Baltic Sea Environment Proceedings No. 129A

Development of a set of core indicators:
Interim report of the HELCOM CORESET project

PART A. Description of the selection process

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Disclaimer: This publication does not necessarily reflect the views of the Helsinki Commission. While the ultimate aim is that the set of core indicators will be measured by all Contracting Parties, this interim report should rather serve as expert input to follow up the implementation of the Baltic Sea Action Plan, including the facilitation of the national implementation of the EU MSFD for those Contracting Parties that are also EU member states, according to the role of HELCOM as a platform for regional coordination."

Number of pages: 101

Content

Executive summary

This HELCOM report presents intermediate results and expert advice by the HELCOM CORESET project on the development of core indicators for biodiversity and hazardous substances. The report provides background information, descriptions and justification to the set of proposed core indicators, candidate indicators and supplementary indicators, as well as to the setting of targets for those indicators. The ultimate aim of the core indicators is to enable indicator-based follow-up of the implementation of the HELCOM Baltic Sea Action Plan (BSAP) and facilitation of the implementation of the EU Marine Strategy Framework Directive (MSFD) in those HELCOM Contracting Parties that are also members of the EU. Proposed core indicators will be developed into operationalised, regularly monitored and updated indicator reports, providing assessment data utilisable in HELCOM assessments, and placed on the HELCOM website. This further development will take place in the further HELCOM CORESET process until June 2013.

Amongst hundreds of potential indicators, 15 core indicators were proposed for the assessment of biodiversity and 13 for hazardous substances and their effects. In addition, 23 and 4 candidate, and several supplementary indicators were listed for biodiversity and hazardous substances, respectively. The proposed core indicators fill most of the assessment needs arising from the BSAP and MSFD especially for hazardous substances but not all for biodiversity. For example, an obvious gap is the lack of proposals for underwater habitats and several key functional groups and species of the Baltic Sea have only limited representation in the proposed set. Many of these gaps could be filled in by further development of candidate indicators into core indicators. Candidates are indicators that are considered promising but which at this stage were not proposed as core indicators since they did not fulfil all the set criteria. However, several of the candidate indicators are expected to be developed into core indicators during the project and therefore this distinction should not be focused on too much in this report. Eutrophication core indicators have been developed in a separate HELCOM MONAS process and they are only briefly introduced in this report. Several of the proposed biodiversity indicators however also strongly respond to nutrient enrichment or eutrophication effects.

The ambitious aim to have a common set of core indicators for biodiversity, hazardous substances and eutrophication in the Baltic Sea is within our reach. This report presents the process for the selection of core indicators and reports the first results from this process. The proposed set of core indicators should be seen as an early outcome of the project, presenting frames for further indicator development, whereas more detailed methodologies for the sampling, analyses and computation of indicator values are partly missing and boundaries for good environmental status are suggested only for some proposed indicators or parts of the Baltic Sea.

The HELCOM Baltic Sea Action Plan (BSAP) provides an important starting point for coherent indicator-based approach towards assessing the state of the Baltic environment by defining a common vision for the healthy Baltic Sea divided into four strategic goals that are further specified by a number of ecological objectives. Moreover, the need to follow-up the progress towards the ecological objectives, goals and vision by the use of indicators and associated quantitative targets as was put forward by the BSAP and later the Declaration of the HELCOM Moscow 2010 ministerial meeting provided the basis for the concept of core indicators.

The BSAP and the MSFD have a high degree of coherence and in practice the BSAP can be considered a Baltic Sea's regional response to the MSFD also when it comes to assessment needs. The HELCOM CORESET had a starting point that the approaches to be developed for the BSAP should also be applicable for the MSFD. The goals of the hazardous substances and eutrophication segments of the BSAP, supported by their ecological objectives, well match the corresponding qualitative descriptions of good environmental status in the MSFD. The biodiversity goal of the BSAP consists of three ecological objectives at three different levels of ecosystem organisation, while the MSFD defines the good environmental status related to biodiversity more in detail. There are four qualitative descriptors of good environmental status of biodiversity focusing on different aspects of marine biodiversity: Descriptor 1 addressing biodiversity more in general terms, Descriptor 3 on commercial fish stocks, Descriptor 4 focusing on marine food webs and Descriptor 6 addressing seafloor integrity and benthic ecosystems. The MSFD also provides a finer level of detail for defining the good environmental status descriptors, the criteria of descriptors in the European Commission's decision from 2010. In practice, the ecological objectives of the BSAP and the criteria of the MSFD are the meeting point providing an important grounding for what core indicators have been proposed. In addition, the lists of indicators for these MSFD criteria have also been used as a starting point for HELCOM's core indicators.

The HELCOM CORESET indicator selection process was started by a scrutiny of the assessment requirements arising from the BSAP, MSFD and related documents, including the HELCOM Monitoring and Assessment Strategy. Common principles for the core indicators, their targets and integration methods were created and endorsed at the HELCOM heads of delegation level, which guided the process. These principles included the guidance that each proposed core indicator should have a link to an anthropogenic pressure, it should be backed up by monitoring data or at least a proposal for monitoring, it should have policy relevance and be scientifically justified. The selection process for biodiversity indicators to be proposed as core, candidate or supporting indicators from a large variety of potential indicators was coherently structured. It started by identification of key species, functional groups and predominant habitats and screening of human pressures on those. The following steps included consideration of the common principles and e.g. whether it would be possible to develop a target for the indicator. The selecting of indicators for hazardous substances considered the same common principles but also the availability of thresholds for good environmental status and PBT properties, *i.e.*, persistence in the environment, bioaccumulation in organisms and toxicity.

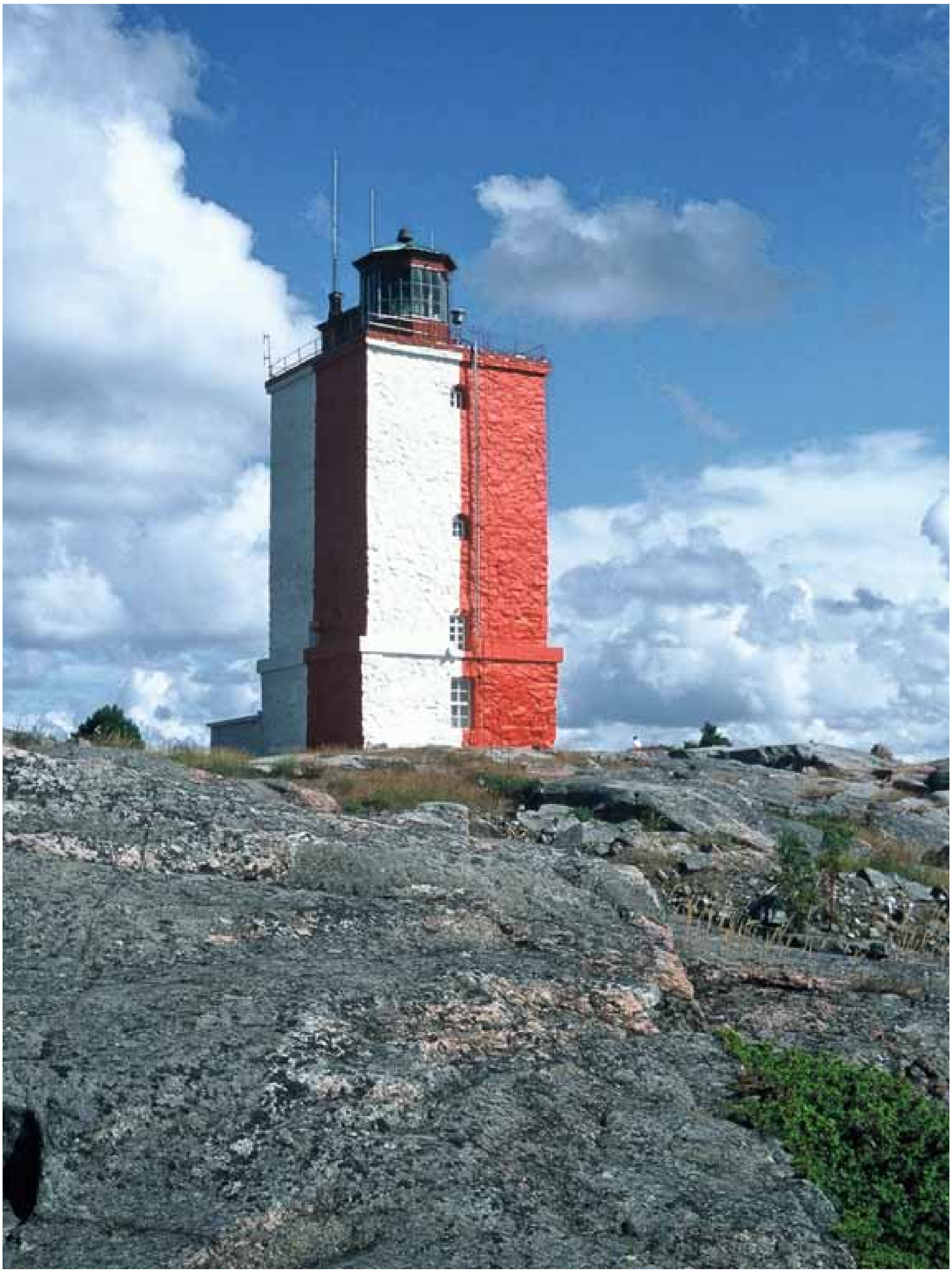
The identified core indicators describing biodiversity included three indicators for marine mammals, two for waterbirds, six for fish and an indicator for both benthic invertebrates and macrophytes. In addition, the CORESET biodiversity expert group developed a core indicator to assess the status of non-indigenous species. In the group of candidate indicators, there are also indicators, which would fill gaps in the assessments of zooplankton abundance, phytoplankton diversity, quality of benthic communities and habitats and abundance of breeding waterbirds.

