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Background document on an overview of marine biodiversity indicators in the framework of EU Directives and Regional Sea Conventions

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Summary

The Marine Strategy Framework Directive (MSFD) establishes a framework within which Member States must take the necessary measures to achieve or maintain good environmental status (GES) in the marine environment by the year 2020 at the latest (EC, 2011). GES shall be determined on the basis of the qualitative descriptors that are listed in Annex I of the Directive. A series of criteria in relation to each descriptor have been specified for assessing the extent to which GES is being achieved. The criteria are accompanied by a list of related indicators to make such criteria operational and allow measuring subsequent progress (EC, 2010). However, for a number of criteria and indicators the need for further development and additional scientific information has been identified. Member States have the responsibility to determine the characteristics of GES and establish targets and associated indicators.

The Regional Sea Conventions have monitoring programmes in place to collect data and information on the state of their marine environment, including biodiversity related issues. These data are used to produce a number of assessments and reports that are published periodically. In addition, some of the Conventions have adopted core sets of indicators and ecological objectives to support the process of measuring progress against their targets.

This background document compiles the indicator related activities within the MSFD, and the different biodiversity related data, parameters and indicators developed under the Regional Sea Conventions and other initiatives. The purpose of the document is to support future discussions on the potential use of existing marine biodiversity indicators in the context of the SEBI set and the EU Biodiversity Strategy.

1 Introduction

The goal of this background document is to get an overview of the developments of indicators related to marine biodiversity in the framework of the EU Directives and the Regional Sea Conventions. The implementation of the EU Marine Strategy Framework Directive (MSFD) has led to the development of a number of activities on marine indicators; the links with the Regional Sea Conventions are also part of the current discussions. This overview should also contribute to prepare an update and/or improvement of the SEBI set of indicators and to complete the assessment of the EU Biodiversity Strategy.

2 Descriptors, criteria and indicators in the framework of the MSFD

The MSFD establishes a framework within which Member States must take the necessary measures to achieve or maintain good environmental status (GES) in the marine environment by the year 2020 at the latest (EC, 2011). The definition of criteria for achieving GES is the starting point for the establishment of a comprehensive set of environmental targets and for the determination of characteristics of GES (EC, 2010). Member States have the responsibility to determine the characteristics of GES and establish targets. However, the determination of GES may have to be adapted over the time taking into account the dynamic

nature of marine ecosystems, their natural variability and the variability of pressures and impacts on them in relation to human activity and climate change (EC, 2010).

In the framework of the MSFD the following definitions are considered (EC, 2008):

- '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;
- 'Criteria' means distinctive technical features that are closely linked to qualitative descriptors;
- 'Environmental target' means a qualitative or quantitative statement on the desired condition of the different components of, and pressures and impacts on, marine waters with respect of each marine region or subregion.

Other definitions to support a common understanding in the context of this document are (WG GRS, 2011):

- Indicator: a parameter chosen to represent (indicate) a certain situation or aspect and to simplify a complex reality. In the context of the implementation of the MSFD indicators are specific attributes of each good environmental status criterion that can be measured to make such criteria operational and which allow measuring subsequent change in the attribute to be followed over time. Given the complexity of good environmental status descriptors, it is common practice to use a set of indicators to assist in monitoring and to simplify the assessment.
- Index: a statistic which represents an aggregated measurement or calculated derivative of several different parameters, usually determined across different biodiversity components.
- Parameter or metric: a measurable single characteristic. Parameters can be used as simple indicators.

2.1 Descriptors and initial assessments

The MSFD states that GES shall be determined on the basis of the qualitative descriptors that are listed in Annex I of the Directive.

Table 2.1.1 Qualitative descriptors for determining GES

D1	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
D2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
D3	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
D4	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.
D5	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

D6	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
D7	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
D8	Concentrations of contaminants are at levels not giving rise to pollution effects.
D9	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
D10	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
D11	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Source: EC, 2008

The 'Commission Decision on criteria and methodological standards on good environmental status of marine waters (2010/477/EU)' specifies a series of criteria in relation to each descriptor for assessing the extent to which GES is being achieved. The criteria for GES build on EU existing obligations and legislation such as the Water Framework Directive (WFD), which applies to coastal waters, the Habitats Directive, the Birds Directive, a number of instruments developed in the framework of the Common Fisheries Policy and information gathered in the context of regional sea conventions. The criteria are accompanied by a list of related indicators to make such criteria operational and allow subsequent progress (EC, 2010).

Under Article 8 of the MSFD Member States shall make an initial assessment of their marine waters, in respect of each marine region and subregion. The assessment should comprise an analysis of the essential features and characteristics and current environmental status of those waters, and of the predominant pressures and impacts, based on the indicative lists of elements set out in Annex III of the Directive. In addition, under Article 10 of the Directive Member States shall, in respect of each marine region or subregion, establish a comprehensive set of environmental targets and associated indicators for their marine waters so as to guide progress towards achieving GES in the marine environment (EC, 2008).

Initial assessments under the MSFD, for the most part, comprise information generated from reporting carried out under other European commitments such as (WG GES, 2011):

- Water Framework Directive
- Habitats Directive
- Birds Directive
- Nitrates Directive
- Dangerous Substances Directive
- Shellfish Waters Directive
- Bathing Waters Directive
- Analysis of commercial fish stocks carried out by the International Council for the Exploration of the Sea (ICES) and the General Fisheries Commission for the Mediterranean (GFCM)
- Regional Conventions such as OSPAR, HELCOM (especially the HELCOM Baltic Sea Action Plan) , Barcelona and Bucharest Conventions
- Subregional co-operations such as the Trilateral Wadden Sea Cooperation (TWSC); or the Agreement on Cooperation for the Protection of the Adriatic Sea and Coastal Areas from Pollution

In this regard, it was encouraged that in waters with overlapping regimes, the boundary for GES coincides with the boundaries/thresholds of 'favourable conservation status' for the

Habitats directive and 'good ecological status' and 'good chemical status' for the Water Framework Directive. However, it should be noted that good status under the MSFD or the WFD may not be sufficient to meet the specific objectives of the Birds and Habitats Directives (WG GES, 2011).

