10 in particular, is expected to also include non-biodiversity aspects of ecosystems.

Descriptors D1, D3, D4 and D6 can primarily be considered as defining the desired state of marine ecosystems, whilst the remaining Descriptors are primarily relating to the desired level of pressures on marine ecosystems. The inter-relationships between the Descriptors (pressure and state) are shown in Table 2-3.

[10] The definition of pollution in the Directive includes loss of biodiversity (Art. 3.8).

Table 2-3. Relationship between GES Descriptors. Each of the 'state' Descriptors are assigned to the major components of marine ecosystems; coloured cells indicate which 'pressure' Descriptors are most likely to affect these major ecosystem components. Nb: other pressures, including climate change, may occur and descriptors for ocean processes and water/sediment chemical quality are expressed only as pressures.

	Pressure Descriptors	**D2 Non-indigenous species**	**D 5 Eutrophication**	**D7 Hydrographical changes**	**D8 Contaminants**	**D9 Contaminants in seafood**	**D10 Litter**	**D11 Energy**
Ecosystem structural components & functions	**State Descriptors**							
Ocean processes (pH, T, S, water movement, turbidity)								
Water & sediment chemical quality (nutrients, O2, other chemicals, radioactivity)								
Pelagic/mobile species (plankton, cephalopods, fish, mammals, reptiles, birds)	D1 Biological diversity D3 Commercial fish & shellfish D4 Food webs							
Marine landscapes (e.g. estuaries, fjords, seamounts)	D6 Sea-floor integrity							
Seabed habitats/communities & species (coastal, shelf, deep sea)	D1 Biological diversity D3 Commercial fish & shellfish D4 Food webs D6 Sea-floor integrity							
Ecosystem functions (e.g. coastal defence, nutrient cycling)								

2.5 Relevant policies and conventions

The key policies and multilateral agreements of relevance to Descriptor 1 are:

- EC Habitats Directive (HD)
- EC Bird Directive
- EU Biodiversity Strategy
- EU Water Framework Directive (WFD)
- Common Fisheries Policy (CFP)
- Bern Convention on the Conservation of European Wildlife and Natural Habitats
- Bonn Convention (CMS) – ASCOBANS, ACCOBAMS, AEWA
- Helsinki Convention (HELCOM)
- Oslo and Paris Convention (OSPAR)
- Barcelona Convention (BARCOM)
- Bucharest Convention
- Ramsar Convention
- Convention on Biological Diversity (CBD)

3 Assessing biological diversity: key concepts and approaches

3.1 Introduction

One of the main challenges for developing international assessment and monitoring processes is to reach a common understanding of both the concepts involved and the ways in which the various attributes, components and criteria of biological diversity can be assessed and monitored.

This chapter expands on the interpretation of Descriptor 1 (Section 2.1) by describing the key concepts of biological diversity, its range and variation and how it can be assessed. This takes into account existing practices linked to relevant EU legislation and the work of the regional seas conventions.

Section 3 builds on these key concepts to provide guidance on how they should be applied in practice to meet the requirements of the Directive, including considerations of scale, the practicalities of addressing the very broad scope of this Descriptor, and the potential use of the other Descriptors in assessing Descriptor 1.

3.2 What is biological diversity?

3.2.1 Application of the CBD definition

The Convention on Biological Diversity definition of biological diversity (CBD, 1992) will be used as a basis for developing guidance for this Descriptor: "*the variability among living organisms from all sources including, inter alia, [terrestrial,] marine [and other aquatic ecosystems] and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*".

The CBD definition encompasses "diversity within species, between species and of ecosystems". These elements represent different levels of ecological organisation and each is important to consider in an overall assessment of biodiversity. An outline of their meaning and relevance to the marine environment is provided below:

a. '<u>Within species</u>' variation is expressed by the occurrence of discrete sub-species and populations and by genetic diversity. Such intra-specific variability is important, for example, in the survival of a species when facing a new or multiple natural and anthropogenic pressures, and also for evolutionary change. At the intra-specific level, ecological and phenotypic traits (e.g. geographical range and size distribution within a population) and genetic traits (e.g. genetic structure and diversity) are important features of the overall state of a species.

b. '<u>Between species</u>' variation is expressed by the wide range of marine animal and plant species in many taxonomic classes. Annex III of the Directive lists the main groups of marine species: phytoplankton, zooplankton, angiosperms, macrophytes, invertebrates, fish, mammals (cetaceans and seals), reptiles (turtles) and seabirds. Maintenance of species diversity is a major goal for international biodiversity policies, in view of the accelerating rate of extinction of species in some ecosystems and the increasing numbers of species being listed for protection (e.g. by IUCN). The importance of taxonomic variation (or distinctness) has attracted recent attention in the marine environment (e.g. Clarke & Warwick 1998) where the value of maintaining variety at higher taxonomic levels (e.g. at phylum or class levels) is advocated.

c. '<u>Of ecosystems</u>' – variation within and between ecosystems represents levels of ecological organisation above the species level, and provides both wide regional variation and represents aspects which are vital to the overall functioning of ecosystems. Although the term Ecosystems can be applied at many different scales, they are often considered to be very large marine systems (termed Large Marine Ecosystems), similar in scale to the regions and subregions provided in the Directive. These large systems can be subdivided into marine landscape and habitat/community types, representing two different ways of characterising the marine environment at organisational scales between large marine ecosystems and species (Connor et al. 1997).

i. <u>Habitats and their associated communities</u> of species – on either the seabed (benthic species living on the seabed, attached to it as epibiota or living in the sediment as infauna) or in the water column (plankton). Habitats are defined on the basis of their physical, hydrological and chemical characteristics (e.g. substrate, temperature, salinity, water movement, nutrient and oxygen levels). Communities of species are associated with particular types of habitat. This combination of abiotic and biotic elements is technically termed a <u>biotope</u> (Connor et al. 1997).

ii. <u>Landscapes</u> – topographically-defined features, generally large in scale, (e.g. estuaries, fjords, seamounts, deep-sea canyons) which comprise combinations of particular (seabed) habitats/communities and also often certain mobile species (e.g. anadromous fish in estuaries, bentho-pelagic fish on seamounts), due to the physical and hydrological characteristics of the feature.

iii. <u>Ecosystems</u> - The habitat/community level (seabed and plankton) and species level (for large/highly mobile species) are expected to be the main units of assessment for Descriptor 1 (Sections 4.3 and 4.4). However, for an ecosystem-orientated assessment, as required by the Directive, species and habitats/communities should not be considered in isolation from each other, but as part of the wider ecosystem. This can in part be addressed by considering broader aspects of habitat diversity and their spatial pattern and the overall composition and community structure of pelagic/mobile species.

3.3 Assessing biological diversity

3.3.1 What is a status assessment?

In most biodiversity policy mechanisms, species and habitats/communities (benthic, plankton) are typically assessed individually. Such assessments are generally based on a number of criteria and lead to judgements on the overall condition (state) of the species or habitat/community within a given geographical area. The assessments are sometimes allocated to specific status categories (e.g. endangered, threatened, favourable).

Assessments are usually judged in relation to a previously known state (such as a baseline condition) or to environmental conditions which are deemed to be relatively natural and unimpacted by pressures from human activities (a reference condition). Sound assessment techniques take into account long-term climatic fluctuations and natural processes (such as fluxes in predator-prey relationships), such that the assessment can:

a. Provide a sound judgement on the long-term viability of the species or habitat/community;

b. Indicate how far the state has deviated away from a defined reference or baseline condition and a desired target state;

c. Indicate any trends in state (improving, deteriorating), and preferably the rate of change;

d. Identify possible causes of any deterioration in state, whether they are from anthropogenic pressures or natural causes (e.g. disease events).

Such assessments are most often applied to species and habitats considered to be under some form of threat and hence in need of specific conservation action. Examples include the IUCN Red List process (IUCN 2001), the assessment of Favourable Conservation Status for the Habitats Directive (EC, 2006) and the listing of species and habitats by the Helsinki, OSPAR (OSPAR 2008) and other regional seas conventions[11]. The assessment of commercial fish stocks, although undertaken from a different perspective, has some similarities in approaches. These policy mechanisms each have different approaches depending on the perspective of the policy and the geographical scale at which it is applied. Table 3-1 provides an overview of key European policy mechanisms and their biodiversity scope.

Table 3-1. Scope of biodiversity assessments in key EU legislation and the regional seas conventions (latter refers to specified Lists for protection or routine monitoring, rather than broader assessments).

	Habitats Directive	**Birds Directive**	**Water Framework Directive**	**Helsinki Convention**	**OSPAR Convention**	**Barcelona Convention**	**Bucharest Convention**	**MSFD**
Geographic scope	All Member State waters	All Member State waters	Out to 1nm	Baltic Sea	North-East Atlantic	Mediterranean Sea	Black Sea	All Member State waters
Assessment area	Member State level	No formal assess-ments	Water body	Region Level	Region level (≡ MSFD subregion)	Member State level	Region level	Region/ subregion level
Birds		Selected species		Selected species	Selected species	Action Plans	Selected species	Yes
Reptiles	Selected species				Selected species	Action Plans		Yes
Mammals	Selected species			Selected species[12]	Selected species	Action Plans	Selected species	Yes
Fish	Selected species		Transit-ional waters only	Selected species	Selected species	Action Plans for cartilagenous fishes	Selected species	Yes
Cephalopods (pelagic)								Yes
Phytoplankton			Yes	Yes			Yes	Yes

[11] http://www.unep.ch/regionalseas/regions/med/t_barcel.htm

[12] All resident species (Grey seal, Harbour seal, Ringed seal, Harbour porpoise), except otters.

	Habitats Directive	Birds Directive	Water Framework Directive	Helsinki Convention	OSPAR Convention	Barcelona Convention	Bucharest Convention	MSFD
Zooplankton				Yes[13]			Yes	Yes
Microbes (viruses, bacteria)				Yes[14]				Yes
Benthic communities (inc. angiosperms, macroalgae and invertebrates)	Selected habitats, selected species (maerl)		'Aquatic flora' Benthic inverte-brates	Selected habitats, selected species (incl. habitat-forming species)	Selected habitats	Action Plans for marine vegetation	Yes + Selected habitats	Yes

Traditionally there has been only limited attention given to the interactions between species and habitats/communities in a more holistic ecosystem-based approach. The Water Framework Directive (WFD) requires a more holistic approach for its assessment of Good Ecological Status, as it is concerned with all species (of benthic invertebrates, marine flora, fish and phytoplankton) in the waters to be assessed. Fisheries management is increasingly embracing a more holistic multi-species approach, although this typically is restricted to commercial fish species. As with the WFD, this Directive requires a more holistic approach, as it concerns all aspects of biological diversity within its overall aims for achieving GES.

A consequence of moving from an individual to a multi-species and multi-habitat/community approach is that the dynamic interactions between species and habitats/communities need to be embraced within the assessments. There is thus a need to recognise that increases in populations of species or the extent of habitats/communities is likely to be at the 'expense' of other species and habitats. Additionally, for any particular location, a variable range of communities and species may naturally occur over time. As such, setting targets needs to allow for such natural dynamics and balances in the ecosystem, rather than consider one specific combination of species and communities as the right one.

3.3.2 Criteria for assessing status

The biodiversity policy mechanisms mentioned above follow a variety of approaches to their assessments, differing partly as a result of purpose (e.g. species or habitat assessments *sensu stricto* or wider ecological assessments), and partly due to addressing differing taxa, with their inherent differences in characteristics and the practicalities of undertaking their assessment. The criteria used in these assessments are summarised in Table 3-2.

[13] Not currently a core variable in the HELCOM Combine monitoring programme, but data from national programmes are used to assess zoolplankton status in the HELCOM biodioversity assessment (HELCOM 2009).

[14] Cyanobacteria form an important component of the phytoplankton community in the Baltic, and are assessed.

Table 3-2. Overview of criteria used for assessing biodiversity status in selected international policy mechanisms.

Policy	Species	Habitats/communities
Habitats Directive Assessment of Favourable Conservation Status (EC, 2006)	Range Population Habitat for the species Future prospects	Range Area covered within range Specific structures and functions, including typical species Future prospects
Water Framework Directive Assessment of Good Ecological Status (EC, 2000)	Composition and abundance of fish fauna	Composition, abundance and biomass of phytoplankton Composition and abundance of other aquatic flora Composition and abundance of benthic invertebrate fauna Hydro-morphology (e.g. structure of seabed, wave exposure) and chemical/physico-chemical (e.g. salinity, nutrients) supporting elements
OSPAR Convention Assessment of threatened and declining species and habitats for Quality Status Report 2010 (OSPAR, 2010)	Distribution Population (incl. future prospects) Condition (incl. future prospects) Evaluation of threats & impacts Global importance Regional importance Rarity Sensitivity Keystone species Decline	Distribution Extent (incl. future prospects) Condition (incl. future prospects) Evaluation of threats & impacts Global importance Regional importance Rarity Sensitivity Ecological significance Decline
OSPAR Convention Biodiversity assessment for Quality Status Report 2010 (OSPAR, 2009)	Range Population abundance Condition of species/populations	Range Extent of habitat Condition of habitat
IUCN Red List criteria (IUCN, 2001)	Population size (abundance) • Extent and quality of habitat • Levels of exploitation • Effects of pressures • Projected population size (abundance) Geographic range • Fragmented occurrence • Extent of occurrence • Area, extent and quality of habitat • Number of locations or subpopulations • Number of mature individuals	

Although there are differences in the criteria used, Table 2-2 indicates there is also much commonality across the different mechanisms, with some providing more detail (sub-criteria) and others with alternative terms for the same issue. Additionally, some criteria can be considered as supporting criteria which do not *per se* contribute to the environmental status of a species or habitat/community (e.g. OSPAR's sensitivity and keystone species criteria are inherent properties of biodiversity rather than criteria to assess their state). These supporting criteria may be relevant in considering why status may be changing or to inform priorities for management action (e.g. a higher priority for features which are highly sensitive to ongoing pressures or rare as a consequence of past deterioration in status).

3.3.3 Geographic scale for assessments

The outcomes of a status assessment are highly dependent on the geographical scale at which they are undertaken. The assessment scale can be set ecologically or by policy. For ecologically relevant scales, ideally the assessment should cover the entire range of the species or be related to discrete populations (e.g. for large/mobile species). For habitats/communities it is most appropriate to assess within biogeographic zones, as functionally similar habitats can have global distributions (for example, exposed sandy beaches in California, the Bay of Biscay, South Africa and Australia all provide the same functional habitat but are occupied by species particular to their regional biogeography). In practice policies are often applied at specific geographic scales relating to the scope of the policy or national jurisdictions (e.g. EU Member States' waters, Regional Seas Convention areas, national territories) and thus can lead to different classifications of status for the same species/habitat (assuming a common use of criteria and target values). For the Habitats Directive, Favourable Conservation Status (FCS) is determined at the level of the Member State; for the WFD, assessment is undertaken in much smaller geographical units (water bodies).

In order to facilitate monitoring and management, and to reflect biogeographic and genetic variation, the assessment scale should reflect the variation in biological diversity that operates at a range of spatial scales related to distinct populations or sub-species and, for communities, biogeographic regions. For example, there are distinct sub-species of harbour porpoise *Phocoena phocoena* in the Greater North Sea subregion, leading to the need for assessment at finer scales than the North Sea as a whole. In order to maintain their genetic diversity, the state of individual populations of harbour porpoise therefore needs to be assessed. Conversely, some migratory fish may need to be assessed over very large areas, at the regional scale or across two or more marine regions. Similarly, part of the assessment might need to cover any freshwater or terrestrial systems necessary for spawning, breeding or other parts of life cycles.

3.3.4 Biodiversity status affected by anthropogenic pressures

Status assessments need to be undertaken against the backdrop of natural environmental variation. This essentially needs to be based on a deviation from what might be expected under natural circumstances (i.e. the prevailing physiographic, geographic and climatic conditions, including climate variability; see Section 3.3.4 and 3.3.5). Such deviation is principally caused by pressures (from human activities) which have an adverse impact on species, habitats/communities or the wider ecosystem. Pressures include physical damage, contamination, removal of individuals in a population, introduction of species and changes in nutrients and hydrological conditions.

Anthropogenic pressures may cause a range of impacts; these can affect biodiversity structure or its ability to function as part of the wider ecosystem. For example, wide-ranging species are susceptible to pressures acting over large areas, such as contamination by hazardous substances, and physical disturbances such as litter and noise. Plankton communities are affected by pressures influencing water quality (e.g. nutrient enrichment, hazardous substances), hydrological changes and biological disturbances (e.g. microbial pathogens, non-indigenous species). Habitats and communities on the seabed are particularly affected by pressures acting at smaller spatial scales (e.g. physical disturbance, organic enrichment and contamination from point sources).

Components of biological diversity respond to degradation gradients in different ways, but in general, the following responses are typical:

a. Reduction in diversity (of genes, species, communities and habitats). This may occur as a general decline in species, or an increase in opportunistic taxa at the expense of others;
b. Various lethal and sub-lethal effects, including reduction in reproductive success or species viability;
c. Temporary or permanent relocation of mobile species.

Table 3-3 provides a generalised categorisation of these impacts on species, communities and habitats.

Table 3-3. A generic scale of impacts on biodiversity with examples of associated pressures (and activities). Note that increased intensity or persistence of a pressure is likely to increase the severity of impact.

Increasing severity	**Categories (degrees) of impact**	**Example pressures**
	Species level (population or individual) - sub-lethal effects (e.g. affecting reproductive ability)	Contamination by hazardous substances; underwater noise
	Species level (population or individual) – lethal effects	Removal of target species (e.g. fishing), introduction of pathogens (e.g. from sewage)
	Community level – changes in species composition and relative abundance	Nutrient enrichment, introduction of non-indigenous species
	Habitat level – physical damage	Physical disturbance of seabed (e.g. trawling)
	Habitat level – loss	Land claim; placement of structures on seabed; dumping of dredge spoil

Variation in the intensity of pressures and their persistence over time (e.g. one-off, continuous) can lead to differing degrees of impact for the same pressure/activity. For example, high concentrations of contaminants or prolonged exposure to them may lead from sub-lethal to lethal effects on species.

Where there is a known causal link between state and pressures, remedial action can be taken to reduce the intensity, duration or extent over which the pressure occurs. Environmental and biodiversity protection in such circumstances typically takes into account a number of factors, including the cost of such action, the sensitivity of the species or habitat/community, and often the level of public profile of the situation.

Variation in sensitivity to pressures

The intrinsic sensitivity of species and habitats/communities to various types of pressure varies considerably. Sensitivity comprises two components: resistance and resilience.

Some species are robust (resistant), being able to withstand a considerable level of a pressure before showing detrimental effects. Others are very fragile and easily damaged or destroyed by minor levels of a pressure. Additionally sensitivity varies between pressures (i.e. a particular species or habitat/community may be very sensitive to some pressures whilst being rather resistant to others).

Species and habitats/communities also vary markedly in their ability to recover (resilience), should the pressure be removed or the activity cease. Recovery can be within hours or days or may take decades. Recovery depends on inherent characteristics of the species or habitat/community and on how quickly the pressure is lost from the environment (some, for example contaminants, can persist for decades after they were introduced to the marine environment).

Population abundances of species and their composition within communities fluctuate over time. Time-scales of change range from diurnal, seasonal, annual and decadal to centennial, depending on the component. The recovery of species populations and communities, after being impacted, will also take effect at a variety of temporal scales, and may take decades following the cessation of an activity that has had an impact.

These inherent attributes of sensitivity, i.e. resistance and resilience, need to be considered when setting target threshold values for biodiversity status, such as the degree or frequency of pressures permitted within the assessment area (Robinson et al. 2008b).

3.3.5 Other causes of change in the state of biodiversity

Sometimes the state of species and habitats/communities can change but no direct link to anthropogenic pressures can be made. Species populations may vary dramatically and, even after incorporating long-term averaged trends, significant declines in populations can be found. Where a link to an anthropogenic pressure cannot be demonstrated, there is often a need to undertake further research into possible causes. These can include a variety of factors, such as disease events (e.g. the seagrass *Zostera* wasting disease events of the 1930s) or wider changes in environmental conditions.

Our responses to changes that can be attributed to such environmental events vary. Sometimes, they are to ensure the survival of the species or habitat through proactive management, whilst on other occasions there may be an acceptance of the declines which are considered to be beyond the scope of human intervention.

Where there are elements of uncertainty in the causes of decline, it is often prudent to undertake further investigation, to continue to monitor the species or habitat/community and to make efforts to protect the feature where practicable.

3.3.6 Determining the state of biodiversity

Reference and baseline conditions

The current state of a species or habitat/community is usually assessed in relation to a degree of change over time or degree of change relative to:

a. A previously known state (a baseline condition), or

b. Environmental conditions which are deemed to be relatively natural and unimpacted by pressures from human activities (a reference condition).

Baseline conditions often encompass a degree of deterioration from reference conditions, such as past hunting and fishing of a species or the loss of habitat through coastal infrastructure developments. Baseline conditions are often used because they mark the start of available monitoring data or the introduction of a policy initiative (such as a Convention). Occasionally, moving baselines are used, such as the change in state over the past 5 or 10 years. These can be helpful in indicating recent trends in state (e.g. improving, deteriorating) but, if not referred to a specific reference or baseline condition can effectively mask long-term deterioration in state. For example, assessments which use reductions in the proportion of a species population or extent of a habitat type over a recent period can mask long-term deterioration in state. The FCS assessment guidelines for the Habitats Directive have elements of this approach. Because the use of baseline conditions ignore long-term changes caused by anthropogenic activities over the past 100 years or more, and are often set to different standards (e.g. inception dates for policies), they yield a number of conceptual problems in status assessment. Equally, the use of reference conditions where these are established on a pre-industrial state level often gives considerable difficulties due to the lack of suitable data on which to derive the conditions and the fact that natural ecosystem dynamics in the intervening period are not taken into account. However where reference conditions are established in relation to conditions which reflect an unimpacted state, they should better reflect conditions that might reasonably be expected should existing pressures be removed and take account of prevailing environmental conditions. These thus offer a preferable condition (state) to assess present conditions against, in particular because the management of pressures is the principle tool for marine environmental management (there tends to be very limited direct management of the environment itself).

This concept of unimpacted state as Reference Condition provides the same role as the Reference Condition concept used for the Water Framework Directive; however the latter does not explicitly encompass ongoing climatic changes but rather refers back to historical conditions.

Targets and limits

Having established a reference or baseline condition, assessment systems usually then define a target value against which to make the judgement of whether the state of a biodiversity component is considered to be acceptable or not. Such target values may be set at a lower level than reference conditions (and indeed also baseline conditions), representing a deviation away from such conditions and thus allowing for some levels of impact from human activities. The target can also be set as a range of conditions, rather than a single threshold value. Where set as a range, it is important to maintain the biodiversity component in a state above the lower end of the range, and to ensure that relaxation of management measures does not lead to its state dropping below this lower value.

In some assessment systems, values are set for a limit, beyond which the condition should not deteriorate (e.g. some stock assessments for fish, certain OSPAR Ecological Quality Objectives). Such limit values usually represent conditions where the viability of the species (or habitat) is considered to be at severe risk. In the Directive's overall aims to achieve Good Environmental Status, as set out in Art. 1.2 and Art. 3.5, it is clear that the aspiration of the Directive is not to have an ecosystem where its quality and functioning is only just prevented from collapse. As such, the use of limits marks the opposite end of environmental quality to that which is sought by the Directive; the use of limits is therefore not considered further in this report.