The report proposes nine core indicators for concentrations of hazardous substances, of which eight are EU Priority Substances or on the final revision list of those. In addition, four of the core indicators are also on the list of HELCOM BSAP. The identified core indicators for the effects of hazardous substances are in use in the Baltic Sea, North Sea and Mediterranean.

The availability of monitoring data was the only criterion where exceptions were allowed with certain conditions. Recognizing that the HELCOM joint monitoring programmes do not currently cover more than a couple of biodiversity parameters and that only a few hazardous substances parameters are mandatory to monitor for all countries, it was agreed that core indicators could be proposed from outside current monitoring programme under the conditions that the parameter is cost-efficient to monitor, guidelines for the monitoring will be proposed and the monitoring will be established in association with the next HELCOM monitoring revision.

The development of core indicators is a process which cannot be completed in a short project. After publishing of this interim expert report, the activities of the project will continue with the aim to have the operational core indicators with full textual reports placed on the HELCOM website by 2012 and the full indicator-based follow-up system of the BSAP ready by the middle of 2013. Although environmental indicators are always simplifications of processes going on in the environment, a jointly monitored set of core indicators will form a firm basis for Baltic wide assessments and facilitate understanding of the linkages of anthropogenic pressures and the state of the Baltic Sea.

1 Introduction



1.1 Background for the HELCOM work on core indicators

In the Baltic Sea Action Plan (BSAP), the Contracting Parties to the Helsinki Convention agreed to periodically evaluate whether the targets of the Action Plan have been met by using indicator-based assessments (HELCOM 2007). The vision of the BSAP – a healthy Baltic Sea – was built on both ecological and management objectives, leaning on a structured and coherent approach for environmental assessments (**Figure 1.1**). Three years after the adoption of the BSAP, the HELCOM Moscow Ministerial Meeting of May 2010 reconfirmed HELCOM's assignment related to environmental assessments:

"this work shall continue to be based on the following common principles:…a common understanding of the good environmental status of the Baltic Sea that we want to achieve by 2021, based on the agreed visions, goals and ecological objectives, and jointly constructed quantitative targets and associated indicators as initiated with the HELCOM Baltic Sea Action Plan"; and

"as practical implementation of the above principles WE DECIDE that core set indicators with quantitative targets shall be developed for each of the segments of the HELCOM Baltic Sea action Plan, while ensuring that the indicators can also be used for the other international monitoring and reporting requirements inter alia the EU Marine Strategy Framework Directive, and that a full indicator-based follow-up system for the implementation of the HELCOM Baltic Sea Action Plan be further developed and placed on the website by 2013" (Moscow Ministerial Declaration).

The EU Marine Strategy Framework Directive (MSFD, Anon. 2008) – adopted a year after the BSAP – reiterated the need for the protection, sustainable management and restoration of the Baltic and other European seas. The directive *inter alia* specified assessment requirements, listed predominant pressures on marine ecosystems and widened the assessment requirement to include socio-economic impacts. It also defined qualitative descriptors for the good environmental status (GES) of the marine environment. The MSFD stipulates that GES 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.*" According to the directive, the determination of good environmental status and the establishment of environmental targets should be developed "*in a coherent and coordinated manner in the framework of the requirement of regional cooperation*" (Anon. 2010, see also MSFD, Article 6).

Assessments of the environmental status of the Baltic Sea have, however, been carried out already long before the BSAP and the MSFD. HELCOM periodic assessments have been elaborated since the early years of the convention (HELCOM 1986, 1990, 1996, 2001, 2003). HELCOM has also established a variety of indicator fact sheets published on the HELCOM website since 2002; however, only the most recent thematic assessments were based on quantitative indicators and environmental targets reflecting good environmental status. The thematic assessments of eutrophication, biodiversity and hazardous substances (HELCOM 2009 a, b, 2010 a) were all based on indicators and their integration through assessment tools. The HELCOM initial holistic assessment of the ecosystem health of the Baltic Sea 2001-2006 (HELCOM 2010 c) integrated the thematic assessments and provided a baseline to follow-up the effectiveness of measures under the BSAP.

The thematic and holistic assessments were the first steps towards fully coordinated assessments since they largely relied on commonly agreed data, indicators, environmental targets and assessment methods (see Section 4.1 and Glossary for definition of target in this report). The experience from the assessment work - as well as the need to cost-efficiently focus monitoring and assessment

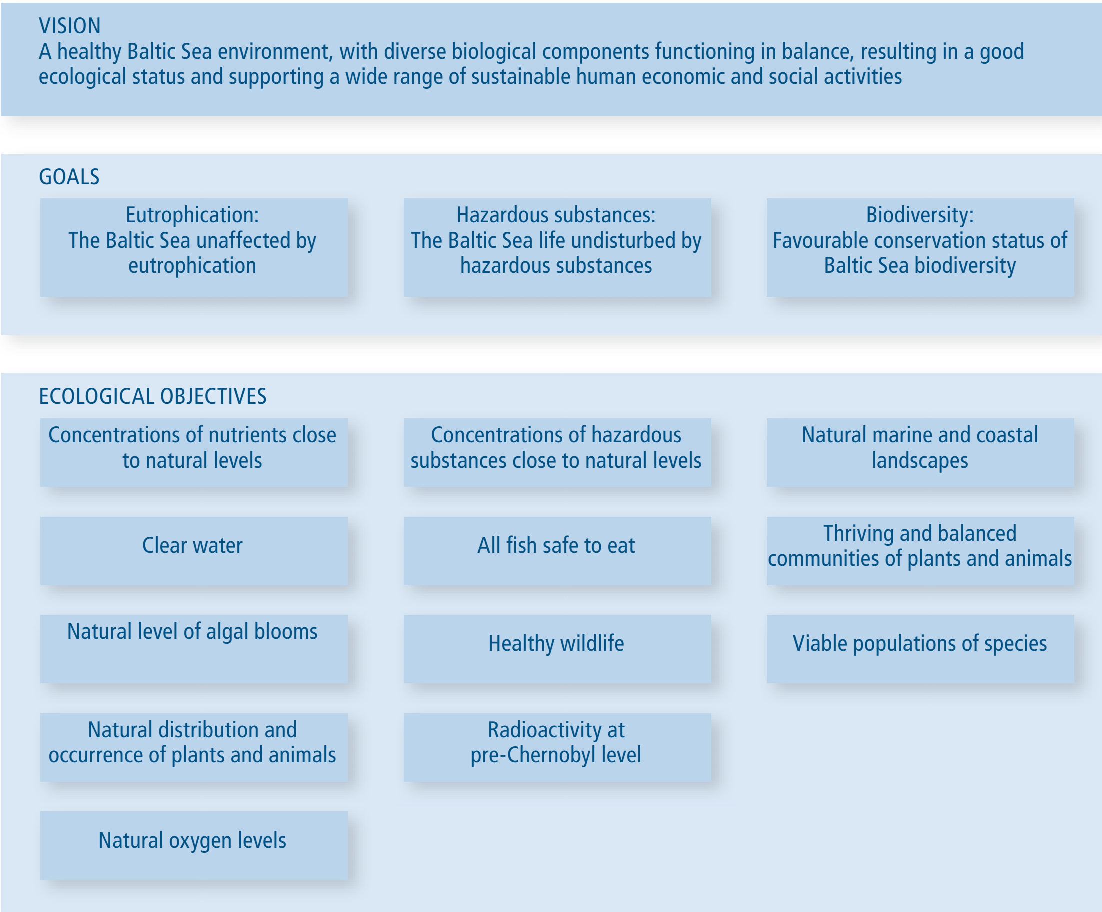


Figure 1.1. HELCOM's vision for a healthy Baltic Sea. The vision is divided into four goals, subdivided into ecological objectives. Each ecological objective is measured by core indicators. The vision, ecological objectives and core indicators measure the state of the Baltic marine environment. Further, behind each core indicator there are indicators for the underlying pressure(s) ensuring a closer link to human activities. The aims of the maritime activities are not included separately in the status assessments.

activities - inspired HELCOM to develop a set of core indicators representative for the entire region, and which can be used to evaluate the effectiveness of the implementation of the BSAP. The requirements for the implementation of the MSFD, e.g. regional cooperation among EU Member States sharing a marine region or subregion, provides an additional policy driver to continue the development of regional indicators.