A rational understanding of the linkages between the determination of GES (according to the descriptors and criteria of Annex I of the Directive) and the initial assessment (along the lines of Annex III) will be needed for pragmatic and efficient monitoring programmes (EC, 2011). Consideration of the criteria and indicators that are relevant for the analysis of current environmental status is essential to identify the most appropriate ones to be used in the first and subsequent assessments (EC, 2011).

2.2 Indicators

The criteria and indicators listed in the Commission Decision (2010/477/EU) generally need to be developed further. Indicators related to the Descriptors broadly assessing state (D1, D3, D4 and D6) require most development. Many of the indicators related to the pressure-based Descriptors are already available for application and can be adopted without further development (WG GES, 2011). In particular, the following areas need further development (EC, 2011):

- Indicators in accordance to the particular species, habitats and ecosystems which will be monitored and in relation to the differing regional characteristics.
- Indicators that focus on the relationships within the food web (e.g. to address energy flow processes, main predator-prey processes, trophic relationships…).
- Indicators for ecosystem assessment for both structural and functional aspects.
- Indicators that integrate complex situations, such as mixed fisheries and cases where ecosystem interactions are important. In relation to the disturbance from fisheries the current approach is based on the concept of maximum sustainable yields, which remains associated to the assessment of individual stocks.
- Non-indigenous species indicators potentially useful to ensure they are operationally applicable in different regions and in relation to the different predominant habitat types, also in relation to vectors and introduction pathways.
- No criteria and indicators have been developed yet in relation to pathogens.
- The development of targets and indicators of underwater noise has been identified as a first priority. Criteria and indicators related to other forms of energy might be developed later.
- Further development is required with regard to standardized methods for monitoring litter which floats, in the water column and on the sea-floor. There is also a need for further development of indicators relating to the impacts of litter.
- The use of certain species as a monitor for plastics in the environment needs to be extended to more regions in the EU.
- One question is whether additional criteria and indicators should be developed in relation to by-catch and discards.
- Microbes and viruses, which play a key role in ecosystem functioning, need further attention.

In relation to the links between monitoring requirements of the MSFD and monitoring requirements under other EU legislation and regional sea conventions, only a few indicators

in the MSFD are not covered by other existing requirements. These indicators are (JRC, 2012):

- 1.3.2 Population genetic structure, where appropriate
- 6.2.3 Proportion of biomass or number of individuals in the macrobenthos above some specified length/size
- 6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community
- 10.1.3 Trends in the amount, distribution and, where possible, composition of micro-articles (in particular micro-plastics)
- All indicators related to Descriptor 11 (11.1.1, 11.2.1)

For the rest of indicators under the MSFD there are relevant monitoring programmes in place under other legislation. However, they often only partially cover the requirements under the MSFD and there are several limitations to their application (JRC, 2012).

The MSFD Good Environmental Status Working Group Technical Report of the Workshop on Biodiversity theme (Descriptors 1, 2, 4 & 6), held in Brussels on 7-8 November 2012, states that 'a set of common biodiversity indicators is under development and contains indicators on marine mammals, birds, fish, benthic and pelagic habitats, non-indigenous species and food webs. The objective is to agree on a first set of common biodiversity indicators in the beginning of 2013' (WG GES, 2012). However, there were no further developments in this regard by the time this background document was produced.

2.3 Monitoring programmes

Monitoring programmes in the framework of the MSFD need to be adaptive to enable appropriate reaction on changes in the marine environment such as climate change, new understanding and emerging issues. They should be designed in a way that they can be easily and timely adapted to changes in the determination of GES, environmental targets, the evaluation of risks and technical and scientific developments (MSFD, 2013).

Relevant monitoring programmes that are already in place in the framework of other policies and conventions, in addition to the ones under the WFD, the Habitats Directive and the Birds Directive, are the following (EC, 2011):

- Monitoring programmes have been established for most commercial fish and shellfish stocks through the Data Collection Framework under the Common Fisheries Policy. However there are considerable differences between (sub)regions and issues in relation to the suitability of some existing data sources.
- In relation to microbial pathogens, two bacteriological parameters have to be monitored by Member States in the framework of the Bathing Water Directive: intestinal enterococci and *Escherichia coli*.
- Monitoring developments in the framework of Aichi Target 9 on invasive alien species of the Convention on Biological Diversity (CBD) Strategic Plan 2011-2020.
- Monitoring activities implemented as part of the MED POL under the Barcelona Convention focus on presenting periodic assessments of the state of the environment in hot spots and coastal areas to determine temporal trends of some selected contaminants.

- In the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP), each country is obliged to undertake ecological monitoring in marine stations.
- In relation to nutrients and organic matter enrichment, for the coastal strip the combination of surveillance, operational and investigative monitoring within the WFD and the Nitrates Directive should provide the fundamental basis for the MSFD purposes with respect to eutrophication.

Monitoring programmes that should be put in place or further developed are listed below (EC, 2011):

- Long-term monitoring programmes to assess trends and distribution patterns in the amounts of litter.
- In relation to contaminants, there are existing monitoring programmes for fish and seafood for public health reasons which generally focus on estimating consumer exposure rather than assessing environmental status; monitoring should link better to the source in the marine environment of the contaminated seafood. Further development work is also necessary to expand the range of target levels to include a greater number of contaminants and biological effects.
- The monitoring of open waters at stations well offshore requires the use of methodologies of ocean observation systems, including satellite remote sensing. A long-term monitoring and research infrastructure is needed, including marine/oceanic observation capabilities that include continuous plankton recorders and long-term fixed stations of data collection for model validation.