The targets set for biodiversity assessments (and indeed for other environmental assessments) are threshold values which mark the boundary between acceptable and unacceptable conditions. They may be set for a variety of quality elements individually (e.g. single species and habitats, elements of macro-invertebrates and plankton for WFD assessments). Some assessment systems have rules for their integration to derive overall status assessments (e.g. the one out-all-out system used for WFD).

The conceptual relationship between reference and baseline conditions, targets and limits is shown in Figure 3-1.

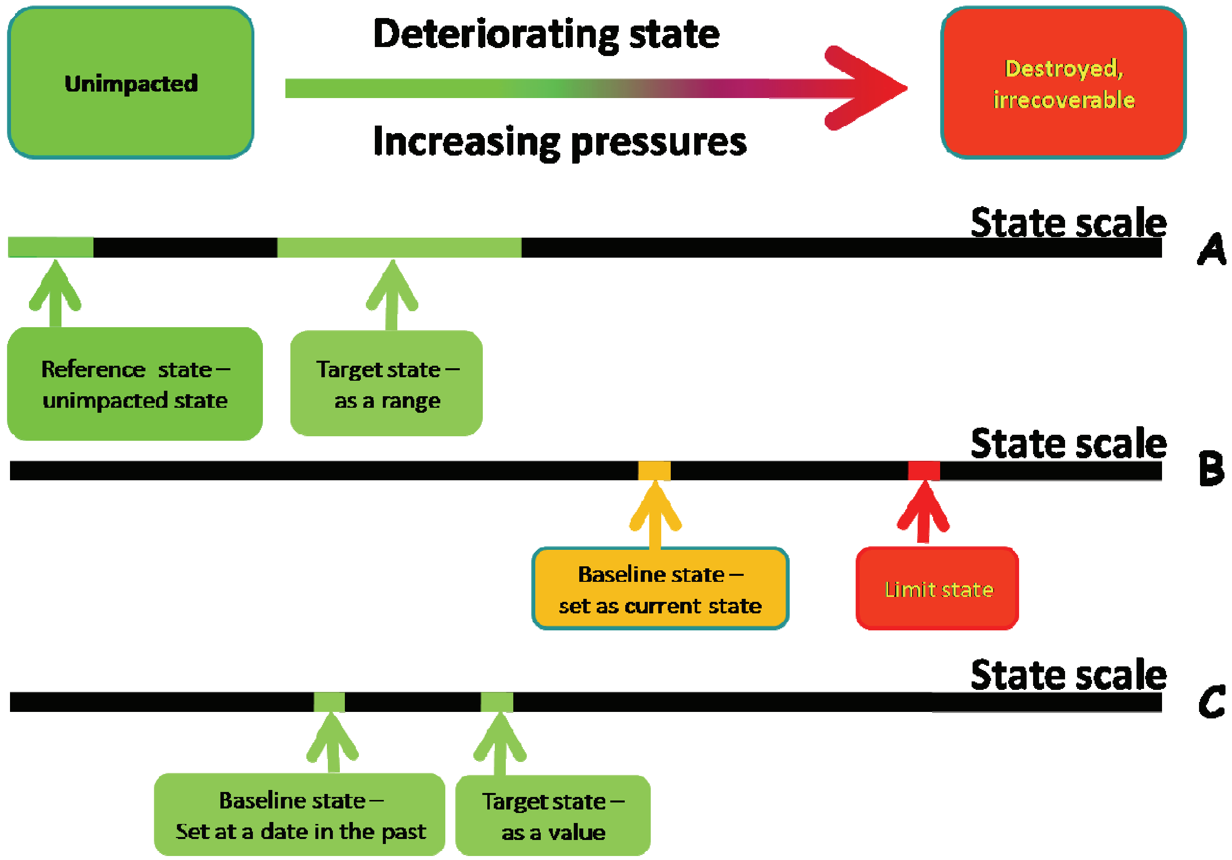

Figure 3-1. Environmental state can be considered as a gradation from unimpacted conditions to destroyed or an irrecoverable state (top of figure). Assessment systems variously set reference, baseline, target or limit points (or ranges) along this gradient to assist in status assessment and for monitoring progress against time and actions. Here three different approaches are shown (A, B, C).

<u>**Status classifications**</u>

In the Water Framework Directive, classifications are applied to the overall assessment (of each water body), and also to each quality element (e.g. phytoplankton, macrophytes, hydromorphology) used in the assessment. For the Habitats Directive, classifications are applied to each species and habitat. The IUCN system of species assessment uses a set of seven classes along a gradient of status (from Least Concern and Near Threatened to Endangered and Extinct). These systems and MSFD, regardless of the number of classes, set an overall quality goal to be achieved (Good Environmental Status, Good Ecological Status, Favourable Conservation Status), with effectively a single target boundary between acceptable and unacceptable status.

The classes of status used in MSFD, the WFD and the Habitats Directive are presented in Figure 3-2, to illustrate a possible broad equivalence. Note that, for the same quality element (and based on the same criteria and geographical scale), the lower limit of target condition between the three Directives are not necessarily equivalent (i.e. state of a particular species or habitat/community could be different in each Directive).

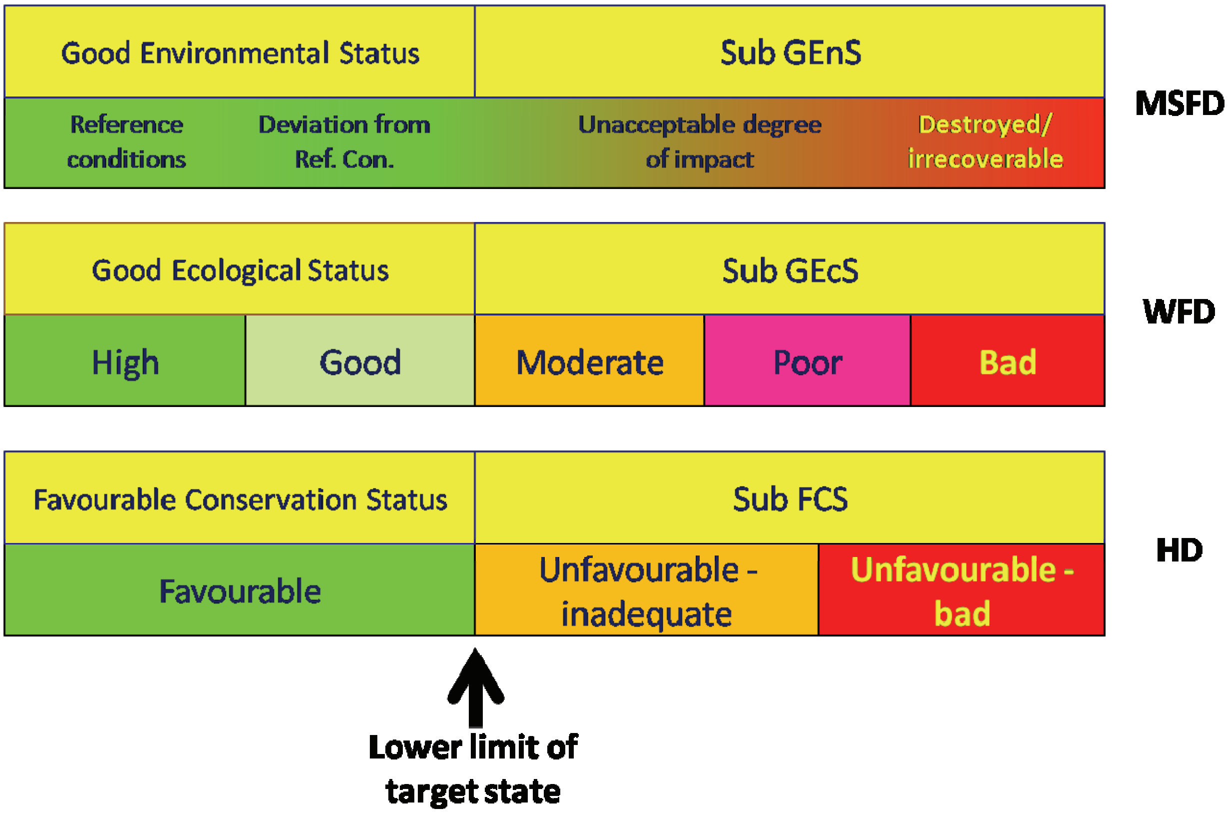

Figure 3-2. Status classifications in the Marine Strategy Framework Directive (MSFD), the Water Framework Directive (WFD) and Habitats Directive (HD) and their possible relationship. MSFD has two classes (above and below Good Environmental Status - GEnS); a range of conditions, from Reference condition through to destroyed/irrecoverable, are added for illustrative purposes. WFD has five classes for assessment of Good Ecological Status (GEcS) and HD has three classes for assessment of Favourable Conservation Status (FCS). There is currently no formal equivalence between the classes or their boundaries (i.e. GEnS, GEcS and FCS for the same quality element, such as benthic invertebrate communities, do not necessarily equate to the same quality).

Quality and quantity issues in assessing status

The loss of a few individuals from a population or the damage to a small area of habitat may not be significant to the overall population, habitat or area being assessed. Assessments therefore need to consider both the degree of impact from anthropogenic pressures and the extent over which they occur. This can be expressed simply as the quality and quantity aspects of an assessment, as advocated by Kontula and Raunio (2009).

The application of these two aspects for status assessment in other policy mechanisms varies considerably. For instance, the WFD provides detailed guidance on qualitative issues (EC, 2000) but is weak on the use of quantitative thresholds. Conversely, the Habitats Directive FCS guidance (EC, 2006) is weaker on specific qualitative guidance, but sets clearer quantitative threshold values.

A combination of the degree of impact (quality) and the extent over which it occurs (quantity) needs to be used to define target threshold values for species and habitats/communities. Such boundaries might need to vary for different types of species and habitats, for different areas and possibly also for different pressures. The latter is depicted conceptually in Figure 3-3, which shows a flexible approach to deal with a range of pressures and their varying degrees of impact on species and habitats/communities. This approach, however, may be difficult to apply in practice to all species, habitats and pressures based on current levels of knowledge.

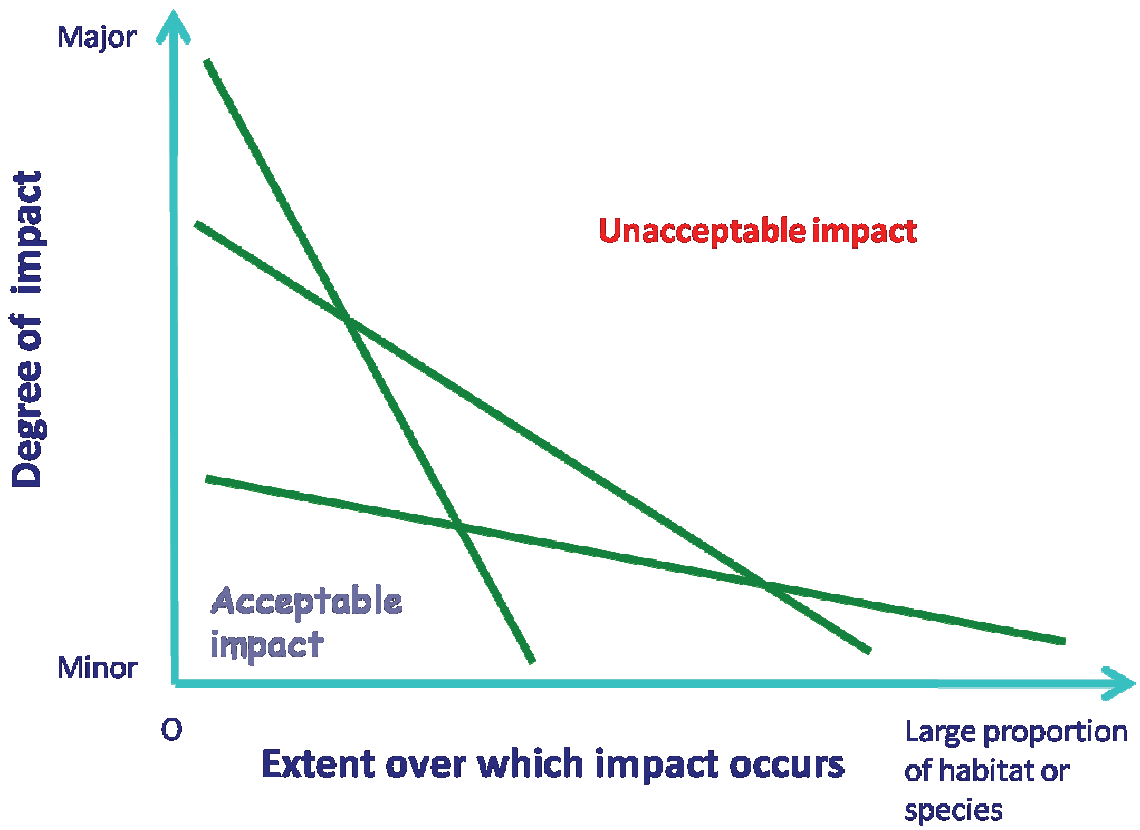

Figure 3-3. Conceptual representation of how acceptable levels of impact could be assessed for a given assessment area, based on a combination of the degree of impact (from anthropogenic pressures) and the proportion of a habitat/community or species affected. The values chosen for each axis could vary according to the species/habitat, the area and the pressure, and should take into account sensitivity to the pressure and the persistence of the pressure. Vertical axis relates to the scale in Table 3.1. Horizontal axis could be expressed as a percentage.

A less complex approach is to define target quality levels (in relation to each pressure, and based, where possible, on the Guidance provided for other Descriptors) and to set target quantity levels per species (group) and habitat/community. See Section 4.7 for practical guidance.

3.3.7 Use of indicators

Given the complexity of biodiversity, both in its range of character and the number of aspects (criteria) which contribute to an assessment of state, it is common practice to use a set of indicators to assist in monitoring and assessment programmes. These help limit the range of parameters that need to be monitored to those which can most effectively represent wider aspects of status, or particular issues in relation to pressures and hence be linked to management requirements.

The task of identifying indicators as a monitoring tool for assessment of biological diversity is complex (see Féral et al. 2003). In theory, measures of biodiversity may provide information on one or several of the following categories:

a. Biodiversity itself;

b. Ecosystem health;

c. Influence of specific pressures.

Guidance on identification of suitable indicators, in relation to the criteria for assessment and in relation to pressures is outlined in Section 4.7.5.

3.3.8 State, pressure and response monitoring

Assessment of state and its change over time depends on having a strong body of evidence on which to make the assessments. Strength of evidence is important in supporting management decisions, particularly where these have an economic or social impact. However gaining such robust evidence in the marine environment can be costly and time consuming, and given the complexities of biodiversity (encompassing complex interactions between the species themselves, as well as with the environment and further influenced by human activities), effective use of indicators is essential.

Whilst it is common to only consider monitoring of the biodiversity itself as a means of assessing its state, this has two distinct disadvantages. Firstly it can be very costly and secondly, it may provide limited information in relation to pressures and management issues. It is therefore worth considering a more balanced strategy:

a. **Monitoring pressures** – monitoring activities and the pressures they exert on the environment is of key importance to understanding the level of risk to biodiversity and the wider environment. Such monitoring is often undertaken anyway, either by regulatory authorities or by industry as part of their licensing agreements.

b. **Monitoring state** – without some understanding of how the state of the environment and its biodiversity is responding to change, including any pressures exerted upon it, it is not possible to assess the state of the biodiversity or to effectively inform management requirements. State monitoring includes assessment of impact from pressures (where causal linkages can be established), as well monitoring of state where links to pressures are not necessarily expected or established.

c. **Monitoring response** – where management measures are established to protect the biodiversity, monitoring of their effectiveness is important as part of the feedback to changes in the state of biodiversity.

Where there is a strong causal relationship between the pressures from activities and their impacts on biodiversity, the use of such a balanced approach can provide a more effective and cost efficient monitoring strategy. For example, use of bottom trawling gear is known to be highly damaging to cold-water coral reefs. Monitoring of the distribution and intensity of fishing activity (using Vessel Monitoring System satellite tracking or other systems) is far easier and cheaper than monitoring the seabed in depths of 500-1500 m where the coral reefs occur. Where areas of sea are closed to such activities to protect the reefs, the VMS system can also be used to monitor compliance with the regulatory measure. Such monitoring of pressure and response can then be complimented by direct targeted monitoring of the reefs to assess their state and any recovery, but at a lower temporal frequency, thereby reducing overall costs.

4 Framework for assessment of Descriptor 1

4.1 Introduction

4.1.1 Overall aims and cycle of assessment, monitoring and measures

Having described biological diversity and general principles for its assessment in Section 3, it is necessary to turn to how these can be applied in the context of the Directive. Due to the exceptional scope of biological diversity, the overall aims set in the phraseology of Descriptor 1 and in the definition of GES, and the large geographic areas of some Member States and regions/subregions, a strategic approach which provides an effective and efficient assessment of the Descriptor is needed. This can be addressed in two key ways:

a. Firstly, by identification of particular aspects of biodiversity, such as selected species and habitats/communities, that can be considered to represent the wider state of biological diversity (proxies or surrogates).

b. Secondly, by adopting a risk-based approach (as indicated in Art. 14.4), such that assessment and monitoring is focused, wherever possible, on key pressures that are, or may be, affecting the state of biological diversity. This is most applicable to habitats and may be less easy to apply to higher predators (e.g. fish, mammals) where causal linkages to direct pressures may be more weakly understood. It is also easier to apply to those pressures which are more directly linked in space to an activity (unlike diffuse pollutants).

The overall aim should be to undertake assessment and monitoring across a sufficient range of species (and their discrete populations where appropriate), habitats/communities, geographical areas and pressures, to enable a robust and systematic assessment against the objectives of the Descriptor.

The assessments must enable the regions/subregions (and subdivisions if defined) to be categorised as being either:

a. At GES (i.e. representing target conditions or better), or

b. At sub-GES conditions (i.e. degraded in relation to target conditions).

For areas and biodiversity components at sub-GES conditions, a programme of measures should be devised and implemented (Art. 13), with the aim of improving conditions (i.e. moving towards and achieving target conditions for GES).

The overall aim of the monitoring programmes is to facilitate ongoing assessments of environmental status (Art. 11). These need to be undertaken to assess progress against the environmental targets set for GES (Art. 10), and, once programmes of measures are established, to assess whether these are being effective in achieving the environmental targets for GES. The monitoring programmes should provide the evidence that the marine environment, its functions and its biodiversity are being maintained at, or are returning to, a state which is in accordance with the environmental targets established for the Descriptor.

Once the programme of measures is implemented, follow-up monitoring is needed which will track any improvements in state (towards target conditions) and also compliance with the measures established. A feed-back system can be used to adjust the spatial and temporal intensity of monitoring in the light of changes (hopefully improvements) in environmental conditions. This should provide management with the tools either to ensure that GES will be achieved within the required timeframe, or to make informed decisions if the monitoring results indicate this may or will not be possible.

The overall process and cycle of activities required by the Directive is typical of environmental management systems (Figure 4-1).

Figure 4-1. Role of monitoring and assessment within an overall environmental management cycle (from OSPAR's strategy for biodiversity assessment and monitoring. MASH 09/06/1).

4.1.2 Scope and limitations of this guidance

A framework is presented here which describes the main decision-making processes involved in compiling an efficient and effective assessment and monitoring programme which can be tailored to the region/subregion in question. This aims to provide both guidance to Member States on how to develop suitable assessment and monitoring programmes and a framework which provides a level of consistency across the regions and subregions. Consistent assessment methodologies are required (Art. 8.3a) to facilitate the comparability of monitoring results (Art. 11.2a). Consistency in establishing targets for biodiversity would mean that status evaluations for similar types of species and habitats/communities should be equivalent, regardless of geographical area (i.e. the status assessment of a species of seal or bird which lives in several regions/subregions would be equivalent).

Achieving consistency in approach needs, however, to take full account of the variation in regional/subregional characteristics, such that assessments are adapted to reflect the intrinsic characteristics of each region/subregion. The range of biological diversity and the type and intensity of human activities varies considerably across Europe's marine waters, and at a variety of temporal and spatial scales. Therefore, decisions on the specific assessment and monitoring systems needed for this Descriptor, and where and what to monitor within a region or subregion (or subdivisions thereof) are not addressed in this guidance. Even within a region, subregion or their subdivisions, both pressures and biological diversity are seldom distributed evenly. As a result, the assessment and monitoring programme will probably need to involve different suites of indicators or assessment tools in different areas, even within the same region/subregion. For this reason, the details of the assessment and monitoring programme will have to be set by the Member State, in cooperation with other Member States in the region/subregion (see Section 4.2.1).

4.2 Cooperation and synergies

4.2.1 Regional cooperation

Art. 5.2 of the Directive sets out the requirements for regional cooperation, including cooperation to ensure the following are coherent, coordinated and follow a common approach:

a. Initial assessment, including the assessment methodologies and consideration of transboundary effects (Art. 8),

b. Determination of GES (Art. 9),

c. Establishment of environmental targets and indicators (Art. 10),

d. Establishment of a monitoring programme, including use of consistent monitoring methods (Art. 11),

e. Programme of measures (Art. 13).

It is expected that much of this regional cooperation will be channelled through the regional seas conventions, where the requirements of the Directive can be facilitated through their organisational networks.

4.2.2 Synergy with existing monitoring programmes

Wherever possible, both cost-efficiency and knowledge gained should be maximised by achieving synergy between MSFD monitoring activities and any ongoing monitoring. The background information collected on the assessment area during Preparatory Task 1 (see Section 4.7.2) will highlight where ongoing programmes exist. Synergy may be achieved in several ways, such as:

a. Cost-sharing of sampling and analyses, where both activities use the same indicators;

b. Mutual increase in background knowledge, where indicators are different, but together enable a more comprehensive understanding of environmental conditions;

c. Provision of historical baseline information, and

d. Extension of time-series data to understand long-term changes (where previous monitoring has ceased).

Biodiversity-related assessments are needed for multiple policies (e.g. Water Framework Directive, Habitats Directive, Regional Seas Conventions). It is recommended that the assessment and monitoring programmes needed for this Directive are integrated with those for other policies, as far as is possible, to ensure they are mutually beneficial and avoid duplication of sampling and assessment processes. The use of inter-disciplinary programmes of monitoring, where sampling for other pursposes (including other Descriptors) is undertaken from the same platforms (vessels), should be considered. This can bring benefits in sharing of expertise and synergies between the disciplines, as well as reductions in overall survey costs.

4.2.3 Collaboration with research programmes

Collaboration with European research programmes is essential for the monitoring programme. Biodiversity indicators are generally developed through detailed understanding of the interactions between species within ecosystems. Particularly important for monitoring are the impacts of specific pressures on key species, species groups and habitats/communities, and on the wider implications for ecosystem functioning. Much remains to be learnt to fully understand these interactions (see Section 5.2.3).

As new pressures or issues of environmental concern arise, the specific needs of monitoring programmes will continue to evolve. Research efforts are continually improving existing biodiversity indicators, increasing their verification status and may also reveal new tools appropriate for assessment and monitoring needs.

Many research institutes have been conducting intensive research on the biodiversity of particular sites, ranging from all taxon biodiversity inventories (ATBI) and long-term biodiversity monitoring (LTBR[15]) to experimental approaches to increase understanding of ecosystem functioning. Many of the LTBR efforts span several decades, and their function as 'biodiversity observatories' is invaluable. These can supply an understanding of natural background variability in the biological diversity of the area and long-term changes. This has obvious value for all aspects of a monitoring programme, from setting targets and assessing changes linked to pressures to designing the appropriate remedial actions for management. See Section 4.7 Assessment and monitoring programme.