The HELCOM CORESET project for the development of core indicators for hazardous substances and biodiversity started in June 2010. The work on eutrophication core indicators had begun earlier under HELCOM MONAS and ran parallel to the CORESET project. The tight implementation schedule of the MSFD forced the project to aim at the delivery of preliminary indicators with GES definitions already in September 2011. The project, however, runs until June 2013 and is tasked to operationalise the core indicators and prepare an assessment for the forthcoming follow-up meetings of the BSAP. **Figure 1.2** presents the expected time line of the HELCOM CORESET activities during 2011-2013.

1.2 Objectives of this report

This report is an interim outcome of expert work in the HELCOM CORESET project. It describes the process of selecting core indicators and approaches to develop quantitative boundaries for good environmental status (GES). In addition, the report suggests which indicators could be further developed into core indicators. The indicators are tentatively classified into core indicators, candidate indicators and supplementary indicators although many of them still lack detailed methodology or regionally adapted GES boundaries.

The primary objective of this report is to describe the process of developing the selection of core indicators and the justification for their choice. The report: depicts the assessment strategies of the BSAP and MSFD; presents the process of selecting and refuting the indicators; discusses different possibilities for defining the boundary of good environmental status (GES); and identifies gaps - both in terms of knowledge and in meeting the demands of the BSAP and MSFD with the proposed core indicators. The report also aims at facilitating the future work of indicator development and motivating the work towards further improved environmental assessments.

The core indicators presented in this report are not yet products that can be utilised by the Contracting Parties; nor do they cover all ecological objectives of the BSAP or descriptors of the MSFD. They represent a frame for indicator selections – reflecting impacts of the main anthropogenic pressures on selected key species, functional groups or predominant habitats. Hence, the set of core indicators presented in the report have caveats which the next CORESET activities will focus on. More detailed methodologies for sampling, analyses and indicator calculation, as well as a regionally representative definition of GES for the indicator, will be developed within the project before the core indicators are proposed to be adopted by the HELCOM Contracting Parties.

The first part of this report (Part A) focuses on the selection process of the core indicators and only generally presents the identified indicators. The second part (Part B, HELCOM 2012 a) presents the core and candidate indicators, as well as some supplementary indicators in more detail.

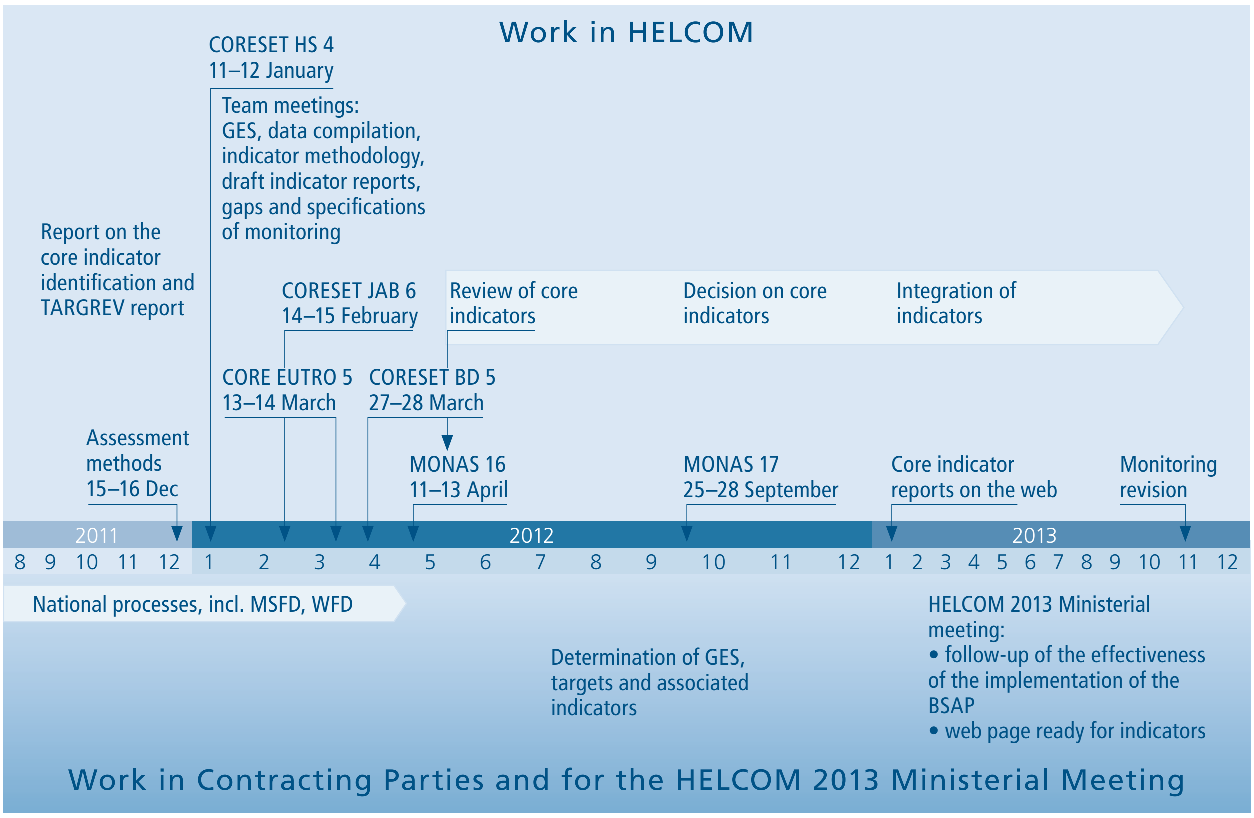


Figure 1.2 **Short-term time line of the activities in the development of core indicators to the assessments of the Baltic Sea marine environment.**

2 What is a core indicator?

2.1 Framework of the core indicators

The HELCOM core indicators are designed so as to enable the follow-up of the effectiveness of the Baltic Sea Action Plan and to measure the progress towards good environmental status of the Baltic Sea, including coastal and transitional waters. Core indicators form the critical set of indicators which are needed to regularly assess the status of the Baltic Sea marine environment against targets that reflect good environmental status.

The set of core indicators is based on the HELCOM Baltic Sea Action Plan, where the vision of a healthy Baltic Sea is divided into four strategic goals, each of which is further divided into ecological objectives (**Figure 1.1**). The full indicator-based follow-up system is due to be placed on the HELCOM website by 2013.

The core indicators aim to allow the assessment of the current status and the tracking of progress towards achieving GES. They are designed to measure the distance from the current environmental status of the Baltic Sea to GES and the HELCOM ecological objectives, goals and vision.

At the goal level, a number of indicators – grouped under the ecological objectives (HELCOM 2009 b, 2010 a) or quality elements (HELCOM 2009 a) – are required to assess the status in an integrated and reliable manner. The integration should be made using assessment tools such as the HELCOM assessment tools, which provide a good basis for the thematic and holistic integrations of indicators, even if they are still subject to further improvement. The preliminary core set of eutrophication indicators and their integration with the HELCOM eutrophication assessment tool (HELCOM 2009 a) provides an example of the way how the core indicators can be integrated to provide a thematic assessment over a certain time period. At the vision level, the core indicators should be developed in a coherent manner in such a way that they could all be used for holistic indicator-based assessment, e.g. with the HOLAS assessment tool (HELCOM 2010 c).