3 Monitoring and indicators under Regional Sea Conventions and other initiatives

3.1 Barcelona Convention

In 1975, 16 Mediterranean countries and the European Community adopted the Mediterranean Action Plan (MAP), the first-ever Regional Seas Programme under UNEP's umbrella. In 1976 these Parties adopted the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention).

In 1995, the Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II) was adopted by the Contracting Parties to replace the Mediterranean Action Plan of 1975. At the same time, the Contracting Parties adopted an amended version of the Barcelona Convention of 1976, renamed Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (UNEP MAP, 2013a).

Currently there are 22 Contracting Parties to the Convention aiming to protect the Mediterranean marine and coastal environment while boosting regional and national plans to achieve sustainable development (UNEP MAP, 2013a).

The MED POL Programme (the marine pollution assessment and control component of MAP) assists Mediterranean countries in the formulation and implementation of pollution

monitoring programmes, including pollution control measures and the drafting of action plans aiming to eliminate pollution from land-based sources (UNEP MAP 2013b).

The Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean, adopted in 1995, states under Article 3 point 5 that the Parties shall monitor the components of biological diversity. Under Article 9 Parties shall, in accordance with the rules of international law, adopt planning, management, supervision and monitoring measures for the specially protected areas including the continuous monitoring of ecological processes, habitats, population dynamics, landscapes, as well as the impact of human activities (SPA and biodiversity Protocol, 1995).

The Strategic Action Programme for the Conservation of Biological Diversity (SAP BIO) in the Mediterranean Region also refers to the identification, development, and validation of adequate biological and socioeconomic indicators to assess the ecological health of sensitive habitats and species, and to evaluate the effectiveness of management measures (UNEP-MAP-RAC/SPA, 2003). The Regional Activity Centre (RAC/SPA) in Tunis coordinates the collection of information on biodiversity (UNEP/MAP, 2012).

The State of the Mediterranean Marine and Coastal Environment report (UNEP/MAP, 2012) provides information on the overall nature of the Mediterranean ecosystems and defines recurrent and new pressures – such as aquaculture and desalination – that affect the state of its environment. In doing so it utilizes a number of indicators that could be relevant to biodiversity, which are listed below.

Table 3.1.1 Biodiversity related indicators included in the State of the Mediterranean Marine and Coastal Environment report

Indicator
Chlorophyll-a concentration
Human development and ecological footprint in Mediterranean countries
Industrial hazardous waste in the Mediterranean countries
Tourist pressure on Mediterranean coast
Water stress in the Mediterranean basin (Water Exploitation index and Existing and planned desalination plants)
Maritime transportation routes in the Mediterranean
Fish catch in the Mediterranean Sea sub-regions
Coastal erosion (EU) and fragile ecosystems in the Mediterranean
Organic water pollutant from point sources
Environmental hotspots on the Mediterranean coast
Composition of benthic communities
Mean concentrations of trace metals in sediments and in blue mussels
Mean concentrations of Persistent Organic Pollutants (POPs) in blue mussels
Possible oil slicks detected by satellites
Mean surface productivity and eutrophic and hypoxic hot spots in the Mediterranean
Hypoxia in the Mediterranean Sea
Fertilizer use and nitrogen release in the Mediterranean region
Non-indigenous species: mode of introduction and species detected
Non-indigenous species over the 20th Century: Number of new species detected per decade
Mediterranean Sea fish landings

Aquaculture production in the Mediterranean
Aquaculture in the Mediterranean and Black seas
Demersal destructive fishing in the Mediterranean Sea
Sea level variations in the Mediterranean
Sea surface temperature increase
Biodiversity in the Mediterranean
Number of species in IUCN Red List categories from Mediterranean countries
Sources of environmental impact on the Mediterranean Sea
Mediterranean cumulative impact model

Source: (UNEP/MAP, 2012)

The Regional Activity Centre for Specially Protected Areas (RAC/SPA) and IUCN Centre for Mediterranean Cooperation (IUCN-Med), organized in October 2012 a two-day workshop in Malaga (Spain) to continue guiding the development of indicators for biodiversity impacts in Marine Protected Areas (MPAs) by the threats of climate change (CC) (RAC/SPA, 2012). The preselected indicators are listed below.

Table 3.1.2 List of preselected climate change indicators in marine protected areas

Indicator
SST and thermal stratification
Basic parameters (O2, salinity, nutrients, cl.a)
Acidification (pH, alkalinity, DIC, pCO2)
Phytoplankton abundance
Flowering of Posidonia oceanica
Seasonality of benthic algae species (Cystoseira)
Seasonality of hydrozoans and colonial ascidians species
Reproduction and breeding date of selected species
Phenology of fish early life history stages
Migration date of seasonal species
Mortality and bleaching events
Episodic species outbreaks (blooms)
Range shift of alien / temperature-sensitive species

Source: RAC/SPA, 2012

3.2 Bucharest Convention

The Convention on the Protection of the Black Sea against Pollution (Bucharest Convention) was signed in Bucharest in April 1992, and ratified in the beginning of 1994. The Convention focuses on the control of land-based sources of pollution; dumping of waste; and joint action in the case of accidents (such as oil spills) (EC, 2013a).

The Black Sea Integrated Monitoring and Assessment Programme (BSIMAP) aims to fulfil the monitoring and assessment requirements of the Convention. The monitoring programme should cover the following topics (Black Sea Commission, 2013):

- The quality of the marine environment and each of its compartments, i.e. water, sediments and biota.
- Natural and anthropogenic impacts which may affect the quality of the marine environment.
- Response of the marine environment to naturally occurred or anthropogenically induced changes.