4.3 Attributes of biological diversity to be addressed

Based on the consideration of the CBD definition of biological diversity in Section 3.2.1, the levels of ecological organisation recommended for assessment of Descriptor 1 are set out in Table 4-1.

Table 4-1 Levels of ecological organisation to be used for assessment of Descriptor 1.

Attribute of biological diversity	Application
Species state (includes sub-species and population state, where they need to be assessed separately)	Species which are large and highly mobile (e.g. birds, mammals, fish) have traditionally been assessed individually, whilst smaller species living in the water column (plankton) or on the seabed (benthos) are typically treated collectively as 'communities' (see below). There are a number of reasons for undertaking assessment at the species level: existing knowledge of certain species is typically greater than for other levels of biological organisation, and the analysis of pressures, impacts and management needs may be better informed for certain species. Many highly mobile species do not belong to a single habitat/ecosystem during their entire life cycle, and therefore cannot be assessed effectively at the habitat/community level. The state of some species, for example top predators that are structurally influential, may reflect the wider community and as such can be an efficient way to monitor biological diversity. Assessment at the species level may be a cost-effective means of assessing biological diversity where it also helps to meet requirements of existing marine environmental policies, directives and international

[15] ATBI and LTBR are concepts developed through the EU-funded programme BIOMARE (www.biomareweb.org) and continued through the network of excellence MarBEF (www.marbef.org).

Attribute of biological diversity	Application
	conventions. Assessment of species state needs to include aspects on intra-specific variation, such as differences in populations and genetic variation, where these are important to the overall status of a species.
Habitat/community state	Habitats and their associated communities provide a well established and practical means of assessing biological diversity, through organising the complex variety of species into more manageable units. For the Directive, Table 1 of Annex III lists habitat types separately from their biological communities (plankton for the water column; angiosperms, macro-algae and invertebrate bottom fauna for the seabed). However, under habitat types it also refers to types identified under Community legislation and by international conventions. As these are typically identified for their biological importance (rather than their abiotic character), the term habitat appears to be used in the Directive's Annex in the sense of biotope (see Section 0 Glossary). Because the state of communities is intrinsically linked to the abiotic quality of the habitat, and typically most aspects are assessed together, for the purposes of implementing the Directive, the habitat and its associated community are best treated together. Habitat/community state should be assessed as an attribute for several reasons. Firstly, it is not feasible to assess all species and their populations individually. Assessments of habitat/community state are a cost-efficient and practical means of assessing biological diversity. Secondly, species interact with each other and with their environment. Habitats and their associated communities reflect these natural levels of organisation. Thirdly, habitats are the abiotic environment on which species depend. Pressures may have an impact on the habitat, rather than directly on species within the habitat.
Landscape state	A number of marine landscape features are listed for protection as 'habitats' in the Habitats Directive and certain Conventions (e.g. large shallow inlets and bays, seamounts). As consideration of these Listed features is required by the Directive, it is appropriate to consider this scale here. It is not however proposed that a more holistic evaluation of marine landscapes be undertaken for this Descriptor because coastal features (within 1nm) are assessed by the Water Framework Directive hydromorphology assessment and offshore features can be adequately addressed at the habitat level.
Ecosystem state	The regions/subregions of the Directive and appropriate subdivisions (see Section 4.6.1) provide suitable scales at which to assess overall aspects of biodiversity state: habitat diversity and their spatial pattern and the overall composition and community structure of mobile species. These aspects are complementary to ecosystem functioning elements addressed in other Descriptors, notably D4 (food webs) and D6 (sea-floor integrity).

In defining these key attributes of biological diversity, it is not considered necessary or possible to assess the state of all habitats, species or variations within species within each region or subregion, due both to the very wide range of features which may be present and, for Member States with EEZs and extended Continental Shelves, the often very large areas of marine waters to be assessed. Instead, a selection can be made, to reflect, for example, risk to their status, the range of pressures from human activities which may cause deterioration in biodiversity status, and geographical coverage within each region or subregion. The selection should be sufficient to meet the overall objectives of the Descriptor.

4.4 Biodiversity components to be assessed

4.4.1 Treatment of biodiversity elements in Annex III Table 1

Table 1 of Annex III to the Directive provides the environmental components to be addressed in the Initial Assessment (Art. 8) and subsequent six-yearly assessments (Art. 17). These are to be assessed in relation to the objectives set in the Descriptors in Annex I and the overall definition of GES in Art. 3.5. The biodiversity components from Annex III of the Directive are listed in Table 4-2 together with their recommended treatment in relation to Descriptor 1.

Table 4-2 Biodiversity components in Table 1 of Annex III to the Directive and their treatment for Descriptor 1. For the relevant criteria, see Table 4-5.

Biodiversity component in Table 1 Annex III	**Treatment for Descriptor 1**
The predominant seabed and water column types	To be treated together with their associated communities as combined assessments per habitat/community type. To be assessed according to the criteria for the attribute habitat/community state. To facilitate the comparability of monitoring results (Art. 11.2a) and consistency of assessment methodologies (Art. 8.3a), a consistent set of broadly-defined types (based on the EUNIS habitat classification) should be used across all regions and subregions (See Section 0) See Phase 2.1 for details, including application of risk assessment and use of surrogates.
Special habitat types, especially those recognised or identified under Community legislation (the Habitats Directive and Birds Directive) or international conventions as being of special scientific or biodiversity interest	To be assessed according to the criteria for the attribute habitat/community state (or landscape state where the listed feature is best considered as a marine landscape type). A set of relevant 'Listed' (special) types should be drawn up for each region/subregion. Their assessment may contribute in whole or in part to the assessments required for the predominant habitat types. They should be subject to a risk assessment process to ensure their assessment and monitoring is effective and efficient. See Phase 2.1.
Habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference. This may include areas subject to intense or specific pressures or areas which merit a specific protection regime.	Appropriate areas are expected to either be: a. Areas subject to specific or multiple pressures and therefore addressed as part of the risk assessment approach for predominant and listed/special habitats, communities and species. See Sections 4.7.3 and 4.7.4; Phases 1 and 2). b. Areas designated as marine protected areas (MPAs) or subject to other forms of protection, such as fishery closed areas. MPAs may provide suitable reference conditions to assist with assessment against targets in the wider region/subregion. See Section 4.7.2(Task 4).

Biodiversity component in Table 1 Annex III	**Treatment for Descriptor 1**
Biological communities associated with the predominant seabed and water column habitats: a. Phytoplankton and zooplankton communities b. Angiosperms, macro-algae and invertebrate bottom fauna	To be treated together with their associated habitats as combined assessments per habitat/community type. Community assessments should include but not be restricted to the biological elements listed in Annex III Table 1; e.g. fish may be included). Refer to predominant habitat types above.
Fish Marine mammals and reptiles Seabirds	To be assessed according to the criteria for the attribute <u>species state</u>, when assessed individually, and for the attribute <u>habitat/community state</u>, when assessed at the multi-species (ecotype) level. To facilitate the comparability of monitoring results (Art. 11.2a) and consistency of assessment methodologies (Art. 8.3a), a consistent set of broadly-defined ecotypes should be used across all regions and subregions (See Section 0). See Phase 2.1 for details, including application of risk assessment and use of surrogates.
Other species occurring in the marine region or subregion which are the subject of Community legislation or international agreements	To be assessed according to the criteria for the attribute <u>species state</u>. A set of relevant 'Listed' species should be drawn up for each region/subregion. Their assessment may contribute in whole or in part to the assessments required for fish, marine mammals, reptiles, seabirds, predominant and listed habitat types. They should be subject to a risk assessment process to ensure their assessment and monitoring is effective and efficient. See Phase 2.1.
Non-indigenous, exotic species or, where relevant, genetically distinct forms of native species, which are present in the marine region or subregion	Non-indigenous, exotic species should be treated in accordance with the guidance for Descriptor 2. For Descriptor 1, they should be treated as pressures which affect or may affect the status of biological diversity. A list of genetically distinct forms of native species should be drawn up for each region/subregion. They should be subject to a risk assessment process (Phase 2.1) to determine the need for separate assessment of each distinct form. Where needed, they should be assessed according to the criteria for the attribute <u>species state</u> (applied to each distinct form).

In considering each of the attributes of biological diversity (Table 4-1) and the components given in Annex III of the Directive (Table 4-2), it is not likely to be necessary or possible to assess the state of all components of each attribute (landscapes, habitats/communities, species) within a Region or Subregion. This is due both to the very wide range of these features present and, for Member States with EEZs and extended Continental Shelves, the often very large areas of marine waters to be assessed.

Instead, a selection should be made which is sufficient to meet the overall objectives of the Descriptor and covers the risk, or potential risk, of biodiversity in the region/subregion not meeting good environmental status. A risk-based approach should cover the range of pressures from human activities which may cause deterioration to biodiversity status within each region or subregion. This could use surrogates or proxies (Phase 3.2) in order to assess the state of biodiversity of the region/subregion for:

a. The predominant habitat/community types;

b. The ecotypes of the groups of mobile species;

c. The species and habitats listed under Community legislation and international agreements.

4.4.2 Predominant habitat types

The predominant habitat types should be based on the EUNIS habitat classification system[16] and cover the following broad ecological zones, where relevant to the region/subregion:

a. water-column habitats in coastal, shelf and open sea zones;

b. seabed habitats in intertidal, coastal, shelf and deep-sea zones;

c. sea-ice habitats.

The assessment of broad habitat types over large geographical areas has been trialled by OSPAR for the north-east Atlantic (OSPAR 2009). The assessment used four habitat types (rock and biogenic reefs, coastal sediment, shelf sediment, deep-sea habitats) to cover all seabed habitats from the intertidal zone to the deep sea. Whilst the assessment process was able to be applied to such broad types, it was found that these assessment 'units' were too coarsely defined. The assessments sometimes masked important differences in habitat ecology and the impacts upon them within a region, such that the required management responses were not always precisely identified. It is therefore recommended that 'predominant' habitats cover the full range of habitats in a region/subregion but are defined at a finer resolution than trialled by OSPAR. A provisional set of predominant habitat types for application in all regions and subregions is given in Table 4-3. This set should be agreed at EU level for consistent application across all regions.The types listed are coarsely-defined habitat types which each comprise a wide range of community types. It may be appropriate to further subdivide these classes for application in certain regions/subregions.

Table 4-3. Provisional set of predominant habitat types for application in assessment of Descriptor 1. Outline depth ranges are given for Atlantic waters for the shallow, shelf, bathyal and abyssal zones. The precise depth ranges vary between subregions and also in the Baltic, Mediterranean and Black Sea Regions.

Realm	**Predominant habitat type**	**Relationship to EUNIS[17] habitat classes**
Seabed habitats	Littoral rock and biogenic reef	A1 + A2.7
	Littoral sediment	A2 (except A2.7)
	Shallow sublittoral rock and biogenic reef	A3 + circalittoral habitats in A4, infralittoral & circalittoral biogenic reefs in A5.7

[16] http://eunis.eea.europa.eu/habitats.jsp. Refer to Section 5.3.1 regarding developmental needs for EUNIS.

[17] EUNIS 200611 version used.

Realm	Predominant habitat type	Relationship to EUNIS[17] habitat classes
	Shallow sublittoral sediment	Habitats in A5 (except A5.6) above wavebase (from 0m down to about 50-70m depth in Atlantic)
	Shelf sublittoral rock and biogenic reef	Deep circalittoral habitats in A4 & A5.7
	Shelf sublittoral sediment	Deep circalittoral habitats in A5 below wavebase (from about 50-70m depth down to the shelf break in Atlantic)
	Bathyal rock and biogenic reef	A6.1 + A6.6 (bathyal zone - ~200-1800m in Atlantic)
	Bathyal sediment	A6.2+A6.3+A6.4+A6.6 (bathyal zone - ~200-1800m in Atlantic)
	Abyssal rock and biogenic reef	A6.1 + A6.7 (abyssal zone - ~>1800m in Atlantic)
	Abyssal sediment	A6.2+A6.3+A6.4+A6.6 (abyssal zone - ~>1800m in Atlantic)
Pelagic habitats	Low salinity water (Baltic Sea)	EUNIS pelagic classification not structured in suitable way for purpose here
	Reduced salinity water (Black Sea)	
	Estuarine water	
	Coastal water	
	Shelf water	
	Oceanic water	
Ice habitats	Ice-associated habitats	A8

4.4.3 Predominant ecotypes for mobile species

In addition to species closely associated with specific habitat types (and dealt with above as part of the habitat/community), some species of fish, mammals, cephalopods, reptiles and birds are associated with multiple habitats during their life cycle. Such wide-ranging species should be assessed separately from the predominant habitat types. It may not however be feasible or desirable to assess all such species individually within a region or subregion. It is however important to assess their overall status, thus providing a similar level of assessment to the predominant habitat types. In order to reflect the status across these main groups of species, both practically and with ecological relevance, it is helpful to assess within appropriate ecological groupings (ecotypes). Such an approach also reflects experience gained from OSPAR (2009) in which assessment at broader levels (e.g. all fish, all birds) was considered too coarse and masked wide variation in biological character and ecological status within each group. It is therefore recommended that 'ecotypes' of the main mobile groups are defined to cover the range of predominant ecological niches of each group. These may be closely associated with one or several predominant habitat types. A provisional set for application in all regions and subregions is given in Table 4-4. This set and should be agreed at EU level for consistent application across all regions.

Table 4-4. Provisional set of predominant species ecotypes for application in assessment of Descriptor 1.

Species group	Ecotype
Birds[18]	Offshore surface-feeding birds
	Offshore pelagic-feeding birds
	Inshore surface-feeding
	Inshore pelagic-feeding birds
	Intertidal benthic-feeding birds
	Subtidal benthic-feeding birds
	Ice-associated birds*
Reptiles	Turtles
Mammals	Toothed whales
	Baleen whales
	Seals
	Ice-associated mammals*
Fish	Pelagic fish
	Demersal fish
	Elasmobranchs
	Deep sea fish
	Coastal/anadromous fish
	Ice-associated fish*
Cephalopods	Coastal/shelf pelagic cephalopods
	Deep-sea pelagic cephalopods

* species which depend upon ice and ice-driven biological processes for habitat, shelter, reproduction or feeding for at least some parts of the year, or for parts of their life-cycle.

4.4.4 Species and habitats listed under Community legislation and international agreements

In addition to the predominant habitat types and ecotypes for species, species and habitats/communities listed for protection under Community legislation and international agreements should be assessed, subject to risk assessments (see Section 4.4.4). A list of those relevant to each region/subregion or subdivision should be drawn up as a starting point for further assessment of requirements for this Descriptor.

[18] Annex III of the Directive refers to 'seabirds'; this term is commonly used to distinguish certain types of marine birds (petrels, gannets, cormorants, skuas, gulls, terns and auks) from water birds (waders, herons, egrets, ducks, geese, swans, divers and grebes). To avoid possible confusion with this narrower use, the term 'birds' is used here. The ecotypes for seabirds (offshore and inshore) are as used by the ICES Working Group on Seabird Ecology for assessment of trends in seabird populations (ICES 2009).

4.5 Criteria for assessing Descriptor 1

As the Directive embraces the Habitats and Birds Directives and the lists of species and habitats established by the Regional Seas Conventions in its assessment process (Art. 8.1a; Annex III Table 1), it is helpful to draw upon their approaches as far as possible in selecting criteria for assessment of the biodiversity attributes given in Table 4-1. Having reviewed the criteria used in these systems (Table 3-2), a generic set of criteria is recommended here to address each of the attributes. These, together with the approaches to their application described later, offer a systematic and logical framework for assessment of all species and habitats/communities, regardless of whether they are listed (protected) features or not. Such an approach is adopted because status assessments for the Directive need a consistent approach, regardless of whether it is a bird or a fish species, or an intertidal or deep-sea habitat. This strategy is adopted for FCS assessments for the Habitats Directive, which uses the same criteria for all species and for all habitat types. Within this generic framework, the wide differences in biological characteristics of different species groups (e.g. generation time spans of species) need to be accommodated in the target setting stage. In assessing status, it is the target values that are set (e.g. the relative change in a species population or extent of loss of a habitat type), rather than the criteria, which lead to a classification of status.

Based on the considerations above and drawing upon the phraseology of the Descriptor ('the quality and occurrence of habitats and the distribution and abundance of species'), the criteria recommended to address the attributes of biological diversity are shown in Table 4-5. There may be a number of aspects to assessing each criterion; these are reflected as a set of indicator classes. Refer to Section 4.7.5 on selecting indicators.

Table 4-5. Criteria to be used for assessing Descriptor 1: Biological diversity, together with an indicative list of indicator classes.

Attribute	**Criteria**	**Indicator classes**
Species state (includes sub-species and populations where they need to be assessed separately; apply criteria to each recognised sub-species/population)	Species distribution	• Distributional range • Distributional pattern
	Population size	• Population biomass • Population abundance (number)
	Population condition	• Population demography e.g.: o body size or age class structure o sex ratio o fecundity rates o survival/mortality (e.g. from by-catch) rates • Population genetic structure • Population health (sub-lethal condition, e.g. disease prevalence; parasite loading; pollutant contamination) • Inter and intra-specific relationships (e.g. competition, predator-prey relationships)

Attribute	Criteria	Indicator classes
	Habitat distribution, extent and condition[19]	• Habitat distributional range • Habitat distributional pattern • Habitat extent • Physical condition • Hydrological condition • Chemical condition
Habitat/community state	Habitat distribution	• Habitat distributional range • Habitat distributional pattern
	Habitat extent	• Areal extent of habitat • Habitat volume
	Habitat condition	• Physical condition (structure and associated physical characteristics, incl. structuring species) • Hydrological condition (incl. water movement, temperature, salinity, clarity) • Chemical condition (incl. oxygen, nutrient and organic levels)
	Community condition	• Species composition • Relative population abundance • Community biomass • Functional traits
Landscape state (where assessed as 'Listed' habitats)	Landscape distribution and extent	• Landscape distributional range • Areal extent of landscape
	Landscape structure	• Habitat composition and relative proportions
	Landscape condition	• As for habitat condition and community condition, as appropriate
Ecosystem state	Ecosystem structure	• Composition and relative proportions of the ecosystem components
	Ecosystem processes and functions	• Interactions between the structural components of the ecosystem • Services provided by biological diversity within ecosystems

Targets and indicators for these criteria need to be adopted to enable assessment of progress towards meeting the overall objectives of the Descriptor and GES. Each relevant criterion (see Table 3-2) should be considered in the assessment of a biodiversity component. Those criteria considered at risk of failing to meet their target (see Section 4.7.4; Phase 2.2) are likely to need monitoring and hence the identification of suitable indicators from appropriate indicator classes. These should, wherever possible, be linked to the pressures considered to be causing the risk.

4.6 Spatial and temporal scales

4.6.1 Spatial scales

GES is to be determined at the level of the Region or Subregion (Art. 3.5). Consequently, for Descriptor 1, this guidance is provided on the basis that Member States will assess GES, in cooperation with other

[19] Consider functional requirements for the species, such as spawning, nursery, feeding and resting areas and migratory routes.

Member States and non-Member States in the same region/subregion, at the scale of the Region (for the Baltic Sea and Black Sea) or the Subregions defined for the Atlantic and Mediterranean Seas. The way in which this should be achieved for biodiversity assessments is elaborated below.

Within this overall frame of assessment at the Region/Subregion scale, two key issues regarding scale need to be accommodated to facilitate assessments for this Descriptor:

a. The natural characteristics of biodiversity, in which species and their populations occur at a variety of scales and communities within habitats change in character according to the biogeographic region (i.e. for the same physical habitat, the species composition of the community changes with location as a result of oceanographic differences, primarily in water temperature and salinity);
b. The need for effective links to management responses, which are often associated with particular pressures (or multiple pressures), locations and administrative zones.

The Directive formally operates at three different geographic levels: the Marine Region, the Subregion and Subdivisions. The first two are defined within the Directive (Art. 4), while it is up to the Member States to apply any subdivisions, whether formally recognised or not. The Directive defines four Marine Regions, based on the four major European seas; these provide a reasonable distinction of the major biogeographic zones across European seas. For the Mediterranean and Atlantic Regions, the Regions are however too large to provide a sensible means of assessment as the ecological variation is too great. Recent experience in undertaking biodiversity assessments at the OSPAR Region scale (equivalent to the subregions of the Directive) (OSPAR, 2009) revealed that even the two smaller OSPAR Regions (Greater North Sea, Celtic Seas) were still considered too large to adequately assess most aspects of biodiversity. These OSPAR Region-scale assessments were considered too high level to effectively identify the main problem areas that needed management action, and too large requiring summarising of status assessments that sometimes masked important variations within the Region (for example, differences in the effects of eutrophication between the east and west sides of the North Sea). The recent biodiversity assessment for the Helsinki Convention (HELCOM, 2009) made use of a series of subdivisions of the Baltic Sea in its assessments, thereby enabling a more effective differentiation between areas of good quality and areas subject to impacts and needing management attention.

It is therefore recommended that, whilst the overall assessment of GES is undertaken at the Marine Region level for the Baltic Sea and Black Sea and the Subregion level for the Atlantic and Mediterranean Seas:

a. A suitable set of <u>ecological assessment areas</u> is defined which can adequately reflect both the ecological scales exhibited by the biodiversity components in each region/subregion and links to areas which are effective for management measures.
b. These assessment areas should generally be smaller than the subregions provided in the Directive, in order to reflect the biogeographic trends at the community level and the population distribution patterns of many mobile species. Where species are very wide ranging and do not appear to have distinct populations, it may be appropriate to establish assessment areas which are larger than the subregion, spanning regions if necessary.
c. The number of assessment areas in a region/subregion should in principle be kept to a minimum, so as to not produce an overly complicated assessment process. The assessment areas should provide a series of nested (rather than overlapping) areas which facilitate aggregation of assessments, where appropriate, up to subregion or region scales.

d. In order to achieve an ecosystem-based approach to management, the assessment areas should be defined according to the criteria provided in Art. 3.2 (hydrological, oceanographic and biogeographic). Given the complexity of scales at which biodiversity operates (particularly mobile species), the assessment areas should represent relatively distinct ecological units, each reflecting distinctive oceanographic and hydrological characteristics within the region/subregion (which in turn reflect differing biogeographic zones). The systems in use by HELCOM (2009) and the UK regional seas approach[20] offer suitable examples; the data sets being prepared by EMODNET[21] should provide much of the relevant data upon which to define suitable areas. The systems developed for each subregion should be of comparable scales and levels of distinction across the regions and subregions[22].
e. Art. 3.2 makes provision for delimiting subdivisions of the Regions/Subregions as long as they are compatible with the defined Regions/Subregions. Member States should determine whether the ecological assessment areas needed for Descriptor 1 are also suitable for application with the other Descriptors and whether these are formally advised to the Commission as Subdivisions as provided for in the Directive.
f. For the Atlantic Region, the Subregions specified in the Directive do not include the waters north of the Celtic Seas and Greater North Sea subregions. If the Directive is applied in these northern parts of the Atlantic Region, further Subregions and assessment areas should be defined according to the recommendations set out above.

For considerations of how assessments made for each assessment area will contribute to an overall assessment at the Region/Subregion scale, see 4.2.

4.6.2 Temporal scales

The Directive requires an assessment of GES in 2012 and every six years thereafter. This therefore represents the minimum frequency for reporting on assessments.

Ecological variation however occurs over a wide range of time-scales, particularly depending on life history characteristics of species (hours to decades), long-term fluctuations in climate (such as the North Atlantic Oscillation cycle) and sometimes very long periods for community structure to re-establish following severe damage (10s-100s of years).