To date, while the HELCOM thematic assessments have used indicators similar to the concept of core indicators, the maturity of the indicators has varied considerably. For example, the eutrophication indicators were much further developed than many other indicators and have since been developed into a preliminary core set available at: http://www.helcom.fi/BSAP_assessment/en_GB/main/. Hazardous substances indicators, on the other hand, were not harmonised over the region but had a more advanced and reliable confidence evaluation than the eutrophication indicators. As the thematic assessment of biodiversity lacked a common and harmonised agreement on indicators and quantitative targets, it only contributed to a pilot indicator-based assessment; for this reason, the results were considered preliminary.

The driving policies for developing a set of core indicators are the HELCOM BSAP as well as the EU Marine Strategy Framework Directive (MSFD), which is of importance for those HELCOM Contracting Parties that are EU Member States. One of the objectives of the HELCOM CORESET project is to develop the HELCOM core indicators in such a way as to ensure coherence among them and coherence with the requirements of the MSFD to assess GES, taking account of the GES descriptors and the criteria and indicators for each descriptor contained in the European Commission Decision on criteria and methodological standards on GES (2010/477/EU, Anon. 2010). The descriptors and criteria provide the foundation for defining good environmental status according to the MSFD (Anon. 2010). **Chapter 3** of this report describes how HELCOM ecological objectives align with the GES descriptors. **Chapters 6, 7 and 8** present the relationships between the identified core indicators and the GES criteria.

The core indicators are also linked to other EU directives: the Water Framework Directive (WFD; Anon. 2000) and the Priority Substance Directive (PSD; Anon. 2008 b). The PSD provides quantitative targets for hazardous substances, while the results of the geographical intercalibration process under the WFD were followed, to a large extent, in setting the quantitative targets of the HELCOM eutrophication core indicators. In addition, the EU Habitats Directive (Anon. 1992) and the Birds Directive (Anon. 2009) provide important frameworks for the development of core indicators and the definition of GES.

2.2 The need for new principles

The concept of core indicators implies that the assessment results are comparable across the region and over time, and that the commonly agreed set of indicators can be used in the whole Baltic Sea area. This requirement implicates that the indicators must be based on common principles. A further need for common principles arises from HELCOM's general aim to harmonise assessment procedures for the whole Baltic Sea region and from the EU legislation. This requires coherence, coordination and cooperation within marine regions when developing targets and associated indicators, and when assessing the status of the marine environment.

Although the HELCOM core indicators were primarily developed to assess the effectiveness of the implementation of the Baltic Sea Action Plan, their other objective is to facilitate the work of those Contracting States who are also EU Member States in the implementation of the MSFD. In this role, the core indicators were aligned with the EU MSFD descriptors as defined through criteria and indicators of Commission Decision 2010/477/EU (Anon. 2010).

In HELCOM, common principles for core indicators, quantitative targets and assessment methodologies mainly exist on the basis of the previous work to develop common methodological standards. Such activities are:

– the HELCOM Monitoring and Assessment Strategy (2005);
– the HELCOM Data and Information Strategy (2005);
– the HELCOM COMBINE programme and associated COMBINE manual, as well as PLC and MORS-PRO monitoring programmes with associated guidelines;
– the Indicator Fact Sheet Procedures (2004);
– the common approaches in the thematic assessments (2006, 2009a, b, 2010a) and the initial holistic assessment (2010b); and
– the MONAS intersessional work for developing the demonstration set of eutrophication core indicators (2008-2011).

The core indicators thus have a good basis in earlier HELCOM decisions and on-going work; however, with the core indicator concept, their principles require common agreement. The new principles can thus be seen as an upgrade of the above-mentioned agreements, aligning the common principles with the national and European standards, and summarizing the whole set of principles in a harmonised way in a single document.

2.3 Common principles of the core indicators and associated targets

The common principles for HELCOM core indicators and their quantitative targets are outlined in **Tables 2.1 and 2.2.** These principles were developed by HELCOM JAB 1/2010 and 2/2011; agreed upon by HELCOM MONAS 14/2011; and endorsed by HOD 35/2011.

Table 2.1 Common principles for HELCOM core indicators, recalling HELCOM Monitoring and Assessment Strategy, as well as the HELCOM Data and Information Strategy.

1	**Compiled and updated by Contracting Parties.** [1]
2	**Science-based:** Each indicator describes a scientifically sound phenomenon. [1]
3	**Link to anthropogenic pressures:** Status indicators should be linked to anthropogenic pressures and indirectly reflect them, where appropriate, and additional pressure indicators are used and they directly reflect anthropogenic pressures and are tightly linked to human activities.
4	**Policy response:** The indicator measures part of or fully an ecological objective and/or a descriptor of good environmental status. [1]
5	**Suitability with assessment tools:** The indicator can be used with the assessment tools but the assessment tools will be open for modifications as necessary (cf. Table 3).
6	**Suitability with BSAP/MSFD, making best use of the synergies with other Directives and according to the HELCOM Monitoring and Assessment Strategy:** The indicator reflects a component contained in the HELCOM system of the vision, goals and ecological objectives and/or MSFD descriptor.
7	**Qualitative or quantitative with a textual background report:** Indicators, either qualitative or quantitative, are numeric, based on measurements or observations and validated models; they must also have a quantitative target level reflecting the lowest boundary of good environmental status. They also contain a textual background report with interpretation of the indicator results. The report should be published on the HELCOM web site and ultimately should take the form of the three-layered indicator report (cf. preliminary core eutrophication indicator reports) with the main page containing a status map and the main message aimed at decision makers; the second page containing trend information, e.g. for different sub-basins; and the third page containing technical background information and information on the confidence of the assessment.[2]
8	**Baltic Sea wide:** The HELCOM indicators should cover the whole sea area. [3]
9	**Commonly agreed:** The finalised indicators and their interpretation are commonly agreed. among the HELCOM Contracting Parties and HELCOM MONAS is the HELCOM body that should approve the publication of the core indicator reports on the HELCOM web page.
10	**Frequently monitored and updated:** Data underlying the indicators are collected within the HELCOM coordinated monitoring (HELCOM COMBINE, MORS-PRO, PLC) and the indicator reports will be updated preferably annually or at intervals suitable for the measured factor. [1]
11	**Harmonised methodology:** Data in an indicator will be collected using harmonised monitoring, quality assured analytical methods, as well as harmonised assessment tools, according to the relevant HELCOM guidelines or EU standards, such as methodological standards or guidelines for GES under the MSFD to be delivered by the EC, other relevant international standards. [1]
12	**Confidence evaluation:** The indicator and the data must be assessed using common criteria and this confidence evaluation is to be included in the indicator report.

1 Indicator Fact Sheet procedure (HELCOM MONAS 7/2004, paragraph 5.12, LD 9, of the Outcome of the Meeting).
2 Outcome of HELCOM MONAS 12/2009, paragraph 6.13.
3 Some biological indicators may be spatially limited due distribution limits or sensitivity of species and/or biotopes. Such indicators should be flexible to include several species, which measure the same phenomenon (e.g. phytobenthos indicator would include eelgrass, bladderwrack, charophytes and other species, e.g. functional indicators).

Table 2.2 Common principles for quantitative or qualitative targets of core indicators.

1	**Targets need to be developed for each indicator separately.**
2	**Purpose of the status targets:** The target reflects the boundary between GES and sub-GES. The boundary can be based on a specific score (cf. ecological quality ratio, EQS, *sensu* WFD and also used in HEAT and BEAT) that can be derived through the use of an 'Acceptable deviation' from a 'Reference condition'.
3	**Purpose of the pressure targets:** The targets reflecting anthropogenic pressures should guide the progress towards achieving good environmental status.
4	**Science-based:** A target level should be based on best available scientific knowledge. In the absence of data and/or modelling results, expert judgment based on common criteria should be involved to support the target setting.[1]
5	**Spatial variability:** Target levels can vary among sub-basins or among sites depending on natural conditions.
6	**Confidence** of the targets must be evaluated by common criteria and included in the general confidence evaluation of the indicator report.

1 Indicator Fact Sheet procedure (HELCOM MONAS 7/2004, paragraph 5.12, LD 9, of the Outcome of the Meeting).
2 Outcome of HELCOM MONAS 12/2009, paragraph 6.13.
3 Some biological indicators may be spatially limited due distribution limits or sensitivity of species and/or biotopes. Such indicators should be flexible to include several species, which measure the same phenomenon (e.g. phytobenthos indicator would include eelgrass, bladderwrack, charophytes and other species, e.g. functional indicators).