The State of the Environment of the Black Sea (2001 - 2006/7) report contains a number of indicators/data, including some related to biodiversity (BSC, 2008). However, many of the information provided has a very restricted geographical scale.

Table 3.2.1 Biodiversity related indicators in the State of the Environment of the Black Sea (2001 - 2006/7) report

Indicator
Annual-mean sea surface temperature (SST) anomaly changes obtained by *in situ* measurements at 3 nm offshore
Changes of annual-mean, basin-averaged sea surface temperature (SST) anomaly and the North Atlantic Oscillation and the East Atlantic-West Russia climate indices
River Danube annual dissolved inorganic nitrogen (DIN), phosphate ($P\text{-}PO_4$) and silicate (SiO_4) loads into the Black Sea based on the measurements conducted at Sulina
Decadally-averaged changes of surface dissolved inorganic nitrogen (DIN) concentration along the western and eastern coastal waters of the NWS as well as surface $N\text{-}NO_3$ concentration in the Romanian shelf
Decadally-averaged changes of surface dissolved nitrogen (DON) concentration along the western and eastern coastal waters of the NWS
Temporal variations of the subsurface peak nitrate concentration within the interior basin
Decadally-averaged changes of $N\text{-}NO_3/P\text{-}PO_4$ ratios in the Ukrainian and Romanian shelf based on the amalgamated data
Average surface chlorophyll concentration for the northwestern shelf and the interior basin
Long-term variations of spatial coverage of hypoxia in northwestern coastal waters
Changes in summer oxygen saturation values of bottom waters at three locations along the Sf. Georghe transect immediately to the south of Danube discharge zone
Long-term variations of winter dissolved oxygen concentration within the layer of density surfaces σt ~14.45-14.6 kg m^{-3} in the offshore region the eastern coastal waters during 1984-2004 and summer-autumn mean CIL temperature of the interior basin
Total of number of oil spills and amount of oil spilt during 1996-2006 on the basis of data reported by countries to the BSC
Composite map of oil spill anomalies in the Black Sea during 2000-2002 and 2004 based on the images taken by Synthetic Aperture Radars (SARs) of European satellites ERS-2 and Envisat
Mean concentration of total petroleum hydrocarbons in surface waters (0-10m depth) around the Black Sea periphery during 2000-2005
Mean concentrations of total petroleum hydrocarbons in sediments around the periphery of the Black Sea during 1996-2006
Long-term variations of annual-mean phytoplankton biomass (g m^{-3}) averaged over all stations in the Romanian (RO), Bulgarian (BG), Georgian (GE) shelves as well as the coastal northwestern sector of Ukrainian shelf

Long-term variations of summer-autumn mean phytoplankton biomass (g m^{-2}), the mean CIL temperature (C) averaged over all stations within interior basin and mean winter (December-March) sea surface temperature (SST)
Long-term changes in species number contributing to annual phytoplankton biomass along the Bulgarian coastal waters
Long-term changes annual-mean phytoplankton to edible zooplankton biomass ratio along the Bulgarian coastal waters
Long-term change in percentage of biomass of main algal groups in Constanta monitoring station during 1986-2005
Long term annual-mean changes of bacterioplankton abundance in the surface layer of northwestern and Bulgarian coastal waters
Long term monthly-mean changes of bacterioplankton abundance in the surface layer of northwestern coastal waters in the Black Sea
Long-term variations of the annual-mean edible zooplankton biomass in the northeastern basin (g m^{-2}) and the western coast (mg m^{-3})
Distribution of summer edible zooplankton biomass (mg m^{-3}) during 1954-1995
Long-term change of total macrophyte biomass (kg m^{-2}) in the northwestern shelf dominated by small, opportunistic species
Cystoseira spp. biomass at different depths along the northeastern coastal zone during 1970, 1988 and 2005
Temporal changes in species diversity of total macrozoobenthos community in the Romanian pre-Danubian and Constanta sectors and the Bulgarian shelf
Changes in dominant zoobenthos species biomass (g m^{-2}) at the 10-30 m depth range of northeastern Black Sea coast during 1936-2005 period
Total catches of main anadromous, demersal and small pelagic fishes in the Black Sea during 1989-2005
Total catch of main molluscs in the Black Sea in 1989 -2005
Long-term changes of Q-value defined as the ratio of pelagic fish catch (in ktons y^{-1}) to phytoplankton biomass (in mg m^{-3}) as a measure of ecosystem vulnerability to the changes by external stressors

Source: BSC, 2008

3.3 HELCOM

The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area was adopted in 1992 and entered into force in January 2000. The Convention covers the whole of the Baltic Sea area, including inland waters as well as the water of the sea itself and the sea-bed. Measures are also taken in the whole catchment area of the Baltic Sea to reduce land-based pollution. The governing body of the Convention is the Helsinki Commission - Baltic Marine Environment Protection Commission - also known as HELCOM (HELCOM, 2013a).

The HELCOM Baltic Sea Action Plan (HELCOM BSAP) is a programme developed by the contracting parties of HELCOM to restore the good ecological/environmental status of the Baltic marine environment by 2021 (HELCOM BSAP, 2007). It aims to address all the major environmental problems of the Baltic Sea through four segments expressed as goals:

- A sea unaffected by eutrophication;
- A sea unaffected by hazardous substances;
- Favourable conservation status of biodiversity; and
- A sea with environmentally friendly maritime activities.

The biodiversity goal means that biodiversity is restored and maintained and all the elements of the marine food webs occur at normal abundance and biodiversity. The goal applies at three levels: landscape (ecosystem), community and species level. HELCOM has taken the decision to revise its existing monitoring programmes, aiming at joint monitoring fully supporting the indicator-based assessment approach and monitoring of the implementation of the BSAP (Fleming-Lehtinen, 2011).