The six-yearly assessments should be based on evidence (environmental and activity/pressures) which is updated at least once within the six-year assessment period; however the periodicity of evidence collection needed to adequately assess trends should be determined in relation to the life history characteristics, environmental and other factors which are, or may be, causing adverse impacts (see Section 4.7.9 Adaptive Management). It is likely that many aspects of biodiversity assessments will need further development of techniques and understanding of change in relation to both environmental factors and anthropogenic pressures. Distinguishing anthropogenic pressures from other drivers of change is a key issue for effective assessments and is likely to require more intensive (and frequent) monitoring, until the relationships are adequately understood and the periodicity of monitoring can reasonably be reduced.

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[20] www.jncc.gov.uk/page-1612. Note: UK boundaries are under review.

[21] http://ec.europa.eu/maritimeaffairs/emodnet_en.html#1

[22] It may be helpful to elaborate this guidance, with worked examples, to assist in the development of a suitable approach.

On the basis of these considerations, it is recommended that:

a. The evidence (environmental, activity/pressure and management measures) used to make the six-yearly assessments of GES for this Descriptor is updated before each assessment is undertaken;

b. The periodicity of evidence collection is determined according to the rates of change in natural and anthropogenic influences in the Region/Subregion;

c. The periodicity of evidence collection is sufficient to distinguish the effects of anthropogenic disturbance from natural and climatic variability, and the need to determine progress against the Programme of Measures;

d. The frequency of sampling in relation to costs be carefully considered. Whilst the costs of more frequent sampling may be higher than initially desired, it may be more costly over the long term to sample too infrequently if this leads to the wrong conclusions, and a flawed and costly programme of measures based on an underdesigned monitoring programme.

e. The natural and climatic variability in biodiversity is taken into account when setting the environmental targets for this Descriptor, and in assessing progress towards the achievement of GES (e.g. persistence of pressures, long recovery times of biodiversity).

4.7 Assessment and monitoring programme

4.7.1 Overview

Driving questions

An assessment and monitoring programme is needed to address the following main questions:

a. What is the current state of biological diversity[23]? State is assessed using the relevant criteria and indicators selected in relation to:

   i. Biodiversity components selected for assessment (within each attribute)

   ii. Pressures occurring across the assessment areas

   iii. Non-pressured areas (potentially reflecting target or reference conditions)

b. What is the deviation between observed conditions (current state) and target conditions across the region or subregion? This should be assessed by quantifying the difference between:

   i. Target conditions for the biodiversity components and;

   ii. Current conditions.

c. What is the direction of deviation from target conditions, and the speed of change?

   i. Degradation (away from target conditions)

   ii. Restoration (towards target conditions)

4. What are the causes of observed changes in biological diversity?

[23] Member States may wish to use the present Guidance in preparing their Initial Assessment for 2012.

i. Can any deviation from target conditions be attributed to pressures from human activities?

ii. Where management measures have been implemented, are they leading to the desired improvements in the state of biodiversity?

iii. Where not linked to pressures, can the observed changes be linked to climate or other environmental changes?

From ideals to pragmatics

It is not practical, possible or even necessary to monitor all attributes and components of biological diversity, throughout the region or subregion. Therefore, a pragmatic approach needs to be adopted, aiming at using resources wisely and to maximise the information gathered to reflect the overall state of biodiversity. The following strategy is recommended:

a. The assessment and monitoring programme should be orientated towards a risk-based prioritisation of the biological components, pressures and locations to be investigated;

b. An initial risk assessment considers the full range of pressures (activities) in a region/subregion and identifies those which, by way of their intensity, duration and extent, appear to provide the highest risk to biodiversity. Note, this may not be suitable for assessing higher predators, where causal links to pressures may be weakly understood.

c. Best use is made of ongoing biodiversity monitoring programmes, bringing these together and integrating them, wherever possible, to meet the needs of assessments for this Descriptor. Integration with other monitoring programmes, including for other Descriptors, is also likely to be beneficial.

d. Consider using monitoring data collected for regulatory purposes (by industry or regulatory authorities) as part of the overall programme. This may require some adjustments to better suit the wider requirements and standards for this Descriptor and appropriate quality assurance.

Coping with limitations in data and knowledge

The task of making assessments for this Descriptor is complex, and will require the integration of existing approaches (assessments and monitoring programmes), the development of new approaches, and the collation of available data for a wide range of biodiversity, activities and pressures. The subsequent sections are intended to provide a framework and step-wise approach to how this might best be achieved. It is expected that some elements will take some time to effectively put in place, either because they need further research, new data or the development of assessment techniques and indicators. This however should not prevent progress being made in other aspects of the assessments, nor in Member States' abilities to undertake initial assessments.

Such initial assessments may be expected to have gaps or to be of lower quality than might ultimately be desirable. It may be necessary to place more emphasis on the use of expert scientific judgement until suitable evidence becomes available to fully support the assessments. Such approaches were adopted in recent assessments for OSPAR (OSPAR 2009), in which the assessments were undertaken by experts in a workshop environment. The approach adopted included documentation of the evidence used and an assessment of confidence in each step of the assessment process. The process also helped identify the key data sets and monitoring needed for future assessments. It should be expected that overall quality of data and assessments should improve with time, giving increased confidence.

The application of modelling should be considered to support the assessment of biodiversity. This could be applied to the determination of biodiversity characteristcs (e.g. habitat and species population modelling), to the assessment of pressures and to the establishment of reference conditions and targets.

Phases of an assessment and monitoring process

A number of preparatory tasks are needed, after which the assessment and monitoring process may be divided into a series of broad phases. The development of an overall approach to biodiversity assessment and monitoring is likely to be an iterative process, such that the sequence offered below may need adjustment to best suit particular circumstances in some regions/subregions and also to provide links and feedback between some tasks and phases.

Preparatory tasks:

Task 1: Collate human activity and environmental data;

Task 2: Identify biodiversity components present in the region or subregion;

Task 3: Define ecologically-relevant assessment areas;

Task 4: Define reference state (conditions);

Task 5: Define targets.

Assessment and monitoring phases:

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

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

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

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

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

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

Phase 7: Adaptive management, adjusting the spatial and temporal intensity of a) the monitoring programme and b) the programme of measures in accordance with observed changes in biological diversity relative to GES targets.

Each of the phases above is further sub-divided as described in Sections 4.7.2 to 4.7.9. Figure 4-2 illustrates the relationship between the phases of the overall process. There is a cyclical progression from implementation to management and advice-giving, with periodic refinements and modifications through adaptive management and research effort.

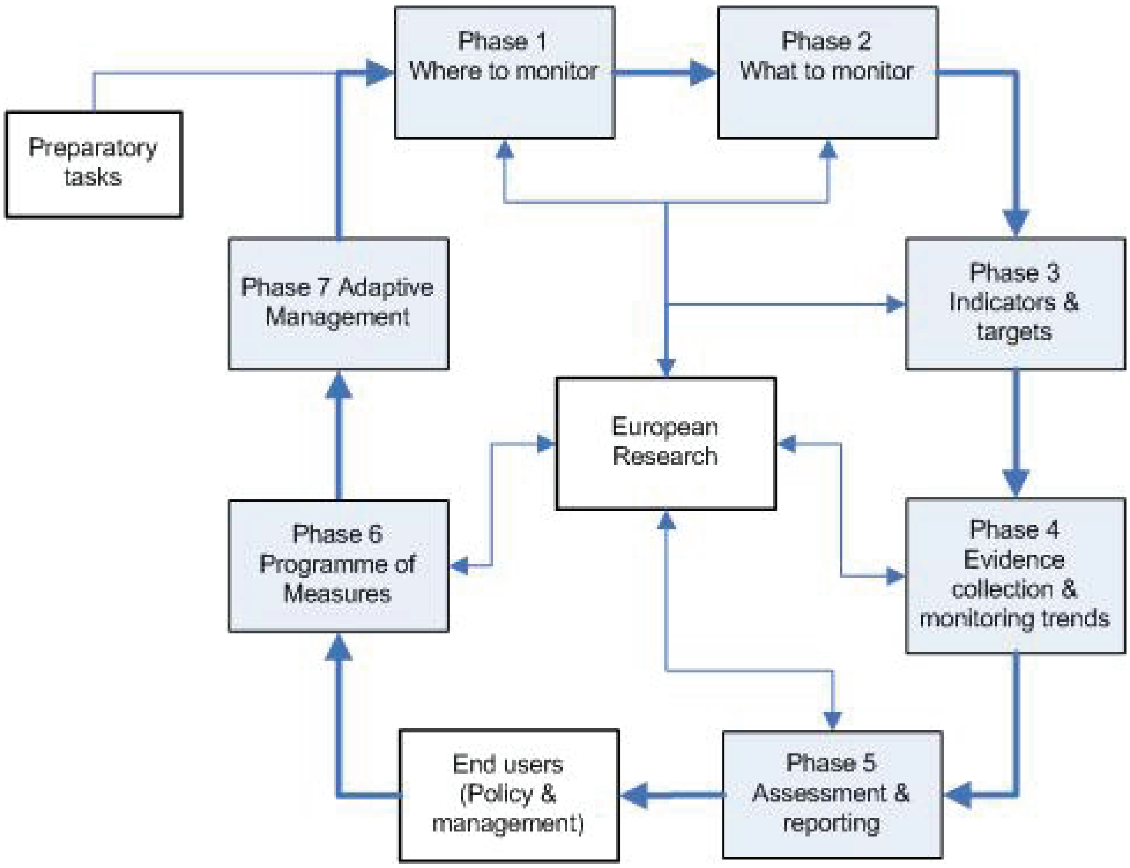

Figure 4-2. Conceptual illustration of the relationships between the phases of the assessment and monitoring process, end users and European research. Adapted from the concept used in OSPAR's strategy for biodiversity assessment and monitoring (Figure 4-1).

The recommended selection and prioritisation process outlined in Section 5.7.4 is illustrated in Annex 0, using a hypothetical environmental scenario and worked examples for the indicator selection procedure for a species attribute (birds) and a habitat/community attribute (soft-bottom shelf sediments).

Further guidance on the application of each stage is given below.

4.7.2 Preparatory tasks

The preparatory tasks required in advance of beginning the main assessment and monitoring process include, but may not be limited to, the following:

Task 1: Collate human activity and environmental data

Development of an assessment and monitoring programme should be based on a holistic understanding of the region or subregion to be assessed. Compiling relevant information in a Geographic Information System (GIS) is recommended to enable a spatial (and temporal) understanding of the relationship between human activities (which may be causing adverse pressures on the environment) and the characteristics of the environment, including its biodiversity.

The following information, which will be of direct use for many aspects of MSFD implementation, should be compiled:

a. The main ongoing or past human activities which potentially may affect or have affected biological diversity.
b. The distribution, intensity and frequency of pressures (cf Table 2 in Annex III of the Directive) from human activities.
c. Noteworthy administrative and regulatory features.
d. Major physical/oceanographic/geological gradients (spatial and temporal) in the region or subregion.
e. Biodiversity characteristics, including:
   i The distribution of the predominant habitat types on the seabed, in the water column, and sea ice habitat.
   ii Distribution of the species ecotypes.
   iii Habitats/communities and species of special interest (i.e. those listed for protection in Community legislation and international agreements).
f. Existing data or ongoing monitoring programmes concerning biological diversity.

Further details on each of the above data and information needs is given in Annex 0. Figure 4-3 illustrates different information layers compiled in a GIS.

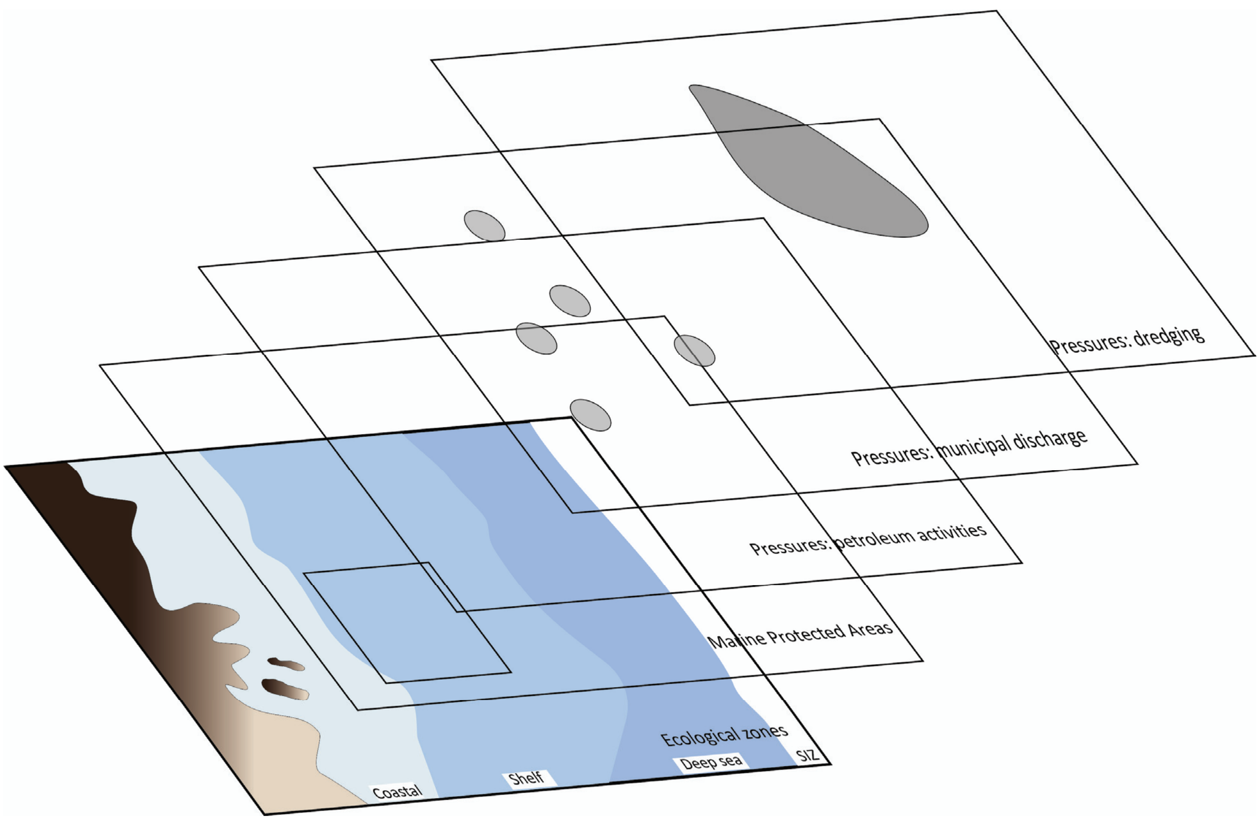

Figure 4-3. Illustration of different types of information layers compiled in a Geographical Information System (GIS). See Figure 4.4 for application in decision-making for prioritising where to monitor.

Task 2: Identify biodiversity components present in the region or subregion

Identify those biodiversity components (predominant habitat types and species ecotypes; listed species and habitats) that are present in the region/subregion. Identify sub-species, populations and genetic variants, where relevant (i.e. where likely to need specific assessment). Species which are vagrants to the region/subregion need not be included. Refer to Section 4.4 for further guidance.

Task 3: Define ecologically-relevant assessment areas

Define a set of ecologically relevant scales (assessment areas) for assessment of the biodiversity components present in the region or subregion. Refer to Section 4.6.1 for guidance on defining ecological assessment areas.

Task 4: Define reference state (condition)

From the options for implementing biodiversity assessment systems illustrated in Figure 3-1, it is recommended that option A, which defines reference conditions and a target range, is followed for Descriptor 1. Section 3.3.6 provides a rationale for this. It may be appropriate for some aspects to use baseline conditions (see below) and to define single target values (Section 4.7.7).

Reference conditions define the unimpacted state of the biodiversity component, and are conditions as would be expected according to 'prevailing physiographic, geographic and climatic conditions'. As stated in Section 2.1, this phraseology is understood to allow for the consequences of climate change. Consequently the adverse effects on biodiversity which are a result of changes in water temperature, salinity and hydrology (ocean and tidal currents, wave action) due to climate change (where these are known) are considered to sit outside the determination of GES for this Descriptor. There is, however, a need to take account of the effects of climate change in making the GES assessments (e.g. to understand how climate change influences particular criteria for a component, particularly species distribution and composition/abundance in a community). This therefore may need a moving reference condition against which to assess state which accommodates natural/climatic changes in the distribution and composition of species in each assessment area.

Reference conditions are specific to the species, ecotype or habitat/community type and to the ecological assessment area within a region/subregion. For example, in the Baltic Sea, the prevailing low salinity conditions give rise to a naturally lower benthic faunal diversity than is the case in seas with more saline water. Therefore, the actual values representing reference conditions for benthic communities in the Baltic will differ considerably (fewer and different species) relative to, for example, the Norwegian Sea. Additionally, because the salinity regime in the Baltic differs markedly from north to south, the values will also differ within the Baltic. Hence reference conditions need to be set to reflect these main variations in ecological character within each subregion (refer to identification of ecological assessment areas in Section 4.6.1).

Reference conditions need only be defined for the biodiversity components and the criteria which are to be assessed and monitored in each assessment area. Reference conditions can be established in a number of ways:

a. Using current data from locations in the assessment area (or equivalent biogeographic areas) which are not considered to be subject to pressures from human activities;
b. Using historical data, taking into account long-term changes in prevailing physiographic, hydrological and/or climatic conditions;

c. Using expert judgement, taking into account the characteristics of the biodiversity component which might be expected under prevailing physiographic, hydrological and/or climatic conditions, and the types of species which are sensitive to ongoing or past pressures from human activities and therefore may not be present now.

d. Some combination of the above options.

Guidance on defining reference conditions for application in the Water Framework Directive is given in European Commission (2003).

Under certain circumstances, it will not be possible to satisfactorily establish reference conditions; instead it may be more appropriate to use baseline conditions, established at a specific time in the past and which are considered to best meet the requirements of reference conditions (i.e. unimpacted by pressures from human activities).

Task 5: Define targets

Whilst the overall objective of the Directive is to achieve GES at the level of the Region or Subregion, this needs to accommodate continued sustainable use of ecosystem goods and services. Some activities, however well managed, will cause a certain degree of (local) impact to biodiversity, and so sustainable use of the marine environment will inevitably bring with it a degree of degradation to biological diversity. It is therefore expected that GES will need to be achieved through varying levels of state in biodiversity within a region/subregion, rather than achieving a consistent quality (state) throughout.

Environmental targets need to be defined (Art. 10) to determine the degree of degradation which is considered to still equate to GES and in particular lower values, below which GES is considered not to have been met.

This section deals with target setting for individual components of biodiversity (i.e. the predominant habitat types, species ecotypes and listed species and habitats). For broader considerations of the overall assessment of Descriptor 1 refer to Section 4.8.

As shown in Figure 3-3, GES can be considered to represent a range of conditions, from unimpacted reference conditions to a degree of degradation relative to reference conditions. This can be considered in two ways: a level of degradation which is considered acceptable (an issue of quality, which can be assessed locally for a particular species, habitat/community or landscape) and the extent (proportion) of the assessment area over which such degradation is considered acceptable (an issue of quantity). The targets needed for Descriptor 1 should be set in relation to the criteria as shown in Table 4-6.

The quality target for a component needs to be used together with its quantity target. For example, habitat and community condition can be assessed locally as to whether it meets the agreed quality target (defined as a level of acceptable impact); the habitat/community needs to meet this quality target over the proportion of the assessment area given as its quantity target (i.e. X% of the habitat/community needs to meet the quality target in the assessment area, where X is the quantity target). Similarly, the condition of a population for a species can be assesssed at specific locations; overall determination of population condition is then assessed in relation to the quantity targets set for the assessment area.

Table 4-6. Criteria for assessment of biodiversity component in each attributes, indicating which need both quantity and quality targets and which only need quantity targets.

Attribute	Criterion	**Quality target** To be achieved locally	**Quantity target** To be achieved at level of the assessment area
Species state	Species distribution		Yes
	Population size		Yes
	Population condition	Yes	Yes
	Habitat distribution		Yes
	Habitat extent		Yes
	Habitat condition	Yes	Yes
Habitat/ community state	Habitat distribution		Yes
	Habitat extent		Yes
	Habitat condition	Yes	Yes
	Community condition	Yes	Yes
Landscape state	Landscape distribution and extent		Yes
	Landscape structure	Yes	Yes
	Landscape condition	Yes	Yes

The application of quality and quantity targets for biodiversity components can be used to balance the requirement for sustainable use of the environment with overall goals to achieve GES. This is particularly important where it is not feasible to reduce or eliminate the impact from certain human activities, for example because of the intrinsic nature of the activity (such as mineral extraction). Under such circumstances, it will be necessary to regulate the extent over which such activities occur in each region/subregion so as to balance the use of each resource (e.g. a seabed habitat type) with requirements to achieve GES.

Wherever possible, the targets for species and for habitats/communities should be consistent such that the overall status to be achieved is comparable across the range of biodiversity, i.e. the degree of acceptable degradation is comparable between species and between habitats/communities.

Defining quality targets (linked to pressures and other Descriptors)

In setting suitable quality targets, some degree of degradation from reference conditions (i.e. what strictly can be interpreted as 'in line with prevailing physiographic, geographic and climatic conditions') within the assessment area needs to be accommodated.

The general axis of degradation shown in Figure 3-1 and Figure 3-2 needs to be applied to the components of biodiversity to determine what degree of deviation from reference conditions should be set as the quality target value for the relevant criteria. This excludes changes caused by environmental changes including climate change. As with reference conditions, these need only be set for the components and criteria selected for assessment and monitoring (Phase 2).

Such deviation is principally caused by pressures (from human activities) which are having, or have had in the past, an adverse impact on species, habitats/communities or the wider ecosystem. Table 2 of

Annex III to the Directive provides a set of pressures and all have the potential to impact on certain aspects of biodiversity. An overview of the relationship between human activities and pressures is given in Annex 8.5. The pressures include physical damage, contamination, removal of individuals of a species and changes in nutrients; additionally a number of other Descriptors (e.g. D2 non-indigenous species, D5 eutrophication, D8 contamination and D10 litter) deal with specific pressures.

Figure 4-4 illustrates three potential ways in which reference conditions change according to different pressures.

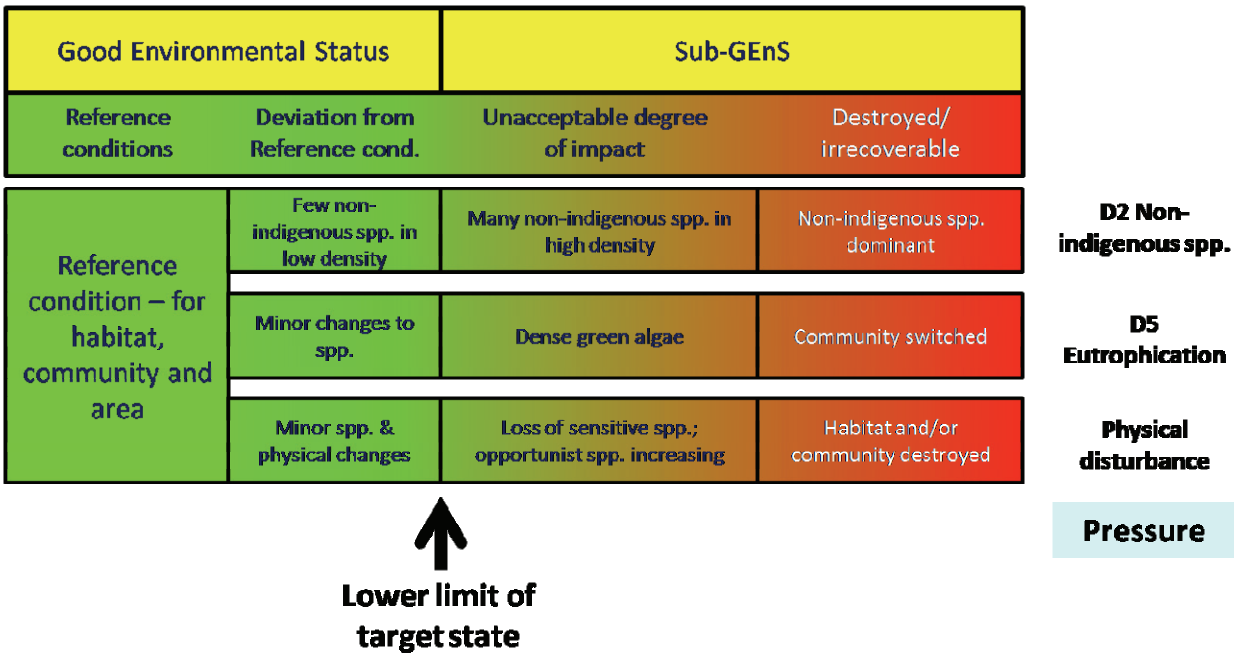

Figure 4-4. Relationship between quality targets and changes caused by different pressures. Types of change are illustrative for the three pressures shown.