HOD 35/2011 also endorsed a set of common principles for assessment methods; however, they are not the subject of this report and are therefore not presented here.

2.4 The CORESET approach to develop core indicators

The HELCOM CORESET project focuses on producing a concise set of indicators for biodiversity and hazardous substances. The project also followed the work on the development of eutrophication core indicators carried out under the HELCOM MONAS group and the HELCOM TARGREV project. The HELCOM strategic goal - "environmentally friendly maritime activities" - was not addressed by HELCOM CORESET. However, certain issues traditionally considered by the HELCOM MARITIME group, such as non-indigenous species, were included under the CORESET biodiversity expert group.

The project has based its work on the common principles and frameworks of the HELCOM BSAP and the EU MSFD. **Figure 2.1** presents the underlying understanding of the role of core indicators in the HELCOM assessment work: environmental data is refined to indicators, and the assessment needs filter a set of core indicators, which give the hard core to marine assessments. All other indicators can be used to support this set of core indicators.

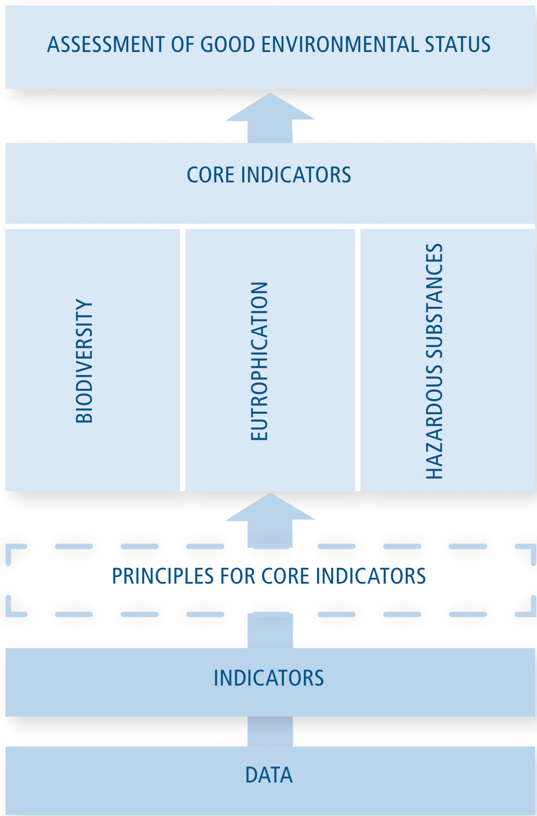
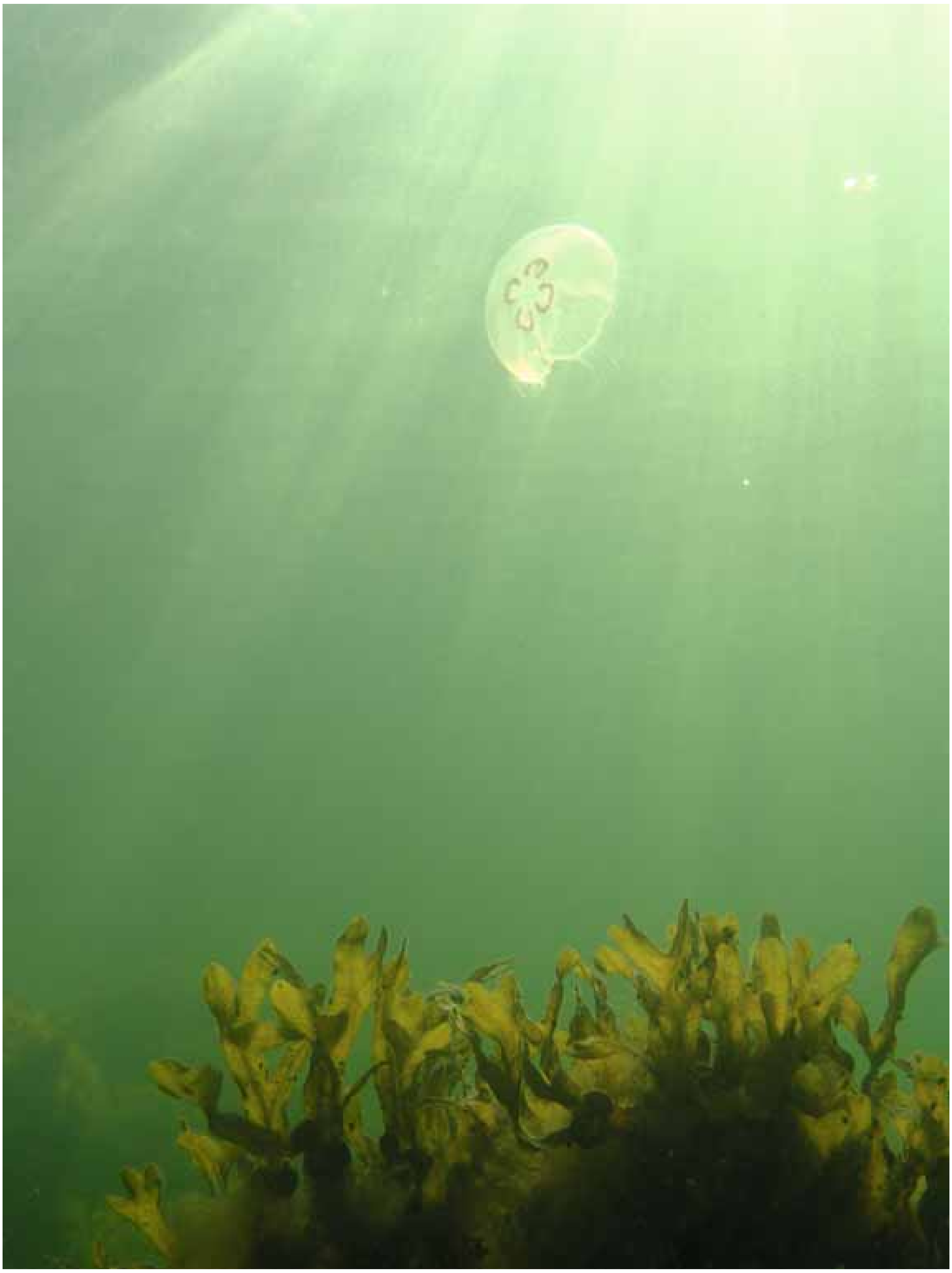


Figure 2.1 HELCOM core indicators represent a selection of indicators from a wider pool of assessments, indicators and data. The set of core indicators are used to assess the environmental status. They must go through a screening protocol to ensure that the HELCOM common principles for core indicators are fulfilled.

3 Are the HELCOM BSAP and the EU MSFD compatible?



According to the MSFD, the EU Member States are to determine a set of characteristics for good environmental status (GES) based on eleven qualitative descriptors listed in Annex 1 of the MSFD (**Table 3.1**). The GES Descriptors 1 (biodiversity), 2 (non-indigenous species), 4 (food webs), 6 (sea floor integrity) and partly 3 (commercially exploited fish and shellfish) are all related to the state of the biological diversity. Descriptors 5 (eutrophication), partly 3 and 7-11 (hydrographical changes, hazardous substances, marine litter and energy/noise) focus on various pressures on the ecosystem. The EC Decision (Anon. 2010) further divides the descriptors to criteria that are mandatory for EU Member States to assess, and indicators that guide the assessment of the criteria.

Table 3.1 Qualitative descriptors of good environmental status according to the EU Marine Strategy Framework Directive (Annex I).

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.
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	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.

Compared to the BSAP, the MSFD GES descriptors cover a wider definition of good environmental status than the BSAP ecological objectives. However, as the BSAP segments, particularly biodiversity, and the associated ecological objectives were only loosely defined in the BSAP, there is no critical difference between the two approaches (**Figure 3.1**). Because of limited resources and time, the CORESET project only focused on developing core indicators for biodiversity and hazardous substances, and cooperated with the HELCOM group developing eutrophication core indicators as well as ICES. However, it was decided that indicators measuring descriptors outside the scope of the project (e.g. noise or litter) can be included in the set of core indicators only if they directly affect the state of the biodiversity, e.g. impacts of noise on marine mammals. The GES descriptors included in the project were: 1, 2, 4, 6, 8 and 9 (see the descriptors in **Table 3.1**). However, the indicators related to fish could also be used partly for Descriptor 3.