Table 3.3.1 Preliminary indicators to measure the ecological objectives for nature conservation and biodiversity under the HELCOM BSAP

Indicator
Natural marine and coastal landscapes
Designated BSPAs, Natura 2000 and Emerald site area as percentage of total subregion area
Percentage of important migration and wintering areas for birds within the Baltic Sea area which are covered by the BSPAs, Natura 2000 and Emerald sites
Percentage of marine and coastal landscapes in good ecological and favourable status
Percentage of endangered and threatened habitats/biotopes' surface covered by the BSPAs in comparison to their distribution in the Baltic Sea
Trends in spatial distributions of habitats within the Baltic Sea regions
Thriving and balanced communities of plants and animals
Percentage of all potentially suitable substrates covered by characteristic and healthy habitat-forming species such as bladderwrack, eelgrass, blue mussel and stoneworts
Trends in abundance and distribution of rare, threatened and/or declining marine and coastal biotopes/habitats included in the HELCOM lists of threatened and/or declining species and habitats of the Baltic Sea area
Trends in trophic structure and diversity of species
Trends in the numbers of detections of non-indigenous aquatic organisms introduced into the Baltic Sea
Viable populations of species
Trends in the number of threatened and/or declining species
Abundance, trends and distribution of Baltic seal species compared to the safe biological limit (limit reference level) as defined by HELCOM HABITAT
Abundance, trends, and distribution of Baltic harbour porpoise
Number of rivers with viable populations of Baltic sturgeon
Spawning stock biomass of western Baltic cod and eastern Baltic cod compared to precautionary level (Bpa) as advised by ICES and/or defined by EC management plans
Fishing mortality level of western Baltic cod and eastern Baltic cod, compared to precautionary level (Fpa) as advised by ICES and/or defined by EC management plans
Trends in numbers of discards and by-catch of fish, marine mammals and water birds
Number of entangled and drowned marine mammals and water birds
Number of salmon rivers with viable stocks

Trends of salmon smolt production in wild salmon rivers

Source: HELCOM BSAP, 2007

The indicators and assessment methods under HELCOM will be further developed and refined. The intention is to have a core set of indicators for each HELCOM priority issue in the future. Currently only a demonstration set of eutrophication Core Set Indicators has been developed and work is on-going under the HELCOM CORESET project to develop indicators for hazardous substances and biodiversity (HELCOM, 2013b).

Table 3.3.2 HELCOM demonstration set of eutrophication Core Set Indicators

Indicator
Eutrophication status of the Baltic Sea in 2003-2007
Winter surface concentrations of nutrients
Water transparency
Status of phytoplankton, measured by chlorophyll a
Status of benthic invertebrate communities in the open Baltic Sea

Source: HELCOM, 2013b

In addition, the Baltic Sea Environment Fact Sheets, compiled by scientists in various research institutes around the Baltic Sea, provide information on the recent state of and trends in the Baltic marine environment. The Fact Sheets provide supporting data and information for the core set indicators (HELCOM, 2013c).

The Biodiversity in the Baltic Sea integrated thematic assessment on biodiversity and nature conservation (HELCOM, 2009) can be seen as a contribution to fulfilling the task of developing a common approach and tools for assessing the conservation status of Baltic Sea biodiversity, agreed by the HELCOM Contracting Parties under the BSAP. The report provides a baseline for monitoring progress towards the goals and targets of the BSAP that relate to biodiversity, including indicator based information. However, for several of the indicators used it has not been possible to make a Baltic-wide evaluation because the geographic data coverage is limited (HELCOM, 2009).

The report also includes the results of testing an indicator-based approach to assessing Baltic marine biodiversity based on a set of 22 national case studies and an overall assessment of the Baltic Proper sub-basin (HELCOM, 2009).

Table 3.3.3 Indicators included in the Biodiversity in the Baltic Sea integrated thematic assessment on biodiversity and nature conservation

Indicator
Number of threatened and declining species in the Baltic Sea
Conservation status of the Baltic Sea marine Natura 2000 habitats in comparison to the HELCOM threat assessment (HELCOM 1998)
Mean (average), maximum, and minimum diatom-to-dinoflagellate biomass ratios in February–May in the southern and central Baltic Proper. The dinoflagellate biomass includes all auto- and mixo-trophic species, but excludes heterotrophs
Phytoplankton spring bloom index in the open western Gulf of Finland, northern Baltic Proper and Arkona Basin