<u>Defining quantity targets</u>

Having determined quality targets (the degree of change or degradation relative to reference conditions) for the relevant criteria, it is necessary to determine the proportion of the biodiversity component in the assessment area which should meet such values (the quantity target) and to define quantity targets for the remaining criteria.

These targets are to be set by Member States and can be applied equally to all species, habitats/communities and landscapes, but may need to be tailored where appropriate to suit the ecological characteristics of the species group/habitat type/landscape type and the geographical scale of assessment.

The setting of targets for species should take into account:

a. Viability of the species in relation to the type of degradation in its condition (reproductive capacity, feeding and other aspects of its life cycle) or population abundance. This should account for the variation in ecological characteristics (e.g. generation times) between species groups; the IUCN approach to population trend analysis may be helpful, noting that adequate data to assess population viability are likely to be available for only a limited number of taxa.

b. The need to maintain intra-specific diversity across the region/subregion (such as viability of individual populations and genetic variants).

Setting quantity targets for habitats should, if possible, be linked to issues of viability and the maintenance of ecosystem integrity. However there is generally insufficient scientific understanding to provide a basis for how this might be determined (i.e. how much loss or degradation of habitat will significantly affect the viability of its communities in the remaining habitat or wider ecostystem functioning). In setting targets for habitat extent, cumulative loss over past decades needs to be taken into account, with targets set against an unimpacted state rather than allowing for a proportion of loss over time. It is therefore recommended that setting targets is based on values that are considered to best meet the overall goals set in the Directive (Art. 1, Art. 3.5), are related to reference rather than baseline conditions and are in balance with the needs for sustainable use of marine resources. Specific targets are set for the Habitats Directive FCS assessments (EC 2006). The OSPAR biodiversity assessment (OSPAR 2009) adopted similar targets; it was acknowledged that it was not possible to set these on a scientific basis (Robinson et al. 2008b).

Where an assessment area spans two or more Member State's waters, Member States will need to define how targets will operate in practice across the assessment area. For habitats, it may be appropriate, for example, to apportion responsibility for achieving the targets in relation to the proportion of Member State territory in the assessment area. For some types of mobile species, this may be inherently more difficult and require a greater degree of cooperation amongst the relevant Member States.

Principles for setting targets

Targets need to be set on the basis of:

a. A deviation from reference conditions which is measurable;

b. A level of deviation which does not compromise the maintenance of the biodiversity component in the assessment area (see Section 2.1) and which reflects the overall goal of the Descriptor and is in line with the preamble of the Directive and the definition of GES in Art. 3.5;

c. An allowance for the natural dynamics and balances in the ecosystem, where individual species and habitats interact with each other and change over time, such that:

    i. Targets should not be set to achieve increases in the population size of a species or the extent of a habitat/community where these would be to the detriment of other species and habitats/communities;

    ii. Targets should accommodate dynamic changes over time, such that a specific combination of species and communities should not be expected to occur in any particular location;

d. A consideration of the inherent sensitivity of the component and its expected exposure in the assessment area to pressures to which it is sensitive (i.e. its vulnerability);

e. A deviation which, preferably, can be measured in relation to particular pressures, bearing in mind that the characteristics of degradation may differ significantly between pressures (Section 3.3.4; Figure 4-4), such that:

    i. the level of degradation (target value) is applied consistently across the regions in relation to specific pressures. Such values may be given in the guidance for other Descriptors and found to be suitable for application in Descriptor 1. For example, use of the target quality values for eutrophication (D5) and contaminants (D8) to define an acceptable level of degradation (quality) for biodiversity components;

ii. the targets represent a comparable degree of degradation between the different pressures;

f. Where considered appropriate, define further quality values, representing greater degrees of degradation (e.g. moderate and severe degradation). These may be considered helpful for use in locations which are subject to significant degradation and where monitoring of progress towards the quality target values (over a period of years) is deemed helpful to show overall progress towards achieving GES.

EXAMPLE: Sub-GES conditions for benthic fauna under pressure from organic loading may range from:

i. moderate impacts, where the community is dominated by opportunistic species, but still contains a wide range of taxonomic and functional groups;

ii. severe impacts, where only very few taxa and functional groups are present, to

iii. complete degradation, where benthic fauna are eradicated (often replaced by anaerobic bacterial mats).

Note, however, that defining such boundaries for multiple components and criteria for quality targets is a significant task; it would be much easier to address this issue through defining intermediate quantity targets.

4.7.3 Phase 1 - Prioritising where to monitor

Phase 1.1: Identify pressures and areas at risk

Assessing the risk of impacts from pressures, based on distribution, intensity and frequency of human activities and the pressures they exert on the environment provides an important analysis on which to base the monitoring strategy and sampling programme.

The monitoring programme should consider the range of pressures which occur within an assessment area. Locations to be monitored should be prioritised to cover at least the following:

a. Areas of influence from anthropogenic activities which are expected to cause impacts upon biological diversity, with priority on the areas at highest risk:

i. High-intensity activities;

ii. Multiple activities;

iii. Areas where impacts may be particularly severe or long-term.

b. Areas considered to represent unimpacted (reference) conditions (i.e. not thought to be subject to, or impacted by, pressures):

i. Without pressure (as far as is possible within the assessment area);

ii. Representing the physiographic and hydrological conditions of the pressured areas identified in (a) (including the same community types or ecotypes).

Overlapping maps in a GIS will help give a holistic visualisation of the assessment area, the anthropogenic pressures acting upon it and locations of current monitoring programmes. This will enable informed decision-making on how to prioritise the areas to be considered for monitoring. Figure 4-3 and Figure 4-5 illustrate the concept.

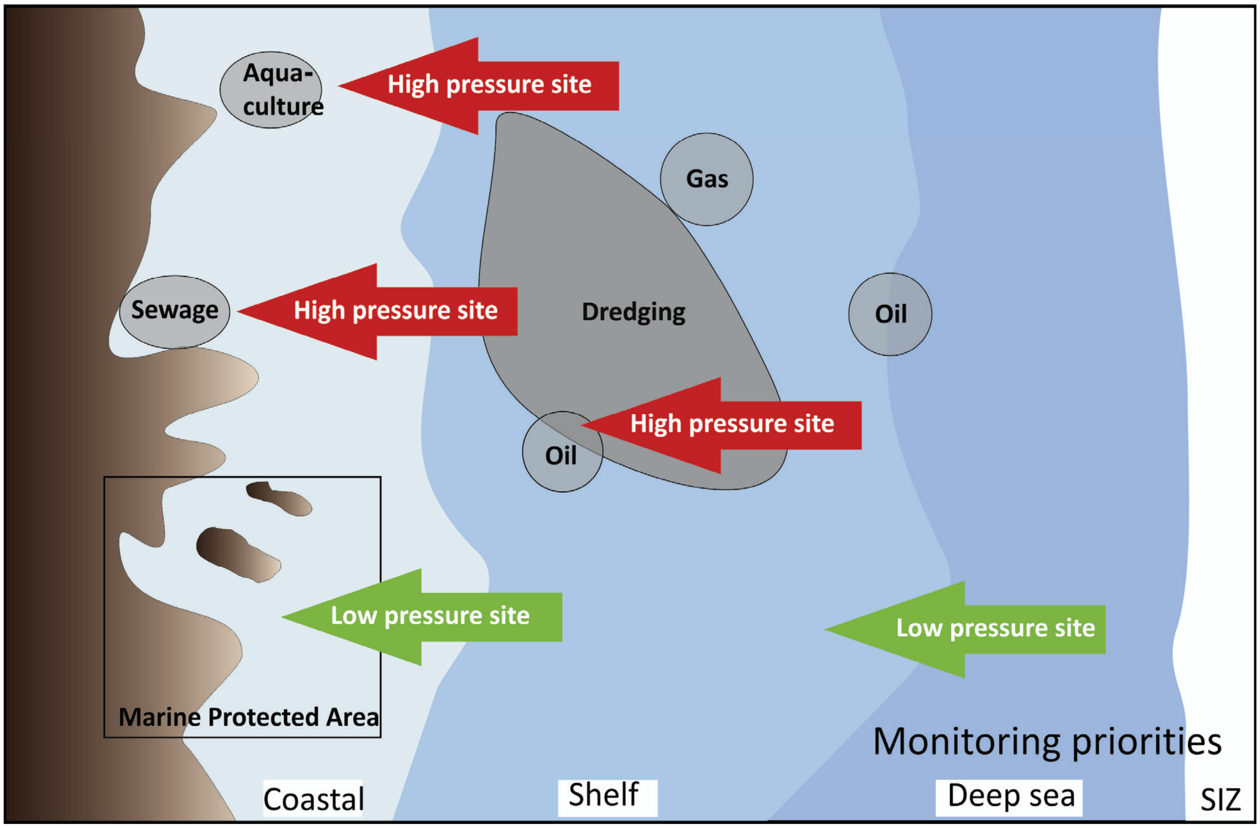

Figure 4-5. Illustration of the utility of GIS in the decision-making process for prioritising where to monitor. SIZ = seasonal ice zone, blue areas representpredominant habitat types (both rock and sediment). Hypothetical scenarios are shown. Arrows = priority monitoring sites.

The degree to which pressures occur in isolation, or in combination and giving rise to cumulative impacts, will affect the intensity of impacts as well as their spatial extent and temporal development. Spatial and temporal scales of change will also vary according to the specific background conditions of each region or subregion.

4.7.4 Phase 2 – Defining what to monitor

Phase 2.1: Identify biodiversity components at risk

The information compiled in Phase 1 on the distribution and intensity of pressures (actual or modelled), should be assessed in relation to the distribution of the biodiversity components in the assessment area to identify the components and locations likely to be at most risk of impact from human activities.

This evaluation should:

a. Identify those activities and pressures that are currently having, or could potentially have the greatest impacts on biodiversity.

b. Assess the degree of risk of impact from human activities (i.e. in terms of the intensity, frequency and extent of the pressure) on each component.

c. Use the results of a-b above, to compile a set of biodiversity components to be monitored and identify locations which represent a gradation from expected high impact to low or no impact.

d. For biodiversity components which do not or cannot be linked directly to known pressures, consider what level of further assessment and monitoring might be appropriate, bearing in mind the provisions in Art. 14.4. For mobile species, there is likely to be a need for some state monitoring, as changes in state may occur for a variety of reasons which are often difficult to link directly to pressures from human activities.

<u>Phase 2.2: Assess risk of targets not being met</u>

For the biodiversity component selected from Phase 2.1, assess the level of risk of the targets not being met to give a prioritised set of components and criteria to be considered for monitoring, by:

a. considering each criterion in relation to the pressures known to occur in space and time;

b. the types of impact caused by the pressures.

For instance, the pressures on a particular habitat type may pose a range of risks to the condition of the habitat (its structure and species composition), but not threaten any reduction in overall extent or distribution in the assessment area. In such cases, monitoring may be focussed on aspects of habitat/community condition.

4.7.5 Phase 3 – Selecting indicators

<u>Phase 3.1: Identify type of monitoring needed</u>

<u>State and pressure monitoring</u>

Phases 1 and 2 will produce a prioritised list of those biodiversity components and geographical locations that should be included in an assessment and monitoring framework for Descriptor 1. The assessment of these components can be done through monitoring of the state of biodiversity, including the level of any impact from pressures, through monitoring of pressures as a proxy for assessing biodiversity state, or a combination of the two. If monitoring of pressures is to be used, a strong causal link between pressure and biodiversity state must be established (existing scientific literature provide suitable documentation). If there is such a link, then measuring pressures may be a more cost-efficient approach and would provide direct evidence to inform management. Wherever possible, such pressure monitoring should be accompanied by state monitoring to demonstrate changes (improvements) in state resulting from reductions in pressures (as a consequence of measures taken); in this combined approach the state monitoring may only need to be at a reduced level compared with situations where no pressure monitoring is included.

<u>Types of state monitoring needed</u>

The types of state monitoring that may be needed should be linked to the criteria and the types of impact to which the component is subjected. A pragmatic stepwise approach should be taken to selecting monitoring parameters for the locations in question, based on knowledge of the following:

a. The range of biodiversity components present, or expected to be present, at the prioritised sampling locations (based on Phase 1);

b. The potential responses of the biodiversity component at those sampling locations to the pressures in the area (see Table 3-3);

c. The availability of suitable indicators for the above, with reference to international standards for monitoring, where these exist (see Phase 3.2).

Phase 3.2: Select indicators

The previous stages should lead to an understanding of which criteria need to be assessed (those at highest risk) in relation to targets and reference conditions for particular components. It is typical to do this by measuring specific aspects of the component (e.g. the length of fish, the diversity of communities) and to analyse these measurements in particular ways (e.g. using certain metrics or indices) to provide a value for the assessment of state. These measurements and metrics form the indicators required in Art. 10 and their repeated determination over time should allow trends in state and progress towards achieving targets to be evaluated.

The main classes of indicator for each criterion are given in Table 4-6. The identification of specific indicators is very much dependent on the situation in each region/subregion and is thus beyond the scope of this report. However, some types of species and habitats/communities and associated pressures are widely distributed across the regions and so it should be possible to identify particular indicators which are common across some regions and subregions. In addition to the state indicators given in Table 4-6, it is likely to be sensible to adopt a complimentary range of pressure indicaters (some are defined for other Descriptors).

Because of the differing ecological characteristics of species and habitats, the varying environments in which to monitor them (e.g. intertidal versus offshore) and the differing pressures to which they are subject, it may be necessary to select different indicators for application in relation to a particular criterion. For example, physical disturbance to the seabed can affect the structure of the substratum (Indicator class: Physical condition) and its species composition (Indicator classes: Species composition and Relative population abundance). If eutrophication affects the same habitat type, it may alter the oxygen and organic content of the sediment (Indicator class: Chemical condition) and change the balance of species in a different way to physical disturbance (Indicator class: Community biomass). The indicators and methods needed to detect such changes may thus be specific to the type of pressure present.

Given the wide range of biodiversity components, the variety of aspects to assessing their state (criteria) and range of environmental conditions for monitoring (intertidal to open seas and deep sea), the possible range of indicators is very large. Section 6.1 provides references and revies to help in this selection process.

The number of indicators needed for a biodiversity component will vary according to the range of risks (pressures) each faces, and also need to consider the available resources and the state of knowledge of appropriate indicators. As each combination of prioritised pressure/biodiversity component should be assessed, each such combination should have <u>at least</u> one indicator (although some indicators may serve several pressure/component combinations). As the aim of this Descriptor is to maintain all aspects of marine biodiversity, rather than certain (charismatic) species, it is important that the indicators chosen represent biodiversity widely, rather than just themselves. There is a tradeoff involved here – the more specific or unrepresentative the indicator is, the greater the number of indicators are necessary to represesent a pressure/component combination. This means that it is probably more efficient to use indicators that are functionally linked to biodiversity, rather than “Umbrella indicators” or “Flagship species" (Simberloff 1998). Such indicators may be directly linked to biodiversity (e.g. number of species), functional indicators such as occurrence of habitat-forming species, or attributes specifically sensititive to certain stresses.

However, if possible the indicators selected to fulfil this role should involve species and habitats that are identified as conservation priorities by existing Community legislation and international conventions, as this will add value to monitoring for Descriptor 1 and make full use of existing monitoring effort. In addition, most point-sources of anthropogenic pressures have legally-binding monitoring and regulatory commitments. Biodiversity indicators usually form a large part of such initiatives, and as such, create possibilities for synergy with monitoring for Descriptor 1.

In order to select the most appropriate indicators for a given component and assessment area, the following two questions need to be addressed:

a. Should the state of the component be monitored and assessed directly, or is it more cost effective to monitor and assess the pressure or pressures that impact upon it (where a strong causal link is established)?
b. Are there particular species and habitats/communities within each species ecotype or predominant habitat type that could act as a suitable surrogate for the the state of the broader component?

Selecting the most appropriate indicators is critical to the success of the monitoring programme as they should provide (a) the most <u>effective</u> means of determining state and trends and the effectiveness of management measures and (b) the most <u>efficient</u> way to assess the very wide scope of this Descriptor.

The selected indicators should fulfil several or all of the following qualities:

a. Targeted to the pressures and expected impacts on biodiversity components relevant to the area, having a high level of sensitivity and accuracy in relation to the pressure;
b. Informative in itself, but also of the wider biological and/or environmental state;
c. Addressing the environmental targets relevant to the area; include species and habitats that are identified as conservation priorities by existing Community legislation and international conventions;
d. Established methodology and high level of maturity (whilst allowing for new developments and the application of new methods and technology where appropriate). Some indicators are well-researched and have a long history of implementation, whereas others are less-developed; some aspects may need the development of new indicators. Further, the detailed application of many indicators is continually being improved by scientific research, and the literature base is immense;
e. Cost-efficient. The concept of cost-efficiency will vary depending on the issues at hand. In some cases, the utility and information gained towards a specific need may exceed cost considerations. Additionally cost should take into account how multiple sampling can be achieved through integration both across biodiversity components and with other programmes (see Section 4.2.2 Synergy with existing monitoring programmes). Fully integrated monitoring programmes may lead to some indicators/techniques becoming much more cost-efficient to use when part of a wider programme (e.g. shared vessel time across multiple techniques);
f. Compatible with other monitoring or research programmes (i.e. using standardised methods and/or generating data which can meaningfully be analysed together with those from ongoing or past monitoring efforts).

Indicators suggested for other Descriptors may be suitable in the context of Descriptor 1, particularly those for the Descriptors that relate to pressures on biological diversity (i.e. D2 non-indigenous species, D5 Eutrophication, D7 Hydrographical changes, D8 Contaminants, D10 Litter and D11 Energy) and the 'state' Descriptors (i.e. D3 Commercial fish, D4 Food webs and D6 Sea-floor integrity).

Given the complexity and regional variation of biological diversity, a definitive set of indicators can not be provided here, and further work will be needed at the region/subregion level to determine an appropriate set. Instead, compilations and reviews of indicators are given in Section 6.1: Recommended further reading on indicators. Qualities and criteria for selection of indicators are given in, for example, Mazik et al. (2010).

4.7.6 Phase 4 – Evidence collection (monitoring)

Phase 4.1: Define sampling techniques, strategy and periodicity

The distribution of biodiversity components and assessment of risks to their status from previous phases, together with the identification of suitable indicators, will inform the type of monitoring strategy and sample design needed, including its spatial and temporal resolution. Sampling strategies need to be devised to collect the evidence needed to assess state, bearing in mind the need to distinguish anthropogenic change from changes due to environmental and climatic variation. The level of evidence required is also likely to be linked to the requirements to relate any impacts found to particular activities and thus inform decisions on the need for management measures. Whilst prioritisation towards biodiversity components and locations most at risk is advocated, this should include sampling of locations considered to be in reference condition to facilitate interpretation of monitoring data and to enable understanding of changes in the wider environment.

Art. 11 requires that monitoring methods used are consistent across the regions and subregions. An outline of issues relating to standardised methodology and associated quality assurance processes is given below.

Methodology and standardisation

Consistent methods for monitoring across a region/subregion are required by Art. 11.2. Some methods are described by international standard guidelines, such as the International Standards Organisation (ISO) and the European Committee for Standardization (CEN). Where suitable guidelines exist, these should be followed, provided they are appropriate for the objective of the monitoring (i.e. to assess the criteria in relation to the targets and reference conditions). Where these are not available, the operating procedures used should be compatible with methods described in the scientific literature for the relevant biological indicators or components. A detailed description of procedures should be developed by the participating laboratories, and as a minimum, standardised between collaborators across the subregion, for example during synergy with other ongoing monitoring and research efforts.

Large-scale inter-disciplinary and international networks such as MarBEF (www.marbef.org) have highlighted the need for assessing biodiversity at the scale of ecosystems rather than localised areas. All monitoring activities should if possible aim to contribute to such large-scale assessment systems covering the European Seas. To achieve this, methodology and approaches for the selected indicators need to be reliable, reproducible and as far as possible inter-comparable between operators across Europe.

Quality control/ quality assurance

The following is modified from ISO 16665, applicable to all biological monitoring.

Quality assurance and quality control measures should be incorporated during all stages of sampling and sample processing programmes. These principles help to guarantee that all data produced are of a specified quality, and that all parts of the work are carried out in a standardised and intercomparable manner. All procedures should therefore be clearly described and carried out openly, such that all of the laboratory‘s activities can be audited internally and externally at any time.

The overall aim is to assure traceability and full documentation of samples and equipment from beginning to end from sampling, sample transport, offloading from survey vessel (where used), placement within and retrieval from a sample store to sample processing, reporting and final archiving.

For some components of biological diversity, such as benthic fauna, international quality assurance and/or ring-testing schemes are well established (e.g. BEQUALM). Approved national schemes exist, such as in Germany (www.umweltbundesamt.de/wasser/themen/g-blm.htm) and the UK National Marine Biological Analytical Quality Control Scheme (www.nmbaqcs.org). For other components, there may be a lack of specific quality assurance schemes, in which case, appropriate modifications may be developed.

Within the International Council for the Exploration of the Sea (ICES) are also two relevant Steering Groups on Quality Assurance of Biological Measurements in the Northeast Atlantic and Baltic Sea, respectively (www.ices.dk).

A quality assurance/quality control scheme should encompass the following:

a. training and training records;
b. traceability of work and samples;
c. standardised practices throughout;
d. calibration of sampling and sample processing equipment or procedures;
e. in-house and external audit, also referred to as Analytical Quality Control schemes;
f. literature updates;
g. reference or voucher collections (where specimens are collected; photographs or other documentation for non-desctructive sampling).

Phase 4.2: Undertake evidence collection programme

The monitoring programmes required to fulfil Art. 11 are expected to include a range of environmental monitoring and the monitoring of activities and their pressures. Additionally it may be appropriate to monitor compliance against management measures. The earlier phases of assessment against risk should have led to a restricted range of monitoring requirements, targeted towards specific biodiversity components, criteria and locations. It will be important to supplement evidence gathered from these monitoring activities with evidence of wider changes in environmental conditions (e.g. oceanographic trends) and trends in human activities over the assessment period.