Although the time constraints and financial limitations of the CORESET project did not allow the development of core indicators for Descriptors 3, 7, 10 and 11, the HELCOM set of core indicators should aim at covering the whole array of MSFD descriptors and criteria in order to reach a holistic view of the ecosystem. In addition, the initial set of core indicators needs to be revisited to ensure that all aspects relevant for the BSAP and MSFD GES are covered as our knowledge increases. It is noted that some indicators suggested in Commission Dec. 2010/477/EU require further development before they can become operational.

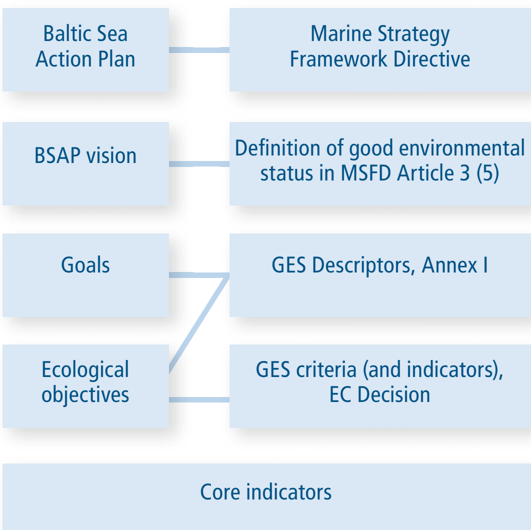


Figure 3.1. Schematic comparison of the assessment requirements of the HELCOM Baltic Sea Action Plan and the EU Marine Strategy Framework Directive.

3.1 An overview of GES criteria and proposed indicators addressed by the CORESET biodiversity expert group

The biodiversity expert group of the CORESET project was tasked to address Descriptors 1 (Biodiversity), 2 (Non-indigenous species), 4 (Food webs) and 6 (Seafloor integrity). It was also agreed that Descriptor 3 (Commercial fish) should not be developed by the project. However, the project includes indicators based on commercial fish species where they relate to the assessment of the other mentioned descriptors. Descriptor 5 (Eutrophication) is addressed by the HELCOM MONAS intersessional work for eutrophication core indicators (see **Chapter 8**) whereas biodiversity related indicators for phytoplankton and other ecosystem components affected by eutrophication have been considered in the CORESET project. Coordination was ensured by information exchange between the MONAS group of eutrophication experts, the TARGREV project and the CORESET project.

Several of the biodiversity descriptors included in the project overlap in terms of GES criteria. The relation between biodiversity and Descriptors 2, 4 and 6 is thus outlined below.

3.1.1 Biological diversity – Descriptor 1

The MSFD describes in its first GES descriptor how the biodiversity of the marine environment in the EU should look like in 2020:

> *"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."*

To describe and assess the marine environment, the MSFD lists physical, chemical and biological characteristics (Annex III Table 1) that shall be taken into account when setting up marine strategies.

According to the EC decision on criteria and methodological standards on the GES of marine waters (Anon. 2010), the assessment of biodiversity should be conducted at three ecological levels: species, habitats (including associated communities) and

ecosystems. In brief, the document outlines the following tasks:

Species: For each region, sub-region or subdivision, a set of relevant species and functional groups should be defined. The assessment at the species level should be based on three criteria: distribution, population size and population condition. The assessment of species should preferentially be linked to an assessment of their habitat. For functional groups of species, the use of the habitat (community) criteria is more appropriate.

Habitats: A habitat is defined by addressing both abiotic characteristics and the associated biological community, treating both elements together in the sense of the term biotope. For each region, sub-region, sub-division, a set of habitat types should be defined. The assessment on the habitat level should be based on three criteria; distribution, extent and condition (including that of the associated communities).

Ecosystem structure: The level of ecosystem structure should be based on one criterion that considers the composition and relative proportion of ecosystem components. Functional aspects of the ecosystem are also important and are partly addressed by descriptor 4 on food-webs.

The proposed indicators of the EC decision for each of the criteria are outlined in **Table 3.2**.

Table 3.2. Proposed GES criteria and indicators to assess GES Descriptor 1, Biodiversity according to EC document 2010/477/EU (Anon. 2010).	
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.	
Species level	
GES Criteria	**Proposed GES indicators**
1.1 Species distribution.	1.1.1 Distributional range. 1.1.2 Distribution pattern within the latter. 1.1.3 Area covered by the species (for sessile/benthic species).
1.2 Population size.	1.2.1 Abundance and/or biomass.
1.3 Population condition.	1.3.1 Population demographic characteristics: (body size or age class structure, sex ratio, fecundity rates, survival/mortality rates). 1.3.2 Population genetic structure.
Habitat level	
1.4 Habitat distribution.	1.4.1 Distributional range. 1.4.2 Distributional pattern.
1.5 Habitat extent.	1.5.1 Habitat area. 1.5.2 Habitat volume.
1.6 Habitat condition.	1.6.1 Condition of the typical species and communities. 1.6.2 Relative abundance and/or biomass. 1.6.3 Physical, hydrological and chemical conditions.
Ecosystem level	
1.7 Ecosystem structure.	1.7.1 Composition and relative proportions of ecosystem components (habitats and species).

3.1.2 Non-indigenous species – Descriptor 2

Descriptor 2 (Non-indigenous species) is partly related to biodiversity (Descriptor 1) but can also be considered as a pressure on the native biodiversity. Nonetheless, non-indigenous species play a significant role in terms of the Baltic biodiversity by decreasing, altering or increasing it. Criterion 2.1 (Abundance and state characterisation of non-indigenous species, in particular invasive species) is a biodiversity indicator in a narrow sense, even though its usability in biodiversity assessments can be questionable. Criterion 2.2 (Impacts of non-indigenous species), on the other hand, is a clear pressure indicator for native biodiversity. **Table 3.3** presents Descriptor 2 and the relation of its GES criteria with Descriptor 1.

Table 3.3. Biodiversity relevant indicators proposed under Descriptor 2.		
Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem		
GES criteria	**Proposed GES indicators**	**Relation to biodiversity criteria**
2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species.	2.1.1 Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non-indigenous species (notably in risk areas) in relation to the main vectors and pathways of the spreading of such species.	Not directly applicable. Invasive species might change biodiversity by filling up niches previously not filled by 'native' species in the young Baltic ecosystem. Thus, there is a relation to D1 by describing species and populations. **State indicator** of non-indigenous species, **Pressure indicator** on other biodiversity components.
2.2 Environmental impact of invasive non-indigenous species.	2.2.1 Ratio between invasive non-indigenous species and native species in some well-studied taxonomic groups (e.g. fish, macroalgae, molluscs) that may provide a measure of change in species composition (e.g. further to the displacement of native species).	Habitat/Community condition (e.g. 1.6.2). Population distribution, size and condition (1.1, 1.2, 1.3).
	2.2.2 Impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible.	An impact/pressure indicator for native species and communities.

3.1.3 Food webs – Descriptor 4

The MSFD criteria for food webs (Descriptor 4) are closely related to the criteria of the biodiversity descriptor. The food web descriptor, however, focuses more on functional aspects than the state and structure of species and communities. An exception is criterion 4.3 (Abundance/distribution of key trophic groups and species) which reflect the state of certain components of biodiversity, but also calls for an identification of a set of key trophic groups and species. **Table 3.4** presents Descriptor 4 and the relation of its GES criteria with Descriptor 1.

Table 3.4. Biodiversity relevant indicators proposed under Descriptor 4.

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

GES criteria	Proposed GES indicators	Relation to biodiversity criteria
4.1 Productivity of key species or trophic groups.	4.1.1 Performance of key predator species (mammals, seabirds) using their production per unit biomass (productivity).	Species/Population condition (1.3.1).
4.2 Proportion of selected species at the top of food webs.	4.2.1 Large fish (by weight).	Species/Population condition (1.3.1) Ecosystem level/Ecosystem structure (1.7.1).
4.3 Abundance/ distribution of key trophic groups and species.	4.3.1 Abundance trends of functionally important selected key trophic groups/ species.	Species/Distribution or Populations size (1.1.2, 1.2.1) and Habitat/Distribution area (1.4.1, 1.4.2, 1.5.1).