Area coverage and intensity of cyanobacterial blooms, as integrated for the Baltic Sea for 1997–2007
Mean biomass (µg C/L) of the cyanobacterium *Aphanizomenon* spp. in June–September in the 1980s, 1990s, and 2000s in different parts of the open and coastal Baltic Sea
Relation between depth distribution of *Fucus vesiculosus* and water transparency in the Baltic Sea entrance area
Maximum depth penetration of *Furcellaria lumbricalis* in different sea areas of the Baltic Sea
Number of Charophyte species in different areas of the Baltic Sea
Present distribution of invasive *Chara connivens* in the Baltic Sea
Modelled distribution of blue mussel on the Vänta litets Grund, Bothnian Sea
Prediction of perch spawning habitats in the southern Quark area
Modelled *F. vesiculosus* distribution in the Askö area, Stockholm archipelago in 1993 and 2006
Biomass of copepods *Pseudocalanus* spp., *Temora longicornis* and *Acartia* spp. in the northern Baltic Proper and in the Gulf of Finland
Wet mass concentration (mg m−2) of *Pseudocalanus* spp., *Temora longicornis*, and *Acartia* spp. in the central Bornholm Basin during summer between 1976 and 2007
Salinity in the upper 3 m
Salinity in the layer between 70 m and 80 m
Temperature in the upper 3 m in July–August
Winter nitrate concentrations (February, March) in the upper 10 m
Reference values and the border between good and moderate (G/M) ecological status in the different subbasins of the open-sea areas in the Baltic Sea depicted as Ecological Quality Ratio (EQR) and the average number of species
Long-term changes in benthic community abundance (individuals per m2) and composition (illustrating species turnover)
Biological traits (BT) at selected stations in the Baltic Sea, expressed as a percentage of the total number of BT identified for the respective main group during 2000–2006
Spawning stock biomass (SSB, in tonnes) and recruitment (age 2, millions) of cod in ICES subdivisions 25–32 and from the mid-1960s
Recruitment (R, age 1 in thousands) and spawning stock biomass (SSB, in tonnes) of the Gulf of Riga herring during 1977–2007
Recruitment (R, age 1 in millions) and spawning stock biomass (SSB, in thousand tonnes) of sprat in the Baltic Sea (ICES SD 22–32) during 1974–2007
Significant trends (Mann-Kendall trend analysis, $p<0.05$) in catch per unit effort (CPUE) of perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) in various localities of the Baltic Sea
Number of stranded (including by-caught) harbour porpoises recorded at the German Baltic Sea coast for the years 1990 to 2007
Numbers of dead porpoises reported from the Baltic Sea by member countries to ASCOBANS in 1950–2005
Numbers of ringed seals counted on ice in the Bothnian Bay, 1988–2007
Numbers of grey seals counted from ground level along the Swedish coast
The mean blubber thickness in 1–3 year-old bycaught grey seals from 1997 to 2007 examined in Sweden

Population of the great cormorant in the western and eastern Baltic
Development of the flyway population and Estonian spring population of the barnacle goose 1959–2008
Number of breeding pairs of barnacle goose in the main Baltic colonies on Gotland and Öland, Sweden
Development of the eider population in Denmark and Estonia during the 20th century
Numbers of wintering Steller's eiders in Estonia and Lithuania, and migrating birds at Hanko-Helsinki, Finland
Development of reproductive parameters of the white-tailed eagle in Mecklenburg-Western Pomerania, 1973–2008
Development of the population of the white-tailed eagle in Baltic Sea littoral countries
Dunlin population in the Baltic littoral countries
Breeding population of the sandwich tern in Denmark, Sweden, Germany, and Poland, 1994–2007
Catch range during the past five years and the current state of selected major Baltic commercial fish stocks
Dynamics of landings of eleven major fish stocks/species in the Baltic Sea from 1952–2006
Magnitude of nitrogen (N) and phosphorus (P) inputs from shipping, including nitrogen deposition from airborne emissions and sewage, and total waterborne and airborne loading of nitrogen and phosphorus to the Baltic Sea
Total oil turnover in major Baltic terminals handling >3 million tonnes (Mt) per year and number of reported accidents for the same time period
Number of illegal oil spills detected by airborne monitoring 1988–2007
Recreational and commercial fisheries of pike and perch in Sweden and Finland in 2006
Integrated classification of eutrophication status based on 189 areas
Total annual emissions (as % of 1990 emissions) of cadmium (Cd), mercury (Hg), and lead (Pb) to air from HELCOM countries in 1990–2006
Mean brood size of white-tailed sea eagle on the Swedish Baltic coast over time
TBT and TPhT concentrations in Baltic Sea water
Temporal trends of HBCDD concentrations (ng g−1 lipid weight) in guillemot eggs in 1969–2005
Number of new alien species observed since the early 1800s in the Baltic Sea (including the Kattegat) and likely vector of introduction
Long-term changes in the Tvärminne area, western Gulf of Finland, in the abundance of zoobenthos described as density (individuals per m2 on y-axis) of the dominant native species (*Macoma balthica*, the Baltic clam, and *Monoporeia affinis*, an amphipod crustacean) and the invasive North American bristle worm *Marenzelleria* spp
Number of alien species recorded (including also those not established in order to illustrate the invasion pressure) in the Baltic Sea according to their area of origin
Hearing sensitivity of marine animals in the Baltic Sea and intensity levels of common activities
Development of the eider bag in Denmark, Finland and Sweden
Quotas and killed grey seals in Finland (excl. Åland) and Sweden during 2000–2008
Overview of marine protected areas (MPAs) in the subregions of the Baltic Sea area, as of January 2009

Size distribution of BSPAs in HELCOM Contracting Parties
Number and size of the designated and managed sites in the HELCOM BSPA database by country
Protection status of Baltic Sea Protected Areas according to national and international legal protection status in HELCOM Contracting Parties
Number and percentage of species reported in the BSPA database
Proportion of the 60 benthic marine landscapes represented within BSPAs
Connectivity between the BSPAs with a 20-km and a 50-km radius indicating 40 km and 100 km, respectively, connectivity distance between the sites

Source: HELCOM, 2009

The MSFD Good Environmental Status Working Group Technical Report of the Workshop on Biodiversity theme (Descriptors 1, 2, 4 & 6), held in Brussels on 7-8 November 2012, states that 'A set of HELCOM biodiversity core indicators have been agreed in principle. There are 4 core indicators for marine mammals, 5 for seabirds, 5 for non-commercial fish, 1 for zooplankton, 5 for benthic biotopes and communities, 1 for non-indigenous species, 3 related to the effects of contamination (fish diseases, reproductive disorders and imposex in snails). The HELCOM core indicators cover most of the MSFD criteria under descriptors 1, 2, 4 and 6, but there are gaps mainly in relation to ecosystem structure and impacts of non-indigenous species' (WG GES, 2012). However, these indicators have not been made available yet on the HELCOM website or related reports at the time this background document was produced.