Whether the monitoring programme is repeated in its entirety, or modified depends on the previous results and assessment of state (see Phase 7: Adaptive Management).

a. Reference locations should always be included, to monitor for changes in the prevailing climatic conditions, which may directly and/or indirectly affect the biological diversity;

b. For locations previously found to be at GES, and where no increase in pressures has occurred, a reduced sampling programme or range of indicators may be appropriate. This needs to be evaluated on a case by case basis;

c. For locations where all indicators show sub-GES conditions, repeated application of the entire monitoring programme will be appropriate;

d. An intermediate approach may be appropriate where some indicators last showed a sub-GES status for certain components of biological diversity, whereas others were at GES.

4.7.7 Phase 5 – Assessment and reporting

General approach

The Directive effectively recognises only two categories of status, namely GES and sub-GES. Figure 4-6 illustrates the concept of GES in relation to environmental conditions which can range from no measurable degradation (reference conditions) through to complete degradation (e.g. a habitat or species lost from an area):

a. GES represents a range of conditions along this axis of degradation, and ranges from unimpacted (reference) conditions through to a degree of degradation. Sections 3.3.6 and 4.7.2 (Task 5 on defining targets) provide guidance on setting the lower target value of GES in relation to the quality and quantity criteria.

b. Sub-GES conditions range from moderately to severely impacted and ultimately to complete destruction or an irrecoverable condition for a habitat or species in an assessment area.

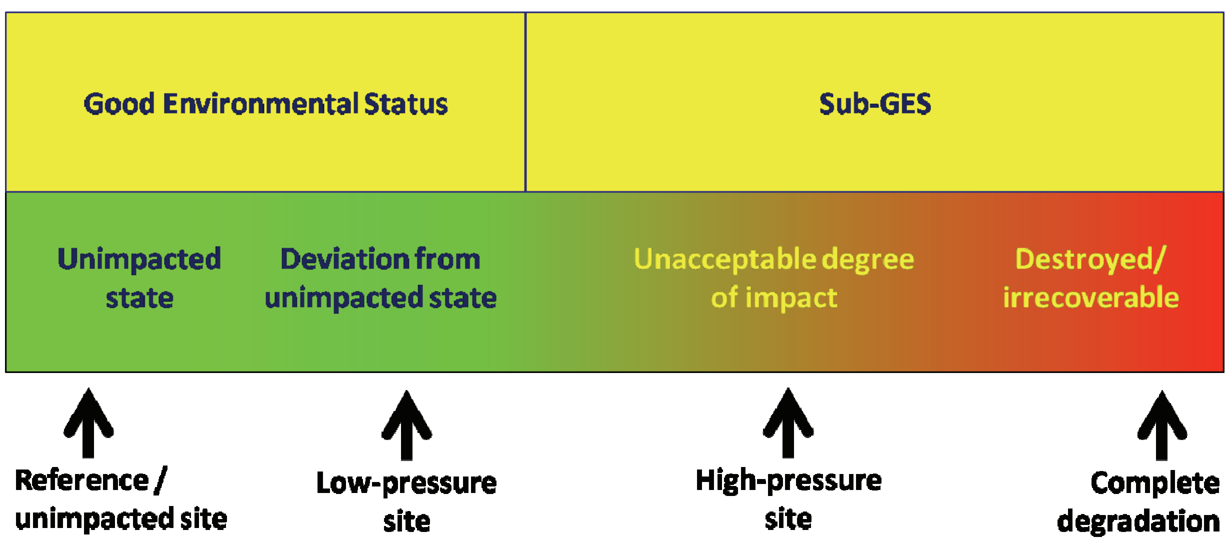

Figure 4-6. Conceptual illustration of the axis of degradation in the state of biological diversity ranging from unimpacted (reference) conditions through to complete degradation. Arrows illustrate results from a hypothetical indicator at example sites along this gradient.

The overall classification of GES is compatible with the WFD assessment of Good Ecological Status (Figure 3-2), but differs in not defining discrete status classes with specific threshold values for each defined class. The possible merits of providing further divisions of the two broad classes of this Directive to provide further discrimination in status assessments and improved monitoring of progress need to be assessed.

Given the overall complexity of biodiversity, it is anticipated that assessment in relation to this Descriptor will need to accommodate a number of considerations, including:

a. Evidence of pressures and activities in the assessment area, including any trends in their distribution, intensity and frequency and how these might have or be affecting the biodiversity components.

b. The evidence available from state monitoring in relation to the criteria and indicators used for each component;

c. Information on any regulatory response to management measures, such as changes in locations of activities or reductions in discharges.

a. Information on wider environmental changes, including climate-related changes. Wide-scale changes and cycles of change due to climate variation need to be considered in assessing local changes. For example, a number of climatic cycles are recognised (North Atlantic Oscillation, Atlantic Multi-decadal Oscillation, Sub-polar Gyre) as well long-term climatic changes (ICES 2010). These can have significant effects on biodiversity (changes in dominant species and communities) within regions which need to be distinguished from more local anthropogenically-driven changes.

b. The information available from assessments for the other Descriptors, which can contribute to assessments of state (Descriptors 3, 4 and 6) and assessments of pressures on biodiversity (Descriptors 2, 5, 7, 8, 9, 10 and 11).

Assessments are needed for each of the biodiversity components present in a region/subregion, although some may have been classed as being at low risk of failure to meet their environmental targets and therefore not been subject to specific monitoring programmes (see Section 4.7.4; Phase 2) whilst others may have been monitored via surrogate species or habitats/communities (see Section 4.7.5; Selecting indicators).

Phase 5.1. Assessing state and proximity to GES

Assessing state and proximity to GES comprises the following process:

- Defining specific reference levels and targets
- Assessing state
- Assessing direction, rate and causes of change
- Determining status in relation to GES

Defining specific reference levels and targets

For the indicators selected in Phase 3, and implemented in Phase 4, reference conditions are defined based on the results obtained, interpreted along the axis of degradation (see Figure 4-6).

Using the combined knowledge of reference conditions, as well as spatial variations and pressures across the area, a lower limit is defined for each of the indicators, representing the lowest acceptable limit of GES conditions. Target values for indicators are therefore defined as being above this level.

Further guidance on setting targets is given in Section 3.3.6.

Assessing state

For each component in an assessment area, the quality criteria should be assessed based on the evidence from the locations monitored (and any supporting evidence). This should provide a series of sample points (for larger species, this may equate to data on a whole population at a given location) which indicate whether the conditions are above or below the target value for that quality element (e.g. the condition of a population or habitat/community at the locations sampled).

Each of the quantity criteria should be assessed individually to give values (of state) in relation to the targets set, based on the indicators used. For the quantity criteria which have a quality element (i.e. assessments of population condition and habitat/community condition), a combination of evidence from across the specific sampling locations within the assessment area and evidence of the known or expected (modelled) extent of pressures on the component can be used to assess the overall proportion of the component which is above or below the quality target.

In evaluating biodiversity data, vagrant species should be excluded from, for instance, measures of species diversity. Non-indigenous species should be treated as pressures which are degrading the quality of the community.

Assessing direction, rate and causes of change

Change is assessed by repeated application of the monitoring programme, as outlined in Phase 4.

The rate of change is expressed in terms of how much change has occurred over the time period(s) between monitoring events. Feedback on rate of change is an important component for Adaptive Management (Phase 7). Note that the rate of change will not necessarily be consistent between all measured biodiversity components, nor among the indicators used.

The direction of change can be assessed by reference to the “axis of degradation” with results of new assessments compared with previous assessments to indicate:

a. Restoration (change towards GES);

b. Status quo (no notable change);

c. Degradation (change away from GES).

Note that the direction of change may not necessarily be consistent between the selected indicators for biodiversity components. Each should be documented on its own merit.

It may not be possible to identify all the causes of change in biological diversity, but in most cases, some main inferences can be made based on the type of observed changes and the pressures acting upon the biodiversity component. For example, organic enrichment causes characteristic successional changes in macrobenthic faunal communities. Such observed biological changes in the vicinity of human activities such as aquaculture, fish processing plants or municipal outlets would suggest a cause-effect link.

However, in some cases, the state of species and habitats/communities can change but no direct link to anthropogenic pressures can be made.

Determining status in relation to GES

Using the framework described in previous sections for each biodiversity component should lead to judgements as to whether target conditions in the assessment area have or have not been met for each criterion.

Conclusions should be drawn for all criteria, indicating the level of confidence in each judgement (which may be based of firm evidence from monitoring programmes and indicators/metrics, inferred from modelled or associated pressure data, or assessed based on low/negligable risk from human activities). This should lead to an overall conclusion as to whether the targets set have been met, including an indication of confidence in the assessment, and hence provide a status for each biodiversity component in the assessment area.

In addition to assessing state, and hence giving a status classification, it is helpful wherever possible to indicate recent trends (e.g. since the last reporting point) and predicted future trends (e.g. over the next 10-20 years. These can form valuable elements of the assessment process which feed into management responses. For instance, if status is good (above target values) but the trend is deteriorating, then a management response may need to be considered to prevent the status falling into sub-GES levels. If status is poor (below target values) but improving, this may indicate any measures taken are having a beneficial effect and act as an encouraging indication of progress towards achieving GES. If status is poor, but not improving or getter worse, further manangement action may be deemed necessary.

Phase 5.2. Reporting

Reporting of assessments is required in 2012 (Initial Assessment) (Art. 8.1) and on a six-yearly basis thereafter (Art. 17). Suitable reporting formats will need to be developed and agreed across Member States, including the submission of information to the WISE-Marine information system.

Given that the characteristics of biodiversity assessments proposed here (i.e. the attributes and criteria) and some of the components (those species and habitats/communities on Community legislation and international agreements) will have a level of commonality with reporting requirements for other purposes (i.e. other Community Directives, international Conventions), consideration should be given to harmonising and simplifying the reporting systems, as far as is possible. This could help achieve consistency between the various biodiversity Directives and Conventions and considerably reduce the effort needed for the reporting process. See Section 5.2 for elaboration.

4.7.8 Phase 6 - Programme of Measures

The implementation of a Programme of Measures (Art. 13) is likely to require reductions in the intensity, duration and/or extent of pressures from those human activities deemed to be contributing to any deterioration identified in biodiversity status. In more isolated cases, there may be a requirement for more proactive restorative measures.

During Phase 5, overall interpretations will have been made as to:

a. The state of the selected components of biological diversity, in relation to the existing pressures;

b. Proximity to GES;

c. Direction and rate of change.

Therefore, all four driving questions of the monitoring programme should have addressed (see Section 4.7.1). On this basis, an appropriate programme of measures should be devised.

Important questions to consider when designing a Programme of Measures are:

a. Where are the locations which deviate from GES in terms of one or more criterion?

b. Can such sub-GES locations be linked with existing pressures?

   i. If so, are these pressures directly caused by existing human activities?

   ii. And if so, how could these human activities be regulated to reduce their impact on the measured components of biological diversity? See below for further considerations on regulation of activities.

c. If there are any sub-GES locations not directly linked with existing pressures, can these be characterised as:

   i. Resulting from previous pressures which have caused a permanent, irreversible degradation;

   ii. Locations which are recovering slowly from a past pressure;

   iii. Not explainable by any pressures; considered part of background variation for the assessment area or in need of further investigation to determine whether there is cause for concern.

d. How much of the region/subregion shall/can achieve GES by 2020 (quantity targets)?

   i. At what scale shall remedial measures be implemented?

   ii. If some assessment areas or locations cannot be expected to achieve GES because ongoing pressures cannot be sufficiently reduced, can they at least be mediated to allow some change in the direction towards GES?

Examples of typical remedial actions implemented in response to documented unacceptable degradation of biological diversity due to human activities include:

a. *Petroleum industry* – (sea floor and water column) shift in type of compounds used in drilling lubricants e.g. from synthetic to water-soluble compounds, closed-system operations;

b. *Municipal discharges* (sea floor and water column) - increased treatment of discharges or extension of outlet pipes to deeper/ faster-flowing water bodies;

c. *Aquaculture* (mostly sea-floor issues dealt with) - improved feeding practices, more frequent fallowing regimes, shift to offshore-type of installations (where water bodies permit);

d. *Wind farms* (mostly air and noise-related impacts) – difficult to reduce impacts once established, but during planning phase, wind farms are positioned and dimensioned to minimise impacts to birds (fatal collisions), mobile species (noise and current disturbances) and substrate-associated species (habitat destruction);

e. *Pipeline installation* (sea floor and water column) – minimising potential biocides released at offshore end at start-up and anti-corrosive compounds from anodes, regulation of either submerging/filling in the pipeline route or leaving pipe exposed, depending on bottom trawling or concerns for biological diversity.

4.7.9 Phase 7 - Adaptive Management

The monitoring of indicators in relation to current state and target values makes it possible to apply the principle of adaptive management. Adaptive management is a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via monitoring (Conservation Measures Partnership 2007).

Once the monitoring programme is initially established, monitoring results are assessed and the Programme of Measures is implemented, Adaptive Management can be applied to all phases of the monitoring programme, from planning what and where to monitor, selection of indicators through to the programme of measures. Actual measures taken will vary depending on what is appropriate to the individual assessment area, at the time in question, but may include:

a. Adjusting the spatial intensity of monitoring stations

    EXAMPLE: if the indicators applied to potentially high-risk areas show target conditions are met, then any adjacent areas further removed from that pressure (and not affected by other pressures) may also be assumed to represent target conditions. For follow-up monitoring, it may be appropriate to reduce the number of sampling stations or observation periods.

b. Adjusting the frequency of monitoring

    EXAMPLE: if an area is shown to be markedly impacted/degraded, the required MSFD monitoring interval may not be sufficient to assess change and apply adaptive management to ensure GES is reached by the target date of 2020. In such cases, interim application of the monitoring programme cycle (sensu Figure 4-2) may be appropriate. Note that such needs may be covered through synergy with existing monitoring programmes, for example in connection with regulation of industrial impacts.

c. Adjusting the suite of indicators used

    EXAMPLE: should new pressures be revealed, or monitoring or research data indicate that impacts extend to components of biological diversity not currently assessed, then new indicators may need to be included in the programme. Conversely, if all indicators applied are united in a conclusion that GES has been achieved, any indicators which will not be expected to change under current conditions (where these fall short of target values) or acceptable decline from current conditions (setting a limit of how much deterioration can be accepted, for example in connection with human activities or needs) are pre-requisites for informed management decisions.

d. Adjusting the Programme of Measures

EXAMPLE: should monitoring data indicate that the rate of recovery of an area is insufficient to allow the target time frame for achieving GES to be met, further reductions in pressures may need to be implemented.

4.8 Overall interpretation

Due to the inherent regional variation in biodiversity, it is not appropriate to consider which region has the most species or habitats, nor to prioritize among regions. Instead, the biological diversity of each region, subregion or assessment area should be maintained *per se*, irrespective of comparisons to other regions. However, in allowing for such regional specificity, this guidance provides a framework that should still enable comparable assessments of GES to be made between regions/subregions (i.e. by adopting a consistent set of predominant habitat types and ecotypes). Differences might arise if targets established by Member States differ substantially between regions/subregions or assessment areas. For example, if different targets are adopted for the same habitat type or species in the different regions/subregions where they occur.

The different components of biological diversity may not respond to pressures in a similar manner, or at similar rates, making it difficult to aggregate the results of assessments for individual biodiversity components. The set of very broadly-defined predominant habitat types and species ecotypes represent distinct structural and functional elements of biodiversity. Assessments for this Descriptor should therefore aim to yield a separate assessment for each of these broad elements of biodiversity (where relevant to each region/subregion). Aggregating these into any broader assessments (or ultimately into a single assessment for biodiversity per region/subregion) is likely to mask significant variation in ecological character and to avoid identification of key problems of impacts or locations in need of measures. Additionally such processes of aggregation become increasing less scientifically robust.

Where the ecosystem components are assessed at the level of assessment areas that are subdivisions of the subregion, suitable rules for aggregation of assessments up to subregion level need to be established for the biodiversity component.

Where individual Listed species and habitats are assessed separately, they may collectively contribute to the assessment of the broader predominant habitat or ecotype to which they belong, and thereby facilitate the assessments of the broader types.

Although full aggregation of assessments across predominant habitat types and ecotypes is not recommended, overall progress towards achieving GES for this Descriptor is likely to be reflected in the number of these biodiversity components which individually achieve their GES targets, and in the extent of each region/subregion which achieves the targets.

The results of the assessment and monitoring of specific biodiversity components (at species, habitat/community and landscape level) need to be used to assess the overall state of the ecosystem.

5 Emergent messages for research and further development

5.1 Overview

Biological diversity in the sense of Descriptor 1 is a complex and wide-ranging subject, and new knowledge is continually being gained. With new knowledge, new questions arise, and more knowledge needs are identified, generally at increasing levels of complexity. This section attempts to outline main areas where the MSFD process would benefit from further research and development. An overview of general research needs within the field of biological diversity is beyond the scope of this report.

Three key areas are identified:

1. Integrating research and monitoring
2. Harmonisation of assessment and monitoring
3. Mapping, assessment and management tools

5.2 Integrating research and monitoring

5.2.1 Rationale

The iterative process of the assessment and monitoring programme, as illustrated in Figure 4-2, shows pathways for mutual benefit between European research and the MSFD monitoring programme. Therefore continued efforts to link and integrate research and monitoring is a key message.

Research provides valuable input for optimising the approaches developed during the initial phases of the monitoring programme (what and where to monitor). Scientific documentation of the various components of biological diversity, encompassing genes, species and ecosystems, and the responses to human-induced pressures, across European and global marine seas facilitates integrated assessments of GES at different spatial scales.

Assessment of GES requires a sound knowledge of not only reference conditions, but fluctuations over time, as a result of natural variation, climatic influences and anthropogenic impacts. Distinguishing between these causal factors of temporal changes will be greatly facilitated through collaboration with organisations who have been conducting long-term monitoring of specific areas and/or components of biological diversity (biodiversity observatories).

Knowledge needs are continually evolving, and TG1 cannot assess all of these. However, microbes and viruses, which play a key role in ecosystem functioning, are highlighted as being in need of further attention. In particular, the development of indicators and cost-efficient assessment methods will be important.

5.2.2 Biodiversity responses to pressures

The understanding of the relationships between pressures from human activities and their effects on biological diversity are still only partially understood, or understood for a proportion of biodiversity. It is expected that there will be a number of aspects of these relationships which will need to be better understood (and suitable indicators developed for their assessment) in order to fully implement the requirements for this Descriptor.

A key research need is to describe the linkage between the sensitivity of habitats and the cumulative pressures acting upon them. How much of an individual habitat can be under influence from multiple pressures before an effect can be seen on the ecosystem and especially how much can it withstand before an irrecoverable effect occurs? Similarly, increased knowledge on the interaction between habitats is needed. Some species depend on different habitats throughout their life cycle and, while some of these habitats might be protected, others are not.

The basic question to be asked in regard to achieving GES for biodiversity components (here habitats) is: how much of any given biodiversity component can be exploited or be under pressure in any given area before irrecoverable effects occurs? Such knowledge is central for informing management decisions and priorities.

5.2.3 Interactions between biodiversity components within ecosystems

Understanding the interactions between the various components within ecosystems will facilitate the development of proxy indicators of environmental status. Issues which directly relate to the assessment of GES include:

- Hypoxia is an expanding problem globally. Hypoxia induces important feedback mechanisms on the ecosystem through altering the biogeochemical cycling of nutrients and changing the benthic community, maintaining benthic habitats in a hypoxic regime. There is a need to better understand and quantify these feedback mechanisms and scale them up to ecosystem level in regard to conserving marine biodiversity.
- The global decline of seagrasses has severely affected some benthic habitats and the shift from benthic to pelagic-dominated production combined with the lack of stabilising effect on sediments prevents recolonisation of seagrasses. Better understanding of the processes underlying seagrass recovery is needed for the successful implementation of restoration efforts and the achievement of GES.
- The coastal zone is an intermediate between land and ocean, and acts as a filter for retaining nutrients and providing habitat for juveniles. Building on the understanding of nutrient cycling from the LOICZ programme, increased knowledge on how the biological systems modulate these responses are needed.
- Trophic cascades and biomanipulation is well studied in lakes but the same mechanisms have to a large extent been overlooked in the marine coastal zone and beyond. Overfishing and destruction of habitats imposes a strong top-down alteration of the food web in addition to the bottom-up effects induced by eutrophication. Improved understanding of ecosystem responses under cumulative pressures is needed if a proper management and ultimately the achievement of GES is to be a realistic goal.

5.2.4 Microbes and viruses

<u>Outline</u>

Studies of microbes and viruses, and their role in ecosystem function, generally are confined to scientific research programmes, or monitoring specific pathogens. Their inclusion in environmental or biodiversity monitoring programmes is extremely rare. Nonetheless it is increasingly clear that microbes and viruses play an important role in energy transfer at the base of the food web. The ‘microbial loop’ refers to a trophic pathway where dissolved organic carbon (DOC) is reintroduced to the food web by incorporation into bacteria. Bacteria are grazed upon by protists, i.e. single-celled organisms such as flagellates and ciliates. In turn, protists are consumed by larger planktonic fauna such as copepods.

Viruses interfere with the microbial food web by lysing ~50% of the microbial biomass every day. When the host organisms are lysed, nutrients are released into the surrounding environment, and in this way, viruses are important for the cycling of carbon and nutrients in the marine environment. In addition, viruses directly affect the abundance and diversity of host cell communities and contribute to microbial gene exchange, which are important for the overall evolution of both the host and the viral community.

DOC in the water column arises from leakage of fixed carbon by phytoplankton, breakdown products of enzymatic lysis of bacteria and the excretion of waste products by organisms, including microbes themselves. DOC is unavailable to most organisms other than bacteria, therefore microbial incorporation of DOC makes additional energy available to higher trophic levels. This bacterial energy recycling process therefore has a profound influence on the productivity of marine systems, from the pelagic realm through to vertical energy transport to the sea floor.

Microbial benthic carbon remineralisation also occurs at the sea floor, and plays a major, although often underestimated, role in benthic productivity. Further, bacteria facilitate the breakdown of organic material in or on marine sediments. Therefore, microbial activity in marine sediments can influence the extent of degradation (deviation from GES) which occurs in response to sea-floor pressures causing organic loading, and also the rate of recovery after a reduction in those pressures.

Research needs

Although there exists a considerable body of research knowledge on microbes and viruses, there is a lack of common understanding of the implications for environmental assessment and management programmes. Some issues are a challenge for future research, whereas others are a challenge for communication between science, management and policy. These should be integrated to mutual benefit.

The research needs may be summarised as follows:

a. Improved understanding on:
    i. The role of microbes and viruses in ecosystem functioning across a range of ecological zones;
    ii. The potential influence of climate-induced warming on microbial function in marine systems;
    iii. The relationships between pressures and microbial function, particularly for sea-floor impacts, such as physical disturbance and organic loading.
b. Methodological challenges
    i. How to incorporate microbes and virus in a monitoring programme;
    ii. Modelling and verification.

Marine microbiology plays a key role in the cycling of carbon in the ocean and a better understanding of microbial function may prove to be mandatory to counteract the processes threatening to change the global climate. Viruses are also important players in this context and thus understanding host-virus relationship becomes essential to investigate the susceptibility of the marine environment to pressures such as ocean acidification and global warming. It is essential to understand the baseline situation before such large-scale changes occur. In addition, it is also important to have knowledge about the basic processes controlling the ocean recourses exploited by man.

There is considerable interest emerging in the Biotechnology industry in the marine environment as a potential source of novel, commercially exploitable genes. As a consequence, major industrial figures are currently engaged in large-scale genomic surveys of marine microbial communities. One such venture began by sequencing the microbial metagenome (community genome) in the Saragasso Sea (Venter et al. 2004) and the most recent of this metagenomics effort on an ocean surface water microbial sequencing survey resulted in an almost doubling of the total number of known protein sequences (Rusch et al. 2007; Yooseph et al. 2007). Another high-profile American entrepreneur, Gordon Moore (founder of Intel Corporation) has invested heavily in a marine microbiology survey (www.moore.org/marine-micro.aspx).