3.1.4 Seafloor integrity – Descriptor 6

Descriptor 6 shares elements with the biodiversity descriptor although it is partly focused on human pressures. Criterion 6.2 (Condition of benthic communities) directly overlaps with indicators under Descriptor 1, particularly criterion 1.6 (Condition of habitats and associated communities), while criterion 6.1 (Extent of seabed disturbance) is linked to the distribution and intensity of human activities, thus reflecting pressures for biodiversity components that depend on the seafloor integrity. **Table 3.5** presents Descriptor 6 and the relation of its GES criteria with Descriptor 1.

Table 3.5. Biodiversity relevant indicators proposed under Descriptor 6.

Descriptor 6 Sea floor integrity: 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.

GES criteria	Proposed GES indicators	Relation to biodiversity criteria
6.1 Physical damage, having regard to substrate characteristics.	Type, biomass and areal extent of relevant biogenic substrate.	Habitat distribution (1.4) or extent (1.5).
	Extent of the seabed significantly affected by human activities for the different substrate types.	A measure of the impact on the seafloor.
6.2 Condition of the benthic community.	Presence of particularly sensitive and/or tolerant species.	Habitat/Community condition (1.6.1, 1.6.2).
	Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and species richness as well as the proportion of opportunistic to sensitive species.	
	Proportion of biomass or number of individuals in the macrobenthos above some specified length/size.	
	Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community.	

3.1.5 Differences and similarities between the BSAP biodiversity objectives and the MSFD biodiversity criteria

The biodiversity goal of the BSAP is to reach "a favourable conservation status of the Baltic Sea biodiversity". The expression *favourable conservation status* stems from the EU Habitats Directive (92/43/EEC) and infers that habitats and species should be likely to exist in a foreseeable future. This goal is in line with Descriptor 1 of the MSFD, which stipulates that "biological diversity is maintained".

The biodiversity segment of the BSAP is further described through three ecological objectives:
- Viable populations of species;
- Thriving and balanced communities of plants and animals; and
- Natural marine and coastal landscapes.

Thus, both the HELCOM BSAP and the EU MSFD recognise that biodiversity must be addressed at different levels. In practice, the different levels addressed by the BSAP cover:
- Species - including genetic aspects;
- Communities - including habitat-forming species; and
- Landscapes – including broad-scale abiotic and biotic habitats.

In turn, the MSFD addresses biodiversity at the levels of:
- Species – including genetic aspects;
- Habitats – including abiotic characteristics and associated biological communities; and
- Ecosystem – including the composition and relative proportions of habitats and species.

The BSAP and the MSFD address biodiversity in similar ways with only minor inconsistencies between the two approaches. The MSFD level related to the extent of habitats is, for example, addressed under 'landscapes' in the BSAP scheme. The MSFD level related to the ecosystem structure is not explicitly addressed in the BSAP, although indicators related to the composition of habitats and species composition are, in practice, addressed under 'Communities' in the HELCOM BSAP scheme. The difference between the two approaches does not hinder the development of individual indicators - biodiversity indicators developed under one framework can be used for the other. Thus, the HELCOM CORESET project has been able to fulfil the demands of both frameworks through one process.

In the BSAP, the non-indigenous species (Descriptor 2) have been included under the maritime segment (the management objective *No introductions of alien species from ships*). In the CORESET project, the JAB decided that it should be addressed under biodiversity (see **Section 3.1.2**).

Descriptors 4 (Food web) and 6 (particularly criterion 6.2 Condition of benthic communities) are not separately mentioned in the HELCOM BSAP. Since the definition of biodiversity in the BSAP is wide, the assessment of these descriptors does not create any conflict between the BSAP and MSFD schemes.

3.2 Human-induced eutrophication

GES Descriptor 5 describes the marine environment without human-induced eutrophication:

> *"Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters."*

This Descriptor is comparable to the HELCOM strategic goal for eutrophication: "Baltic Sea unaffected by eutrophication", but less strict.

The EC decision document divides Descriptor 5 into three themes: 5.1 nutrient levels; 5.2 the direct effects of nutrient enrichment; and 5.3 indirect effects of nutrient enrichment (Anon. 2010). The three criteria are broader than the BSAP ecological objectives (**Table 3.6**), but are not in conflict with each other. The BSAP ecological objectives can be categorized in the same scheme as the criteria. A practical difference is that the BSAP ecological objectives are detailed enough to be assessed with only one or a couple of indicators.

Table 3.6. The MSFD GES criteria for eutrophication and the BSAP ecological objectives for eutrophication.	
Descriptor 5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters	
GES criteria	**BSAP ecological objectives**
5.1 Nutrient levels.	Concentrations of nutrients close to natural levels.
5.2 Direct effects of nutrient enrichment.	Natural level of algal blooms.
	Clear water.
5.3 Indirect effects of nutrient enrichment.	Natural distribution and occurrence of plants and animals.
	Natural oxygen levels.

3.3 Hazardous substances

3.3.1 An overview of the MSFD GES Descriptor 8

The MSFD qualitative descriptors for GES include two descriptors (8 and 9) for the status of hazardous substances and their effects (**Tables 3.7 and 3.8**). Descriptor 8 states that "*Concentrations of contaminants are at levels not giving rise to pollution effects*". The descriptor includes two criteria: the concentrations of contaminants and the effects of contaminants. The EC decision on the GES criteria (Anon. 2010) only includes one broad indicator for the criterion 'concentrations of contaminants' (see **Table 3.7**). The indicator obviously comprises several substances in different matrices (e.g. water, sediment and biota) and emphasises that the substance indicators should be comparable with the list of Priority Substances under the Water Framework Directive (Anon. 2000) and the subsequent Priority Substances Directive (Anon. 2008 b), the latter giving environmental quality standards for the priority substances mainly in water. The EC decision further states that other contaminants which are considered significant should also be taken into account.

The criterion 'Effects of contaminants' has been given two indicators (see **Table 3.7**). The first refers to state indicators which measure the effects of contaminants on organisms (e.g. changes in genes, cells, hormonal levels, general health status, reproductive capacity and malformations), populations (decline), habitats (habitat condition) or ecosystem functioning (inter-specific relationships, changes in trophic chain). The second is a pressure indicator, which has a 'state component' referring to the physical effects of polluting incidents.

3.3.2 An overview of the MSFD GES Descriptor 9

Descriptor 9 states that: "*Contaminants in fish and other seafood for human consumption do not exceed the levels established by Community legislation or other relevant standards*." It considers the hazardous substances from the human point of view - hazardous substances need to be assessed against existing EU food safety standards. Food safety standards are usually based on the dose approach which has been transformed to concentrations, assuming an average consumption of fish or other seafood. The proposed GES indicators for this descriptor are given in **Table 3.8**.

The first indicator in the table is conceptually very wide and comprises two components. The first, 'actual levels of contaminants detected', looks at individual substance indicators, which can be many; the second, 'number of contaminants exceeding maximum regulatory levels', summarizes the substance indicators.

The second indicator is related to the previous indicator; however, instead of looking at averages, it focuses on the frequency of 'target exceedances' at the substance level. It can thus be seen as a stricter indicator since averages can sometimes hide significant exceedances of safety standards.

The GES criteria and the proposed indicators for both descriptors are conceptually wide and, thus, permit regional solutions for the indicator development and target setting. The regionally selected set of substances and targets must be comparable with the list of priority substances and target levels given in the community legislation. This does not hinder developing indicators that give additional information, such as DDTs, PCBs and PFOS, which are of special concern in the Baltic Sea but not included in the current EU legislation. This is specifically stated in the EC decision document (Anon. 2010); however, this does not give any inclination of which quantitative targets should be used for such substance indicators.

Table 3.7. Relations of hazardous substances GES criteria and GES indicators under Descriptor 8 and the HELCOM BSAP ecological objectives for the hazardous substances.

Descriptor 8. Concentrations of contaminants are at levels that do not give rise to pollution effects.		
GES criteria	**Proposed GES indicators**	**BSAP ecological objectives**
8.1 Concentrations of contaminants.	8.1.1 Concentration of the above mentioned contaminants measured in the relevant matrix (such as biota, sediment and water) in a way that ensures comparability with the assessments under Directive 2000/60/EC.	Concentrations of hazardous substances at natural levels.
8.2 Effects of contaminants.	8.2.1 Levels of pollution effects on the ecosystem components concerned with regard to the selected biological processes and taxonomic groups where a cause/effect relationship has been established and needs to be monitored.	Healthy wildlife.
	8.2.2 Occurrence, origin (where possible), extent of significant acute pollution events (e.g. slicks from oil and oil products) and their impact on biota physically affected by this pollution.	