3.4 OSPAR

The OSPAR Convention for the Protection of the marine Environment of the North-East Atlantic was adopted in 1992. The mission of OSPAR is to conserve marine ecosystems and safeguard human health in the North-East Atlantic by preventing and eliminating pollution; by protecting the marine environment from the adverse effects of human activities; and by contributing to the sustainable use of the seas. OSPAR's work is organized under six strategies, including the Biodiversity and Ecosystem Strategy and the Strategy for the Joint Assessment and Monitoring Programme (EC, 2013b).

The OSPAR Convention contains a general obligation to collaborate in regular monitoring and assessment of the state of the marine environment in the maritime area. In 2010 a renewed Strategy for the Joint Assessment and Monitoring Programme (JAMP) for the period 2010 to 2014 was adopted, which provides a framework for work to develop OSPAR's monitoring and assessment programmes, with a particular focus on supporting the work to implement the EU MSFD. The core marine environmental monitoring activity under the JAMP is the OSPAR CEMP. The CEMP is currently focussed on monitoring of the concentrations and effects of selected contaminants and nutrients in the marine environment. All data collected under the CEMP are reported to ICES (OSPAR Commission, 2013a).

OSPAR publishes Quality Status Reports (QSR) which are comprehensive reports on the quality of the marine environment for the whole North-East Atlantic based largely on the work under the JAMP. The first full QSR for the OSPAR maritime area was published in 2000 and the QSR 2010 (OSPAR, 2010) was launched at the 2010 Ministerial Meeting of the Commission. It summarises the results of the JAMP over the period 2000 to 2010, comparing

the quality of the marine environment with 2000 and providing case study examples of how OSPAR has tackled specific issues (OSPAR Commission, 2013a).

The QSR 2010 includes the results of a pilot assessment approach that aims to determine the status of ecosystems building on the identification and quantification of the main pressures and their cumulative impacts on species groups and habitat types. The pilot provided important insight into the complexity of assessing ecosystems, and the lessons learnt are an essential contribution to the further development of assessment methodologies (OSPAR, 2010).

Table 3.4.1 Biodiversity related indicators in the OSPAR Quality Status Report 2010

Indicator
Changes in the distribution and abundance of marine species in the OSPAR area
Marine acidification in the Kattegat and Norwegian Sea
Reduction of discharges and losses of nitrogen and phosphorus to problem areas reported for 2005 relative to 1985
Annual riverine inputs and direct discharges of nitrogen in the period 1990–2006
Geographical distribution of status and temporal trends in contamination from cadmium, mercury, lead, PAHs and PCBs in biota (fish and shellfish) and sediments
Distribution and temporal trends in contamination from lindane in biota
Atmospheric deposition of lindane
Hexabromocyclododecane in the Arctic
Status of chemical contamination in OSPAR Regions
Annual discharges of total β-activity (excluding tritium) and tritium from the nuclear sector between 1990 and 2007
Average discharges of total α-activity and total β-activity (excluding tritium) from the nuclear sector in the period 2002–2006 relative to the baseline period 1995–2001
Time series of environmental concentrations (1995–2006) for some indicator radio nuclides and matrixes with statistically significant change between assessment and baseline period
Annual discharges of oil from the different sources within the offshore oil and gas industry (1998–2007)
Annual amounts of produced water discharged and injected (2001–2007)
Total use and discharge of chemicals offshore (2003–2007)
Number and total quantities of oil spilled in small (≤1 tonne) and large oil spills in the OSPAR area
Emissions to air from the offshore industry (1999–2007)
Status of fish stocks assessed by the International Council for the Exploration of the Sea (ICES) for which maximum sustainable yield (MSY) is defined
Landings from the North-East Atlantic of demersal fish, pelagic fish, and shellfish over the period 1998–2008
Proportion of stocks where spawning stock biomass and fishing mortality are significantly different in 2007 compared with 1997 for OSPAR Regions I to IV and for the OSPAR area as a whole
Status of ICES assessed stocks (excluding those in the Baltic Sea) for the period 2003 to 2009
Percentage (by weight) of fish >40 cm in length
Finfish and shellfish production in the OSPAR area in 2006
Finfish production in the OSPAR Regions (1998–2006)
Oil spills detected using aerial surveillance in the North Sea in 2008
Trends in the average number of items of marine litter collected on reference beaches in three-month periods in Regions II, III and IV

% of fulmars with more than 0.1g plastic in their stomach
Non-indigenous species in the OSPAR area that have been identified as problematic
Reported information on the distribution of threatened and/or declining coastal and shelf-sea habitats
OSPAR List of threatened and/or declining species adopted in 2003 and the current key pressures with impacts on the species listed
OSPAR List of threatened and/or declining habitats adopted in 2003 and the current key pressures with impacts on the habitats listed
Local sandeel availability to black-legged kittiwakes
OSPAR network of marine protected areas
Distribution of OSPAR marine protected areas by Region

Source: OSPAR, 2010

In addition, Ecological Quality Objectives (EcoQOs) have been developed as tools to help OSPAR and the North Sea Conference process fulfil commitments to apply the ecosystem approach to the management of human activities that may affect the marine environment. Within the concept of a "healthy and sustainable marine ecosystem" for present and future generations, EcoQOs are intended to provide a set of clear environmental indicators stating aspirations for a healthy North Sea as part of the ecosystem approach (OSPAR Commission, 2013b).

The EcoQOs developed so far cover many elements of the ecosystem, including phytoplankton, benthic species, fish, seabirds and marine mammals (OSPAR EcoQOs, 2010). However, the EcoQO system needs to be further developed to provide a more comprehensive coverage of ecosystem components and pressures. Additional EcoQOs are already under development on seabird population trends, threatened and/or declining habitats and marine beach litter (OSPAR, 2010).