Although European research on microbes and viruses does exist, its profile is far behind that of the USA. Because of their fundamental role at the base of the food web, micro-organisms are a fundamental part of biological diversity and ecosystem function. Therefore, further understanding their diversity and function in European systems is an important part of the current quest of the MSFD to achieve Good Environmental Status.

5.2.5 Pan-European biodiversity observatories

The MARS network of European research stations (see Section 1.4 and www.marsnetwork.org) was founded in recognition of the need for collaboration between institutes conducting research and monitoring of marine biological diversity. Part of the MarBEF legacy is continued efforts to bring together relevant institutes, researchers and data series, to form a platform of biodiversity observatories.

Precisely such an observatory network will be invaluable for assessment of biological diversity within the MSFD, particularly in documenting reference conditions, natural and background fluctuations and long–term changes. This information will be essential for assessment of the results of the monitoring programme as well as setting targets.

A similar concept of scientific observatories is under development for the Arctic (www.arcticobserving.org).

5.3 Harmonisation of assessments and reporting

5.3.1 Rationale

To achieve a representative and, as far as possible, correct picture of the state and development of biological diversity across Europe, common operating practices are required on both spatial and temporal scales:

- Within sub-regions, between individual parties carrying out evidence collection (monitoring);
- Between sub-regions and
- Between all parties, for each monitoring period.

Monitoring of marine biological diversity is a time-consuming and cost-intensive process, and it is important to achieve maximum use of the data which emerge from the MSFD monitoring activities. Standardised procedures, common data policy and frame of use are therefore recommended.

5.3.2 Optimising sampling and data resources

It may be advantageous to develop and carry out joint monitoring programme for adjacent Marine Regions and/or Subregions. Sampling vessels, gear and personnel could advantageously be shared, and use of indicators of broad interest implemented jointly. This would lead to major joint surveys at appropriate intervals, to mutual advantage.

Each monitoring event carried out within the MSFD should be seen as a part of a greater whole. Therefore, the following practices are recommended for collected data on biological diversity:

- Requirement to submit MSDF data in common data formats to national data centres;
- Dedicated data management procedures/personnel;
- Open data resource, available for research and management purposes
    - For example, available on request, by membership or by subscription, as appropriate.

5.3.3 Integration of assessments across regions

The evaluation of status assessment for species and habitats should, wherever possible, be consistently applied across different policy mechanisms (i.e. for a given geographical scale of assessment, the status of a particular species or habitat should not differ due to the policy under which it is assessed). Where assessments are done at different geographical scales, they should ideally adopt similar principles, adjusted where appropriate to take account of any geographical scale issues. A generic framework is proposed for application within MSFD, which embraces assessments for the Habitats Directive, regional seas conventions and other mechanisms, but which highlights that there are differences across the different mechanisms. Further work to fully harmonise these methods would be highly beneficial. To compliment any harmonisation of assessment methods, harmonisation of reporting requirements (and timelines) should also be considered, as this could substantially reduce effort and streamline reporting processes (to WISE-Marine and other reporting systems).

5.3.4 Standardisation and quality assurance

A variety of data synergies are aimed for within the MSFD, including:

- Within and between regions;
- Between MSFD monitoring and other monitoring programmes, including environmental monitoring of industrial and municipal activities, biodiversity and habitat mapping;
- Between MSFD and existing data – including historical data series.

These synergies are based on compilation of individual data sets to form a larger whole, either by direct data-sharing or by building upon published data. For this to succeed requires consistency in the methods used as well as quality assurance of the data, for example:

- Compatible sampling methods (equipment used, sampling strategy, quantification methods etc.);
- Properly geo-referenced sampling stations/observation areas;
- Assurance of reliability of sample processing, at least up to the point where data records are made (e.g. counts of individuals, biomass measurements etc.);

- Reliable archiving in case of future cross-checking needs.

Consistency in methods used will greatly facilitate consistency in the further assessment process.

Synergies involving multiple owners of data will benefit from establishing a clear data policy, as well as good records kept of the data available, preferably in the form of an openly-accessible metadatabase.

5.4 Mapping, assessment and management tools

5.4.1 Development of EUNIS habitat classification

Use of the EEA's EUNIS classification, for both water column and seabed habitats, is recommended as the basis for biodiversity assessment and monitoring. The classification is increasingly used as the standard scheme for national and international marine initiatives. The EC has recently commissioned the preparation of broad-scale seabed maps for the Baltic, North Sea, Celtic Seas and western Mediterranean Sea (EUSeaMap project) and has stipulated that the maps should use a standardised EUNIS classification throughout the four regions to depict the habitat classes.

The current EUNIS classification for marine habitats requires further development to ensure it is of full practical use for application within the Directive. The EUSeaMap project expects to test and validate the upper parts of the classification (levels 2-4) and make recommendations for modifications to the current classification in late 2010. It is anticipated that the Baltic region will require substantial restructuring, as well as the deep sea and potentially aspects of the Mediterranean Sea. Additionally, HELCOM is embarking upon a revision of the more detailed aspects of habitat classification for the Baltic Sea (levels 4-6) to ensure the full range of communities is adequately described. It can be expected that other areas for which there are limited data or limited application of the EUNIS scheme (e.g. Iberian coast, parts of the Mediterranean and Black Seas) will also require further refinement of the classification. The current structure of the pelagic part of EUNIS (A7) is rather complex and unsuitable for direct application in the Directive. Further development of EUNIS should be tied in closely with the development of reference conditions. A scientific panel to review proposed changes/additions to EUNIS should be established to assist in this work.

5.4.2 Mapping of seabed habitats

Much progress has been made in recent years to prepare both broad-scale habitats maps, using modelling techniques (e.g. BALANCE, MESH, EUSeaMap) and fine-scale maps using state of the art seabed survey techniques (e.g. REBENT in France, Mareano in Norway, InfoMar in Ireland). The importance of having such habitat maps to support environmental assessments, such as for GES, and management, including marine spatial planning is now widely recognised.

The broad-scale mapping provides an important tool for assessment and planning (of monitoring programmes) over large areas (regions/subregions) and as such should form an essential part of the early phases in development of the Directive. Efforts should be made to prepare broad-scale maps of the remaining areas of Europe's waters.

For detailed assessments, particularly in relation to specific impacts from pressures and human activities, it is necessary to have fine-scale maps to facilitate the establishment of monitoring stations and to enable interpretation of the results and completion of habitat assessments. Continued survey to prepare high quality habitat maps, particularly of areas considered to be under most pressure from human activities, should be encouraged. In addition to benefits for implementation of this Directive, such maps are also valuable for achieving the wider goals of long-term sustainability mentioned in the EU Maritime Policy and Lisbon Agenda. The maps will thus support the future management and development of industry, and provide the basic ecological input for maritime spatial planning. Similarly, habitat maps can provide a detailed information layer in regard to the amount of resources available in any given area and thus be related to overall pressure or use of specific limited resources.

5.4.3 Mapping of pelagic habitats

While much progress has been made in regard to the development of mapping and modelling seabed habitats, only minor efforts has been made in regard to the development of coherent broad-scale pelagic habitat maps. Pelagic habitat maps can show important hot spots for pelagic species such as feeding grounds, up-welling areas and spawning areas (as illustrated for Baltic Cod by the BALANCE project). Such maps can inform on both species living in the water (fish, mammals) as well as upon it (birds) and can thus be used for both informing fisheries as well as nature / ecosystem conservation issues.

Another element of pelagic habitat mapping is the continued development of connectivity maps which can show how different areas are connected by ocean currents and help to identify source and sink areas. Such information is not only important in regard to prioritising areas and management effort in regard to nature/ecosystem conservation, but can also be used for various industrial purposes e.g. informing shipping, spot for exchanging ballast water, inform maritime assistance areas (with minimum dispersal opportunity for oil etc.) and for tracking oil spills.

There is a need to develop more detailed coherent habitat maps of the pelagic systems compared to the existing oceanographic maps.

5.4.4 Maps for species

Further work is required to develop ways to aggregate the EUNIS classes (primarily at levels 5 and 6) into suitable ‘habitat’ classes for the mobile species, recognising that some depend on a very wide range of habitats through their life cycle. This sort of classification and mapping is often referred to as Essential Fish Habitat for fish species.

5.4.5 Ecosytem valuation

Marine biological diversity provides a large proportion of the goods and services provided by ecosystems. These are summarised in Table 5-1.

Table 5-1. Goods and services provided by marine biological diversity. From Beaumont et al. 2007.

Category		Good or service
Production services	1	Food provision
	2	Raw materials
Regulation services	3	Gas and climate regulation
	4	Disturbance prevention (flood and storm protection)
	5	Biomediation of waste
Cultural services	6	Cultural heritage and identity
	7	Cognitive benefits
	8	Leisure and recreation
	9	Feel good or warm glow (non–use benefits)
Option use value	10	Future unknown and speculative benefits
Over–arching support services	11	Resilience and resistance (life–support)
	12	Biologically–mediated habitat
	13	Nutrient recycling

Valuation of marine ecosystem services is important for environmental governance, to place biological diversity in a context which is directly relevant and understandable to people, from individuals, schools, coprpoate organisations to nations and international coalitions. However, such valuation is challenging, especially because there exist both monetary and non-monetary components.

A considerable body of recent research and compiled information has been produced through the EU 7th Framework programme Network of excellence, MarBEF (Beaumont et al., 2007; 2008, Derous et al., 2007; 2008 – available on MarBEF open archive at www.marbef.org).

Due consideration of valuation of marine biological diversity is beneficial.

5.4.6 Management tools using biodiversity

In order to achieve an ecosystem-based approach to management, management tools which combine various aspects of sustainable use and biodiversity conservation and restoration are needed. Such tools may include:

a. Description of the linkage between various trophic levels – e.g. linkage between a benthic habitat, prey and (top) predators. Strong linkages could help inform and prioritise cost-effective GES indicators.

b. Maritime spatial planning based on basic ecological information in order to plan and manage activities according to ecosystem capacity. Here it is especially important to be able to assess ecosystem capacity and compare / prioritise it according to human needs.

c. Integrated assessment tools. Focus should be on developing a tool which is capable of assessing GES based on different types (levels of detail) of information from different geographic locations. This includes a confidence assessment of the evaluation. It also includes guidance on how to prioritise among indicators at any given locality as well as a scientifically sound approach to identifying the necessary (quantitative and qualitative) indicators for a cost-efficient GES assessment (biodiversity and in total).

d. Guidance on which biodiversity components which are not covered by existing Community conservation measures (Natura 2000 and closed areas for fisheries). This includes guidance and tools for setting up a representative, coherent and connected network of protected areas as well as other conservation measures.

e. Proxies and surrogates (see also sections 5.2.2 and 5.2.3).

6 References

6.1 Recommended further reading

The scientific literature on marine biological diversity and indicators thereof is vast, and important publications are continuously being added. A comprehensive review or even list is beyond the scope of this report, but the following sources of information (and references therein) are useful.

Féral, J.-P.; Fourt, M., Perez,T., Warwick,R.M., Emblow, C., Heip, C., van Avesaath, P., & Hummell, H. (2003). European marine biodiversity indicators: report of the European Concerted Action: BIOMARE implementation and networking of large scale, long term Marine Biodiversity Research in Europe. NIOO/CEME: Yerseke, The Netherlands. ISBN 90-74638-14-7. 130 pp.

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Indicator reviews undertaken for the Joint Nature Conservation Committee and Healthy and Biologically Diverse Seas Evidence Group of the UK Marine Monitoring and Assessment Strategy (to be published early 2010):

1. Austin, G.E., Cook, A.S.C.P., Maclean, I.M.D., Mitchell, P.I., Rehfisch, M.M., & Wright, L.J. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for seabirds and waterbirds.
2. Benn, A., Hughes, J. A., & FitzGeorge-Balfour, T. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for deep-sea habitats.
3. Duck, C. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for seals.
4. Mazik, K., Boyes, S., McManus, E., Ducrotoy, J-P., Rogers, S.I., & Elliott, M. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for sediment habitats.

5. McQuatters-Gollop, A., Edwards, M., Reid, P.C., & Johns, D. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for plankton.

6. Mieszkowska, N., & Langmead, O. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for rock and biogenic reef habitats.

7. Pinn, E. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for cetaceans.

8. Schroeder, D. 2010. Healthy and Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for microbes.

<u>Other useful resources:</u>

MarBEF open access publication archives – available at www.marbef.org.

Keyword searches on Google Scholar (www.google.scholar.com).

ISI Web of Knowledge (http://sub3.isiknowledge.com/ - subscription required)

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Annexes

MSFD Annex III - Indicative lists of characteristics, pressures and impacts

Table 1 Characteristics

Physical and chemical features	— Topography and bathymetry of the seabed,
	— annual and seasonal temperature regime and ice cover, current velocity, upwelling, wave exposure, mixing characteristics, turbidity, residence time,
	— spatial and temporal distribution of salinity,
	— spatial and temporal distribution of nutrients (DIN, TN, DIP, TP, TOC) and oxygen,
	— pH, pCO2 profiles or equivalent information used to measure marine acidification.
Habitat types	— The predominant seabed and water column habitat type(s) with a description of the characteristic physical and chemical features, such as depth, water temperature regime, currents and other water movements, salinity, structure and substrata composition of the seabed,
	— identification and mapping of special habitat types, especially those recognised or identified under Community legislation (the Habitats Directive and the Birds Directive) or international conventions as being of special scientific or biodiversity interest,
	— habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference. This may include areas subject to intense or specific pressures or areas which merit a specific protection regime.
Biological features	— A description of the biological communities associated with the predominant seabed and water column habitats. This would include information on the phytoplankton and zooplankton communities, including the species and seasonal and geographical variability,
	— information on angiosperms, macro-algae and invertebrate bottom fauna, including species composition, biomass and annual/seasonal variability,
	— information on the structure of fish populations, including the abundance, distribution and age/size structure of the populations,
	— a description of the population dynamics, natural and actual range and status of species of marine mammals and reptiles occurring in the marine region or subregion,
	— a description of the population dynamics, natural and actual range and status of species of seabirds occurring in the marine region or subregion,
	— a description of the population dynamics, natural and actual range and status of other species occurring in the marine region or subregion which are the subject of Community legislation or international agreements,
	— an inventory of the temporal occurrence, abundance and spatial distribution of non-indigenous, exotic species or, where relevant, genetically distinct forms of native species, which are present in the marine region or subregion.
Other features	— A description of the situation with regard to chemicals, including chemicals giving rise to concern, sediment contamination, hotspots, health issues and contamination of biota (especially biota meant for human consumption),

	— a description of any other features or characteristics typical of or specific to the marine region or subregion.

Table 2 Pressures and impacts

Physical loss	— Smothering (e.g. by man-made structures, disposal of dredge spoil),
	— sealing (e.g. by permanent constructions).
Physical damage	— Changes in siltation (e.g. by outfalls, increased run-off, dredging/disposal of dredge spoil),
	— abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring),
	— selective extraction (e.g. exploration and exploitation of living and non-living resources on seabed and subsoil).
Other physical disturbance	— Underwater noise (e.g. from shipping, underwater acoustic equipment),
	— marine litter.
Interference with hydrological processes	— Significant changes in thermal regime (e.g. by outfalls from power stations),
	— significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction).
Contamination by hazardous substances	— Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC which are relevant for the marine environment such as pesticides, antifoulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances),
	— introduction of non-synthetic substances and compounds (e.g. heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation, atmospheric deposition, riverine inputs),
	— introduction of radio-nuclides.
Systematic and/or intentional release of substances	— Introduction of other substances, whether solid, liquid or gas, in marine waters, resulting from their systematic and/or intentional release into the marine environment, as permitted in accordance with other Community legislation and/or international conventions.
Nutrient and organic matter enrichment	— Inputs of fertilisers and other nitrogen — and phosphorus-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition),
	— inputs of organic matter (e.g. sewers, mariculture, riverine inputs).
Biological disturbance	— Introduction of microbial pathogens,
	— introduction of non-indigenous species and translocations,
	— selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing).

Terms of Reference for the ICES/JRC Task Groups

Each task group will address the following issues:

1) Initial interpretation of the descriptor

Each task group will start by scoping an initial interpretation of the descriptor as it is formulated in Annex I of the MSFD, addressing the following points:

- definition/interpretation of the key terms used in the descriptor
- describe what is covered by this descriptor and what falls outside its scope
- identification of possible links and overlaps with other descriptors
- identification of relevant policies and conventions related to the descriptor

2) Review of scientific literature and existing methods

Each task group will review existing scientific literature relevant for the descriptor in question, as well as existing relevant methods for quantifying GES, taking into account existing practices linked to relevant EU legislation and regional seas conventions.

The review should address the following questions:

- is there a common scientific understanding of the key concepts of the descriptor (e.g. 'biodiversity', 'alien species', 'litter', 'healthy stock', 'pollution effect', 'adverse effect on marine ecosystems')?
    - if yes: describe the common understanding
    - if no: discuss alternative interpretations and open issues
- is there a common scientific understanding how to monitor the descriptor?
    - if yes: describe the common understanding; is it useful/practical
    - if no: discuss alternative interpretations and open issues
- what are the existing approaches that can be used for assessing GES with regard to the descriptor? To which extent do they cover the requirements of the descriptor? Which aspects of the descriptor are not or poorly covered?

3) Identify relevant temporal/spatial scales for the descriptor

The task group should identify the relevant spatial and temporal scales for the descriptor. Each task group will need to address this issue in a manner that is consistent with their particular descriptor, taking into account the spatial and temporal scales of the relevant physical, biological and ecological systems and also the policy scales in each region.

If different approaches are required in different regions the task group should describe what they are, where they should be applied and the rationale for the differences.

4) General framework for describing environmental status

The task groups should describe the conceptual framework that should be used for the descriptor:

- identify relevant state and pressure indicators

- describe how the indicators respond to a degradation gradient
- identify how to monitor the state and pressure indicators (what to measure, taking into account spatial and temporal scales).

5) Monitoring

- what are the data needs for monitoring compliance to GES under the descriptor
- to which extent are the data needs covered by national monitoring programmes? Which aspects of the descriptor are not or poorly covered?
- are there existing methodological standards that cover these data needs?
- recommendations how to make optimal use of existing monitoring information
- identify where it is possible to make improvements by targeted and focused additional monitoring

The task group should list existing Quality Assurance guidelines for the descriptor e.g. regional conventions, CEN, ISO and national guidelines which could be relevant, and assess where further guidelines need to be developed, identifying the appropriate scale (EU, regional, national).

6) Research needs

The task group should assess the level of maturity of our understanding of the descriptor. This is expected to widely vary among descriptors, but also among marine regions. This should be discussed and where relevant, research priorities identified and recommended.

Collation of human activity and environmental data

Development of an assessment and monitoring programme should be based on a holistic understanding of the region or subregion to be assessed. Compiling relevant information in a Geographic Information System (GIS) is recommended to enable a spatial (and temporal) understanding of the relationship between human activities (which may be causing adverse pressures on the environment) and the characteristics of the environment, including its biodiversity.

The following information, which will be of direct use for many aspects of MSFD implementation, should be compiled:

a. The main ongoing or past human activities which potentially may affect or have affected biological diversity. The following are examples; others may apply:

   i Renewable energy production (including wind and wave turbines);

   ii Extraction of non-living resources (rock, sand and gravel);

   iii Extraction of non-living resources (oil and gas);

   iv Extraction of non-living resources (capital and maintenance dredging);

   v Extraction of living resources (seaweed harvesting, bio-prospecting, maerl);

   vi Extraction of living resources (fishing, shellfish harvesting);

   vii Mariculture (finfish, shellfish);

   viii Man-made structures (cables and pipelines);

   ix Man-made structures (coastal developments and defence, land claim, artificial reefs);

   x Recreational, educational and research activities;

   xi Shipping;

   xii Municipal and industrial discharges.

b. The distribution, intensity and frequency of pressures (cf Table 2 in Annex III of the Directive) from human activities:

   i Hydrological changes (caused by localised human activities) (including water temperature, salinity, movement and clarity changes)

   ii Contaminant levels

   iii De-oxygenation, nutrient and organic enrichment

   iv Physical loss and disturbance to the seabed

   v Other physical pressures (litter, electromagnetic changes, underwater noise, physical barriers to species' movement)

   vi Removal of target and by-catch species

   vii Distribution and abundance of non-indigenous species

   viii Other biological pressures (levels of genetic modification, microbial pathogens)

   These datasets can be taken as direct measurements of the pressures in the environment (e.g. on contaminant and chemical levels or levels of physical disturbance). Alternatively, techniques for modelling the distribution and intensity of pressures from activities (e.g. use of VMS data to model bottom trawling pressures) can be used. The preparation of data sets on pressures is underway in a number of countries. Further work is needed harmonise methodologies and data across regions and subregions and to produce equivalent datasets from differing activities yielding the same pressure.

c. Noteworthy administrative and regulatory features[24]. The following are examples; others may apply:

   i National (EEZs, Continental Shelf areas) and relevant internal administrative boundaries;

   ii Marine Protected Areas and fishery closed areas;

   iii Areas currently legislated under a Management Plan, or for which such plans are under development;

d. Major physical/oceanographic/geological gradients (spatial and temporal) in the region or subregion, for example:

   i Physiographic conditions;

   ii Hydrological conditions;

   iii Climatic changes[25].

   These types of data are also required for the initial characterisation according to the parameters listed in Table 1 of Annex III to the Directive. Many suitable datasets are being prepared under the EMODNET programme.

e. Biodiversity characteristics, including:

   iv The distribution of the predominant habitat types on the seabed, in the water column, and sea ice habitat[26], based on the EUNIS habitat classification system[27]. The predominant habitat types listed in Table 4.3 are very coarsely defined; a refined level of classification is likely to be helpful in linking pressures more specifically to communities for selecting appropriate indicators and subsequent monitoring;

   v Distribution of the species ecotypes for birds, reptiles, mammals, fish and cephalopods;

   vi Habitats/communities and species of special interest (i.e. those listed for protection in Community legislation and international agreements);

   vii Habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference. This may include areas subject to intense or specific pressures or areas which merit a specific protection regime (Table 1 of Annex III to the Directive);

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24 Note: no prioritisation for monitoring is implied.

25 A number of climatic cycles exist, which can have an effect on the biodiversity: North Atlantic Oscillation (NAO), Atlantic Multi-decadal Oscillation (AMO), Sub-polar Gyre, and climate warming.

26 Mostly relevant to Arctic and Baltic regions.

27 For north-west Europe these are currently available at www.searchMESH.net. The EUSeaMap project is preparing broad-scale EUNIS maps for the Baltic, Greater North Sea, Celtic Seas and western Mediterranean. These are due to be released by the end of 2010 (www.jncc.gov.uk/EUSeaMap).

viii Particularly informative biological features which may act as indicators of the wider state of the environment. For example, the presence of large, long-lived, erect, sessile species on the seabed, such as sponges, hydroids and corals, generally indicates a lack of physical/mechanical disturbance to that location.

f. Existing data or ongoing monitoring programmes concerning biological diversity:

i Ongoing monitoring;

ii Recent one-time sampling;

iii Historical data.