Table 3.4.2 OSPAR Ecological Quality Objectives

Ecological Quality Objectives
Healthy seal populations: No decline of greater than 10 % in grey seal pup populations or harbour seal populations over a five-year running mean, taking into account natural population dynamics and trends
Reduce by-catch of harbour porpoises: By-catch rates should be no more than 1.7% of the population
Increase proportion of large fish in the fish community: More than 30 % of fish should be longer than 40 cm
Fish stocks at biologically safe levels: All commercial stocks should be at or above safe levels
Eliminate eutrophication: Dissolved inorganic nitrogen and phosphorus, chlorophyll a, phytoplankton, oxygen and benthic species should not exceed assessment levels
Reduce the level of imposex in dogwhelks and other marine gastropods: Imposex should be below levels indicating negative effects from exposure to TBT
Reduce the number of oiled guillemots: There should be less than 10% of birds found dead or dying which are oiled
Reduce levels of hazardous substances in seabird eggs : Mercury should not exceed reference levels and Organochlorines should not exceed set values
Reduce levels of litter (plastic particles) in fulmar stomachs: There should be less than 10% of fulmars with more than 0.1g of plastic in their stomach

Source: OSPAR, 2010

The OSPAR MSFD Advice Manual and Background Document on Biodiversity is a living document which analyses different approaches to determine GES, set environmental targets and select indicators for MSFD descriptors 1, 2, 4 and 6. It aims at providing a common ground for coordinated and consistent determination of GES and related identification and establishment of indicators and targets within the OSPAR area. The document lists parameters/metrics for the indicators under the MSFD descriptors 1, 2, 4 and 6 and mentions related monitoring programmes (OSPAR, 2012).

3.5 ICES - International Council for the Exploration of the Sea

The International Council for the Exploration of the Sea (ICES) is a global organization that works to enhance ocean sustainability. Its main objective is to increase the scientific knowledge of the marine environment and its living resources and to use this knowledge to provide advice to competent authorities. ICES maintains substantial international databases with long-term data series on marine living resources and the marine environment which are relevant in the process of defining targets and setting thresholds for MSFD indicators. The datasets cover biological communities, biological effects, environmental contaminants, catch statistics and stock assessment, fish eggs and larvae, fish stomach, fish trawl survey and plankton (ICES, 2013).

3.6 BIP - Biodiversity Indicators Partnership

The Biodiversity Indicators Partnership (BIP) is a CBD-mandated global initiative to promote and coordinate development and delivery of biodiversity indicators in support of the CBD, Multilateral Environmental Agreements (MEAs), IPBES, national and regional governments and a range of other sectors (BIP, 2013). BIP proposes a set of indicators to monitor progress towards the CBD Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets, including a number of marine biodiversity related indicators.

Table 3.6.1 BIP marine biodiversity related indicators

Indicators
Number of MSC Certified Fisheries
Coverage of Protected Areas (marine area)
Marine Trophic Index
Proportion of Fish Stocks in Safe Biological Limits
Ocean Helth Index
Cumulative Human Impacts on marine Ecosystems
Red List Index (marine species)
Extent of Marine Habitats

Source: BIP, 2013

3.7 EEA – European Environment Agency

The European Environment Agency (EEA) is an agency of the European Union which provides sound, independent information on the environment. Within its activities it produces

a set of indicators and fact sheets about Europe's environment, including a number of marine biodiversity related indicators. In 2008 it published the report 'Improving EEA marine indicators' (EEA, 2008), which reviews the performance of marine indicators and suggests next steps.

Table 3.7.1 EEA marine biodiversity related indicators

Indicators
Nutrients in transitional, coastal and marine waters (CSI 021/SEBI 015)
Chlorophyll in transitional, coastal and marine waters (CSI 023)
Hazardous substances in marine organisms (MAR 001)
Distribution of marine species (CLIM 015)
Phenology of marine species (CLIM 014)
Ocean acidification (CLIM 043)
Status of marine fish stocks (CSI 032)
Aquaculture production (CSI 033)
Species of European interest (SEBI 003/CSI 007)
Marine trophic index of European seas (SEBI 012)
Invasive alien species in Europe (SEBI 010)
Habitats of European interest (SEBI 005)
Designated areas (CSI 008)
EN15 Accidental oil spills from marine shipping
EN14 Discharge of oil from refineries and offshore installations
Fisheries impact habitats and ecosystems
Fishing fleet capacity (CSI 034)

Source: EEA, 2013

4 Conclusions

A set of indicators have been defined under the MSFD to measure progress towards achieving GES in the marine environment. However, further development of the indicators is needed to make them operational, in particular for the ones assessing state. Most part of the information required for the development of these indicators is being collected through monitoring activities under other EU legislation and Regional Sea Conventions, but there are several limitations to its direct application. Therefore, monitoring programmes will need to be adapted to fulfil the requirements of the MSFD.

The Regional Sea Conventions use data from their monitoring programmes to produce a number of reports and assessments on the state of the marine environment in their respective regions. In general the reports cover biodiversity issues and include parameters/indicators related to biodiversity. However, in many cases the data have limited geographical coverage.

Within the Regional Sea Conventions lists of indicators adopted and in use have been developed so far only by the HELCOM Convention, which has produced a demonstration set of eutrophication core set indicators and is developing core sets of indicators for hazardous substances and biodiversity. OSPAR EcoQO cover many elements of the ecosystem including phytoplankton, benthic species, fish, sea birds and marine mammals and others are under development for seabird population trends, threatened habitats and marine beach litter. The

BIP has also proposed a number of indicators related to marine biodiversity. In addition, the EEA includes marine biodiversity indicators within its set of environmental indicators. The indicators developed/in development under these initiatives could be a good basis for the discussion of an update of the SEBI set of indicators.

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