Much monitoring data is available in connection with industrial impact regulation. These range from simple reconnaissance surveys, to more extensive baseline surveys and repeated follow-up monitoring. Such surveys often gather and use historical data for interpretation of observed changes, as is often the case for more theoretical environmental impact assessments (EIA) and risk analyses. In this case, a synergy may be established, where some sampling/analytical effort is either shared between programmes, or one is supplemented by the other. Ongoing monitoring, generally using standard international methodology, is typically carried out in connection with:

- Aquaculture
- Municipal or industrial discharges
- Petroleum activities
- Marine mining or dredging
- Natura 2000 locations
- Water Framework Directive
- National/regional biodiversity monitoring programmes

Note: the impacts of bottom trawling on sea-floor biodiversity are widely documented in the scientific literature, but regular monitoring of their impactsis not widely undertaken.

Illustrative example: tasks and phases of the monitoring programme

This section aims to illustrate how the various phases of the monitoring programme would be carried out, using hypothetical scenarios as examples.

Further details on links between pressures and biodiversity, as well as more detailed worked examples for primarily North Sea areas and mid- to southern parts of the north Atlantic are given in the attached Excel spreadsheet (Connor and Mitchell 2010). Click on the paperclip. Please note: multiple worksheets (view as full-page to see tabs at foot of page).[28]

Microsoft Office
Excel 97-2003 Worksl

Preparatory Task 1: **Collate environmental data to support assessment** (see section 4.7.2).

Result: Geo-referenced information and GIS-compatible maps of distribution/intensity.

1a. In this example, the human activities are:

- Installations/ coastal fills
- Municipal effluents
- Aggregate extraction
- Fishing
- Oil & gas extraction
- Wind-farms
- Shipping

1b. Which are expected to cause the following pressures:

- Loss of habitat (installations/ coastal fills, aggregate extraction),
- Physical disturbance to seabed (bottom trawling, sedimentation from drilling),
- Contamination (drilling fluids, accidental oil discharges, municipal discharges),
- Organic enrichment (aquaculture, municipal discharges)
- Removal of species (fishing),
- Noise (wind-farms, shipping)

1c. In the sub-region, the area is characterised according to Table 1 of Annex III of the Directive:

Physical and chemical features:

Two discrete areas are identified, characterised by major differences in salinity regime:

1. Low salinity, muddy sediments
   - Comprises a semi-enclosed water body

[28] In case you have the paper version of the report you can find the link to the attached Excel spreadsheet in the electronic version in JRC Publications Repository: http://publications.jrc.ec.europa.eu/repository/

- Low currents, relatively sheltered from wave action
- Ranges from sandy and rocky shores to shallow muddy coastal sediments
- Little depth variations

2. Full salinity, range from:
    - coastal zone (mixed sediments),
    - shelf (mud, with some gravelly banks),
    - slope (mixed sediments, strong down-slope currents)
    - deep-sea (mud sediments, some bathyal features e.g. vents, mud-volcanoes etc.)

Habitat types:

Based on the above, the following habitat types are identified:

Low-salinity

- Intertidal/ nearshore habitats. Mostly sandy shores but some rocky areas.
- Coastal pelagic habitats. Seasonal fluctuations in salinity and nutrient contents – algal blooms prevalent during parts of year.
- Coastal benthic habitats. Mostly homogenous muddy sediments, some minor topographical anomalies e.g. ridges, pockmarks etc. High organic loading; eutrophication effects and development of sediment hypoxia in the most sheltered areas.

Full-salinity

- Intertidal/ nearshore habitats. Mostly rocky shores, but some sandy beaches in sheltered bays.
- Coastal pelagic habitats. Upper water layer highly stratified in spring (snow-melt), dynamic vertical mixing/upwelling processes in e.g. autumn, particularly in fjords, inlets and bays. Varying degrees of winter sea-ice formation, depending on location.
- Coastal/shelf benthic habitats. Mostly muddy sediments, topographical features include gravelly banks with high productivity and dynamic vertical export processes, pockmarks and ridges. Shelf break areas comprise slopes with mixed sediment types, high down-slope currents (with carbon advection) and underwater canyons (dynamic seasonal upwelling processes where deep-water is conveyed onto the shelf);
- Deep-sea habitats (for practical purposes defined by ISO 16665 as below 750 m, due to considerations in sampling gear). Mostly muddy sediments, features include mud volcanoes and hydrothermal vents. Some areas support *Lophelia* cold-water coral reefs.

Special habitat types:

- Habitat types are recognised by the Birds and Habitats Directives include cliffs (bird colonies) and mearl beds.
- Habitats recognised as being under intense or specific pressures are identified (see Task 1b for distribution of these):
    - Coastal/nearshore benthic habitats
    - Shelf benthic habitats
    - Cliffs or other breeding bird habitats
- Habitats recognised as being of strategic importance are identified as being those which are similar to those under pressure, but which are under protection regimes. These are valuable reference areas.

Other features:

A number of harbour areas are listed as being of particular concern due to previously recorded high levels of contaminants (e.g. PCB). Fish and shellfish in these areas are considered unsafe for human consumption.

Particular to the area is marked variations in the relative distributions of two main water masses, leading to marked fluctuations in the composition of the pelagic flora and fauna. This is due to climatic fluctuations, but needs to be taken into account during the monitoring programme.

1d.Ongoing monitoring programmes

These are documented in a metadatabase, containing details of monitoring parameters, frequency and geo-referenced sampling stations. In this example, the following monitoring programmes are identified:

- Petroleum activities – baseline survey before start-up; 3-yearly follow-up monitoring after production. Parameters: benthic infaunal biodiversity, sediment geo-chemistry, organic content and contaminants. Water column monitoring during sensitive periods.
- Municipal effluents – monitoring carried out in connection with Water Framework Directive, in addition to individual needs. Monitoring parameters generally include benthic infaunal biodiversity, sediment geo-chemistry, organic content, nutrients and contaminants. Periodicity as a minimum determined by WFD, but increased if required after assessment of monitoring results.
- National monitoring programmes for biological diversity and habitats. Annual monitoring of seabird colonies. Once-off mapping of seafloor habitats by side-scan sonar, visual methods and spot-sampling by grab/trawl.

Preparatory Task 2. Identify biodiversity components present in the region or subregion

A list is made of:

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

See Section 5.4 for guidance.

Preparatory Task 3. Define ecologically-relevant assessment areas

For this example, the sub-region is divided into two areas based on the salinity regime:

- Area 1: low salinity
- Area 2: full-salinity.

Preparatory Task 4. Define reference state (condition)

Defining reference states has a general and a specific component.

General: for the components of biological diversity present within the assessment area, existing background knowledge of their unimpacted state (i.e. as would be expected according to 'prevailing physiographic, geographic and climatic conditions') should be compiled;

Specific: reference values for indicators used within the monitoring programme needs to be defined in conjunction with Phase 5 Assessment and reporting.

See Section 4.7.2 for guidance.

<u>Preparatory Task 5</u>. Define targets

Defining target states has a general and a specific component.

General: decisions made as to how much deviation from reference conditions can be permitted in relation to each criterion.

Specific: setting target values for indicators needs to be done in conjunction with Phase 5;

Examples of specific targets may be:

- Species distribution (range & pattern):
    - species continues to occur in all areas where formerly known
    - acceptable proportion of extinct and/or new grid squares occupied (changes in pattern can be assessed in terms of whether the changes in distribution have been random or directional)
- Population abundance: mean over monitoring cycle not statistically different from long-term mean.
- Mortality rate: does not exceed a defined percentage as by-catch from fisheries
- Habitat quality: noise levels do not exceed levels known to negatively affect selected species, across more than a defined proportion of the assessment area.

See Section 4.7.2 for guidance.

<u>Phase 1</u>. Prioritise where to monitor.

Based on the information compiled through the Preparatory Tasks, the following monitoring sites are prioritised:

Area 1: low-salinity area

- Soft-bottom sediment habitats (priority on areas shown to be developing hypoxic conditions)
- Nearshore sediments (in vicinity of municipal effluents)
    - done in synergy with ongoing monitoring programmes, municipal and WFD.
- Water column – nearshore and coastal (risk of nutrient loading/ toxic algal blooms)
- Reference areas for all the above – representative habitats in MPAs where available, otherwise as non-pressured as possible.

Area 2: full-salinity area

- Soft-bottom shelf sediments (monitoring sites positioned where highest intensity of trawling, aggregate dredging and petroleum activities)
  - For petroleum activities, done in synergy with ongoing monitoring programmes.
- Coastal and pelagic water column (in major shipping zones)
- Coastal soft-bottom sediments (in highest intensity aquaculture areas)
  - Done in synergy with ongoing aquaculture monitoring programmes
- Shore areas in vicinity of largest-scale windfarm area and where a recent coastal oil spill occurred.
- Reference areas for all the above – representative habitats in MPAs where available, otherwise as non-pressured as possible.

Phase 2. Prioritise what to monitor

Phase 2.1. Identify components of biological diversity at risk

For each of the biological components and features documented through the Preparatory tasks, a listing is made of those *which are at risk from the pressures* documented at the prioritised monitoring sites (Phase 1).

For the example given for Phase 1, the following biodiversity components may be considered.

- Soft-bottom shelf and coastal sediment habitats
  - Benthic fauna: infauna (organisms living mostly buried within sediments), epifauna (organisms moving over, or protruding above the sediment) and hyperbenthos (organisms living within the sediment-water boundary zone).
  - Note – benthic fauna is an important food source for bottom-feeding animals, such as crabs, fish, certain marine mammals and birds.
- Water column habitats
  - Phytoplankton, zooplankton, fish, mammals, birds
- Nearshore habitats
  - Priority may be intertidal macroalgae, intertidal fauna susceptible to contamination, e.g. whelks, birds which nest on coastal cliffs etc.

The subsequent phases of the monitoring programme are illustrated for two prioritised components of biological diversity; birds and soft-bottom shelf sediments. The relevant attributes and criteria, which shall be “in line with prevailing physiographic, geographic and climatic conditions” are as follows (see Section 4.5):

	Birds	***Soft-bottom shelf sediments***
2.2. Components and risks		
Attribute	Species state	Habitat/community state
Criteria	Species distribution Population size Population condition Habitat distribution, extent and condition	Habitat distribution Habitat condition Community condition
Relevant risk in monitoring area	Loss of habitat (wind-farm, installations/coastal fill) Noise (wind-farm)	Physical disturbance to seabed (bottom trawling, sedimentation from drilling), Contamination (drilling fluids, accidental oil

	Contamination (oil spill, municipal effluent)	discharges)
2.2. Risk of targets not met	Targets for all species state criteria may not be met in the immediate vicinity of wind-farms, installations or coastal fills (permanent habitat loss; permanent noise disturbance)	In areas of ongoing dredging or trawling, targets for habitat/community condition may not be met until activities decline Targets for habitat distribution and extent considered to be under little risk

Phase 3. Select indicators

For the prioritised components to be monitored, the appropriate type of monitoring and indicators are selected. See Section 4.7.5 for further considerations.

	Birds	***Soft-bottom shelf sediments***
3.1. Type of monitoring	State monitoring	State monitoring linked to pressure (i.e. state of biodiversity in habitats under pressure, compared with those not under pressure)
3.2 Select indicators	*Criterion: species distribution* Distributional range and pattern – E.g. number of 10km squares of coastline occupied by colonies and at sea occupied by a species at a particular time of year e.g. winter *Criterion: population size* Population biomass & abundance (number), – Abundance of breeding birds – Density of bird aggregations at sea *Criterion: population condition* Population demography – Body size or age class structure – Sex ratio – Fecundity rates and survival rates o Breeding success (no. of young fledged per pair) *Criterion: habitat condition* Habitat distributional range, pattern & extent	*Criterion: habitat distribution* Not considered at risk: no indicator needed *Criterion: habitat condition* Habitat structure (and associated physical characteristics, incl. structuring species) – Sediment structure (granulometry) – Sediment chemical conditions (organic content, C:N ratio in coastal areas, oxygen, nutrients and contaminants as appropriate) *Criterion: community condition* Taxon composition (e.g. sampled by quantitative gear) – Community structure – Relative proportions of higher taxa – Range of functional traits etc. – Relative population abundance of selected species (e.g. indicator species)

	Habitat physical, hydrological & chemical condition – Proxy indicators of habitat condition may include e.g. plankton or fish availability	

<u>Phase 4</u>. Evidence collection (monitoring)

	Birds	***Soft-bottom shelf sediments***
4.1 Define sampling techniques, strategy and periodicity	Periodicity may depend on region – Annual sampling programme is part of national programmes in North Sea countries.	Guidance on designing sampling strategies are given in ISO 16665, as well as guidance documents by ICES, HelCom etc. Periodicity is determined by results of first sampling and knowledge of developments in pressures - see Phase 6 (Programme of measures) and Phase 7 (Adaptive management).
4.2 Undertake evidence collection programme	Carry out sampling and analysis in accordance with defined programme.	Carry out sampling and analysis in accordance with defined programme.

<u>Phase 5</u>. Assessment and reporting

Conclusions made as to a) proximity to GES and b) direction of change. If possible, also the rate of change. Conclusions made on progress towards (or away from) GES.

Because assessment of indicator results vary markedly across regions, specific examples are not given here. Sections 3.3 and 4.7.7 give guidance on assessing state and proximity to GES and reporting.

Phase 5.1.
Assessing state and proximity to GES comprises the following process:

- Defining specific reference levels and targets
- Assessing state
- Assessing direction, rate and causes of change
- Determining status in relation to GES

Phase 5.2.
Reporting will be carried out at the defined intervals and according to an agreed format.

<u>Phase 6</u>. Programme of measures

Appropriate remedial actions defined where GES targets are not yet achieved, and advice on environmental management strategies given.

To be decided by Member States, or in regional conventions, based on the assessment in relation to targets.

Phase 7. Adaptive management

Adjusting the spatial and temporal intensity of a) the monitoring programme and b) the programme of measures in accordance with observed changes in biological diversity relative to GES.

Awaits outcome of monitoring and measures to define what changes may be required.

Outline of a GIS approach to tools for assessment

Some initial considerations of how assessments could be made for each assessment area and contribute to an overall assessment at the Region/Subregion scale are discussed below. Note the GIS concept is integral to the initial phases of the monitoring and assessment cycle (see Figure 4-3 and Figure 4-5).

In order to handle eleven descriptors and an undefined number of indicators describing ecological elements as well as human activities and pressures some sort of flexible geographic assessment system could be developed. Among other things, it should reflect the following:

a. The descriptors and associated indicators will potentially operate at various geographic scales ranging from almost site-specific to covering more than one Marine Region. A flexible, hierarchical geographic system with the capability to merge information from different "layers" might provide a practical solution.
b. The main geographic layers would be: Marine Region, Subregion and any potential Subdivisions. In order to ensure the ecosystem-based approach to management these could, e.g. as demonstrated by HELCOM, be split into relevant biogeographic units/divisions.
c. These biogeographic units could be further divided by a flexible geographic grid system with variable grid size depending on the resolution of the information available (environmental and socio-economic) as well as the activities to be managed. This would typical result in smaller coastal grid cells and larger off-shore grid cells.

The strength of such a system is a follows:

a. It would enable the use of information available from any given locality without requiring that the same information was available for all cells.
b. It operates at the scale necessary for individual components (uses and environmental). For example, it could inform specific site related activities and at the same time compile information from a larger area (by compiling information from several cells).
c. It would encompass any differences that might exist in monitoring data between Member States sharing a Marine Region, while at the same time enable a status assessment.
d. It would allow the use of both actual measured data and modelled data.
e. It would allow for local (site) specific targets and, at the same time, allow for Region-wide targets.
f. It would inform the Programme of Measures by identifying where pressures occur and how much individual activities contribute to the cumulative pressure on specific ecosystem components.
g. It would enable a simple and illustrative measurement of progress towards GES in a Marine Region. For example, for each grid cell a certain percentage of indicators (or specific indicators) should achieve the targets for GES. Similarly, a certain percentage of cells within the biogeographic division/Subregion/Marine region should be in Good Environmental Status for the Marine Region to achieve GES. It would be up to the Member States sharing a Marine Region to specify such a percentage as part of the environmental target setting.
h. It would allow the identification of where any challenges for improvement in environmental conditions might remain and thus inform the management actions required.

The principles outlined above would require further development towards the initial assessment.

Relationship between pressures and ecosystem components

Table 8.1 *Indicative relationship between ecosystem components and pressures from human activities. Coloured (orange) cells indicate which pressures are most most likely to affect each component. Annex I Descriptors and Annex III characteristics (Table 1) and pressures (Table 2)in the Directive are shown against relevant components and pressures.*

			Pressure theme	Climate change	Hydrological changes			Pollution and other chemical changes						Physical loss & damage				Other physical pressures			Biological pressures					
				See note 1	Temperature changes	Salinity changes	See note 2	Non-synthetic compound contamination	Synthetic compound contamination	Radionuclide contamination	Introduction of other substances (solid, liquid or gas)	Nutrient enrichment, incl. deoxygenation	Organic enrichment	Physical loss	Physical removal (of substratum)	Physical damage	Siltation rate changes	Litter	Underwater noise, electromagnetics, light	See note 3	Visual disturbance	Genetic modification & translocationa	Introduction or spread of non-indigenous species	Introduction of microbial pathogens	Removal of species (target & non-target)
		MSFD Annex III Table 2	Pressure themes		Interference with hydrological processes			Contamination by hazardous substances			Systematic and/or intentional release of substances	Nutrient & organic matter enrichment		Physical loss	Physical damage			Other physical disturbance			Biological disturbance					
			Pressures		Changes in thermal regime	Changes in Sal. regime		Non-synthetic substances	Synthetic compounds	Radio nuclides	Introductio n of other substances	N & P-rich substances	Inputs of organic matter	Smothering: Sealing	Selective extraction	Abrasion	Changes in siltation	Marine litter	Underwate r noise			Non-indigenous species & transloc-ations		Microbial pathogens	Selective extraction of species
		MSFD Annex I	Pressures Descriptor		D7. Hydrography			D8. Contaminants D9. Contaminants in fish and other seafood				D5. Eutrophication		D6. Seafloor integrity				D10. Litter	D11. Energy				D2. Non-indigenous species		D3. Commercial fish & shellfish
	Ecosystem components	Annex III Table 1 characteristics	State Descriptor																						
Ocean and atmospheric processes	Air-sea exchanges	-		orange																					
	pH	pH, pCO2		orange																					
	Temperature regimes	Temperature regime & ice cover		orange	orange																				

			Pressure theme	Climate change	Hydrological changes			Pollution and other chemical changes						Physical loss & damage				Other physical pressures			Biological pressures				
				See note 1	Temperature changes	Salinity changes	See note 2	Non-synthetic compound contamination	Synthetic compound contamination	Radionuclide contamination	Introduction of other substances (solid, liquid or gas)	Nutrient enrichment, incl. deoxygenation	Organic enrichment	Physical loss	Physical removal (of substratum)	Physical damage	Siltation rate changes	Litter	Underwater noise, electromagnetics, light	See note 3	Visual disturbance	Genetic modification & translocationa	Introduction or spread of non-indigenous species	Introduction of microbial pathogens	Removal of species (target & non-target)
	Salinity regimes	Salinity																							
	Current & mixing regimes	Current velocity, upwelling, mixing characteristics, residence time																							
	Wave regime & sea level	Wave exposure																							
	Water clarity	Turbidity																							
Water and sediment (chemical) quality	Nutrient levels & balance (N/P)	Nutrients (DIN, TN, DIP, TP, TOC)																							
	Oxygen levels	Oxygen																							
	Levels of other chemicals & heavy metals	-																							
	Radio-nuclide levels	-																							
Highly mobile species	Cephalopods	-																							
	Fish	Fish populations																							
	Cetaceans	Marine mammals & reptiles																							
	Seals																								
	Turtles																								
	Birds	Seabirds																							

			Pressure theme	Climate change	Hydrological changes			Pollution and other chemical changes						Physical loss & damage				Other physical pressures			Biological pressures				
				See note 1	Temperature changes	Salinity changes	See note 2	Non-synthetic compound contamination	Synthetic compound contamination	Radionuclide contamination	Introduction of other substances (solid, liquid or gas)	Nutrient enrichment, incl. deoxygenation	Organic enrichment	Physical loss	Physical removal (of substratum)	Physical damage	Siltation rate changes	Litter	Underwater noise, electromagnetics, light	See note 3	Visual disturbance	Genetic modification & translocationa	Introduction or spread of non-indigenous species	Introduction of microbial pathogens	Removal of species (target & non-target)
Pelagic habitats/ communities	Low salinity water	Phytoplankton, Zooplankton (Water column habitats)	D1 D4	■	■	■	■	■	■			■	■										■	■	
	Reduced salinity water			■	■	■	■	■	■			■	■										■	■	
	Estuarine water			■	■	■	■	■	■			■	■										■	■	
	Coastal water			■	■		■	■	■			■	■										■	■	
	Shelf water			■				■	■			■	■										■		
	Oceanic water			■																					
Seabed habitats/ communities	Littoral habitats	Seabed habitats & biological communities (angiosperms, macro-algae & invertebrate bottom fauna)	D1 D3 D4 D6	■	■	■	■	■	■			■	■	■	■	■						■	■		■
	Shallow sublittoral habitats			■	■	■	■	■	■			■	■	■	■	■	■					■	■		■
	Shelf habitats			■			■	■	■			■	■	■	■	■	■						■		■
	Bathyal habitats			■												■									■
	Abyssal habitats			■																					
Ice habitats	Ice-associated habitats	Habitats & biological communities	D1	■				■	■												■				■
Marine landscapes	Coastal features	Topography & bathymetry of seabed	D1 D4 D6	■	■	■	■							■	■										
	Shelf features			■			■							■	■										
	Deep-sea features			■																					

Note 1 - Climate change pressures: Atmospheric climate change; pH changes; Temperature changes; Salinity changes; Water flow changes (tidal & ocean currents); Emergence regime changes (sea level); Wave exposure changes

Note 2 - Hydrological changes : Changes in water flow, emergence regime, wave action & water clarity

Note 3 - Other physical pressures: Barrier to species movement, Death or injury by collision

Overview of relevant international monitoring standards

Relevant standard guidelines developed within ISO and/or CEN are as follows:

EN ISO 19493:2007	Water quality -- Guidance on marine biological surveys of hard-substrate communities
EN 14011	Water quality - Sampling of fish with electricity
EN 14962	Water quality - Guidance on the scope and selection of fish sampling methods
EN 14996	Water quality - Guidance on assuring the quality of biological and ecological assessments in the aquatic environment
EN 15204	Water quality - Guidance standard on the enumeration of phytoplankton using inverted microscopy (Utermöhl technique)
EN 14757	Water quality - Sampling of fish with multi-mesh gillnets
EN ISO 16665	Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna (ISO 16665:2005)
EN ISO 19493	Water quality -- Guidance on marine biological surveys of hard-substrate communities
prEN 15972	Water quality - Guidance on quantitative and qualitative investigations of marine phytoplankton
Working draft	Water quality— Visual seabed surveys using remotely operated and towed observation gear for collection of environmental data
Working draft	Water quality — Guidance on use of in-vivo absorption techniques for estimation of chlorophyll concentration in marine and fresh-water sample
prEN 15910	Mandated: Guidance on the estimation of fish abundance with mobile hydroacoustic methods.

European Commission

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Abstract

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

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

A Task Group was established for each of the qualitative Descriptors. Each Task Group consisted of selected experts providing experience related to the four marine regions (the Baltic Sea, the North-east Atlantic, the Mediterranean Sea and the Black Sea) and an appropriate scope of relevant scientific expertise. Observers from the Regional Seas Conventions were also invited to each Task Group to help ensure the inclusion of relevant work by those Conventions. This is the report of Task Group 1 Biological diversity.

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