Table 3.8. Relations of hazardous substances GES criteria and GES indicators under Descriptor 9 and the HELCOM BSAP ecological objectives for the hazardous substances.

Descriptor 9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.		
GES criteria	**Proposed GES indicators**	**BSAP ecological objectives**
9.1 Levels, number and frequency of contaminants.	9.1.1 Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels.	Safe seafood.
	9.1.2 Frequency of regulatory levels being exceeded.	

3.3.3 Differences and similarities between the BSAP ecological objectives and Descriptors 8 and 9.

The BSAP ecological objective "Concentrations of hazardous substances close to natural levels"

This HELCOM ecological objective is comparable with GES criterion 8.1 of the MSFD (**Table 3.8**). The BSAP and MSFD define the target setting differently - the BSAP states that the target should be 'natural levels' (e.g. for persistent organic pollutants zero) while the MSFD allows the concentrations to reach a level 'not causing pollution effects' (which is considered equivalent to the environmental quality standards). The quality standards developed for the WFD follow the reasoning of 'pollution effects', as they are based on visible effects in sensitive organisms. The HELCOM BSAP, however, gave also "intermediate targets", which can be seen as equals to environmental quality standards. The thematic assessment of hazardous substances used the environmental quality standards as thresholds to define the boundary between good status and moderate status (HELCOM 2010a).

BSAP ecological objective 'Healthy wildlife'

The ecological objective 'Healthy wildlife' is covered by GES criterion 8.2, which measures the effects of hazardous substances on wildlife. The EC decision document (Anon. 2010) and the background document for the hazardous substances in the BSAP[5] do not give specific guidance on the targets that should be used in this case; however, it is clear from the descriptor that pollution effects on organisms or biological processes with well-

5 http://www.helcom.fi/stc/files/Krakow2007/HazardousSubstances_MM2007.pdf

established cause-effect relationships to pollutants should be targeted. This is mainly covered by the first indicator of this criterion in the Commission Decision (Anon. 2010). The second indicator calls for measurements of the occurrence, extent and impacts of pollution effects. In the HELCOM BSAP, some management objectives under the maritime segment also reflect the pressures behind the pollution effects. These are '*Safe maritime traffic without accidental pollution*', '*Minimum sewage pollution from ships*' and '*Zero discharges from offshore platforms*'.

BSAP ecological objective 'All fish safe to eat'

The BSAP ecological objective and GES Descriptor 9 both encompass the safety of seafood for human consumption. In the BSAP, targets for this ecological objective have used the EU food safety standards. There is, however, a difference between the rationales behind the BSAP and the MSFD: While MSFD considers Descriptor 9 to deal only with human consumption, the BSAP also includes fish-feeding marine predators and thus considers the consumption from the ecosystem point of view. In the HELCOM thematic assessment of hazardous substances, a choice was made to limit indicators under this ecological objective to human consumption because of practical reasons. In the MSFD, the top predators are assessed under Descriptor 8.

It should be also noted that the substances under Descriptor 9 are often the same as under Descriptor 8 and the HELCOM ecological objective '*Concentrations of hazardous substances close to natural levels*'. The EU food-related target levels are not as strict as the environmental quality standards because food safety targets assume that humans eat seafood only as part of their nutrition while marine predators consume solely seafood and are thus exposed to much higher levels of contaminants.

BSAP ecological objective 'Radioactivity at the pre-Chernobyl level'

Radioactivity has not been explicitly addressed by the MSFD GES descriptors and/or indicators. However, the MSFD makes it clear that radioactivity should be included in the assessment of pressures (i.e. discharges of radioactive substances as in Annex III, Table 2). In the HELCOM indicator system, the cesium-137 indicator measures the ecological objective for radioactivity. The target for radioactivity in the Baltic Sea has been set by the HELCOM MORS group (for cesium-137 in fish).

In conclusion, the HELCOM ecological objectives and GES descriptors go almost hand in hand in the case of hazardous substances. All indicators in the HELCOM CORESET project can be developed to benefit both purposes. The difference in the rationales behind the BSAP (close to natural levels) and MSFD targets (no pollution effects) was solved by the expert group in their first and second workshops, where it was decided that the target (defining the boundary for GES) will be set on the basis of the MSFD rationale since the quality standards, in practice, are low enough to help progress towards the BSAP target of 'natural levels'.

4 What is good environmental status for an indicator?

4.1 Terms and concepts used in the MSFD

The central objective of the MSFD is to **achieve** or **maintain** 'good environmental status' (GES) of Europe's marine environment by 2020; further, Article 9 stipulates that GES should be determined in each marine region. The criteria for assessing the extent to which GES is being achieved are those outlined in the EC decision document (Anon. 2010) (see **Chapter 3**). The MSFD refers to two status classes: GES and the status below GES (sub-GES). Thus, for each indicator that is chosen to reflect GES, a definition of GES must be established in order to use the indicator in practice.

The MSFD links the definition of good environmental status to the concept of sustainable use:

> *'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 (Article 3 [5]).*

The directive does not further define the term 'sustainable use' in practical terms.

Furthermore, the MSFD stipulates that a comprehensive set of environmental targets and associated indicators should be established (Article 10), where

> *'environmental target' means a qualitative or quantitative statement on the desired condition of the different components of, and pressures and impacts on, marine waters in respect of each marine region or subregion (Article 3 [3]).*

An interpretation of Articles 9 and 10 and the above-mentioned terms is on-going in a WG GES drafting group co-led by Germany, for example, in which several of the HELCOM Contracting Parties are participating. The interpretation was not finalised during the CORESET indicator development.

In the HELCOM common principles for core indicators, the boundary between GES/sub-GES should be defined in qualitative and quantitative terms and is referred to as the 'target' for the selected indicators. However, it should be noted that the word 'target' may be misleading under the MSFD referring to Article 10, and in cases where the status is already in GES and aim should be to maintain the current status, which may be above the target level. Therefore, the term '*GES boundary*' is used synonymously with 'environmental target' and is the preferred expression when related to state indicators.

4.2 Comparison with other classification systems

Environmental assessments aim at giving an evaluation of the state - i.e. whether GES has been reached or not. Preferentially, environmental assessment should also provide information on the direction of change, i.e. whether the state is moving towards or from GES. As indicated above, the MSFD does not define whether a binomial or a more detailed classification should be used, while the EU WFD (Anon. 2000) uses a five-level classification to describe a more detailed status of ecological status in coastal, transitional and inland waters: the acceptable state is described as 'high' and 'good' and the unacceptable classes as 'moderate', 'poor' and 'bad' (**Figure 4.1)**. The HELCOM thematic assessments have used a similar five-class system. For the chemical status in waters up to 12 nautical miles from the baseline, the WFD uses a two-class system (good chemical status achieved / not achieved).

Since the MSFD and WFD overlap in coastal waters, it is important that the interpretation of 'good status' is in agreement between the two directives. The CORESET project has discussed and noted that this is not obviously the case; the WFD defines good status as only 'slightly' deviating from type-specific conditions and communities (2000/60/EC, Annex V, Table 1.2), while the MSFD definition of GES is linked to 'ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions' as well as to 'sustainable use' as presented above. For the time being, however, the project has taken a pragmatic approach and decided that for those indicators that have previously been used in the implementation of the WFD and are now also proposed to be used as core indicators, the GES boundary should be aligned with the good/moderate boundary defined in the WFD. Thus, the range covered by bad, poor and moderate is tentatively considered as representing sub-GES while the lower range limit of good status is considered to reflect the boundary between GES and sub-GES. Likewise, the GES boundary could tentatively be compared to the boundary favourable-unfavourable conservation status used in the Habitats Directive.

MSFD	GES		Sub-GES		
WFD	High	Good	Moderate	Poor	Bad
HD	Favourable		Unfavourable-Inadequate		Unfavourable-Bad

Figure 4.1. Status classification in the Marine Strategy Directive (MSFD); the Water Framework Directive (WFD); and the Habitats Directive (HD) and their possible relationship. Note that the MSFD uses the concept 'Good Environmental Status'; the WFD 'Good Ecological Status'; and the HD 'Favourable conservation status'. Current HELCOM assessment tools use a similar approach as the WFD for good ecological status.

The HELCOM CORESET project drafted qualitative GES boundaries (see **Annex 2**) to facilitate the development of quantitative targets/GES boundaries for the proposed indicators in accordance with the HELCOM common principles of core indicators, targets and indicator integration methods endorsed by HELCOM HOD 35/2011 (**Tables 2.1 and 2.2**).

4.3 Approaches for setting GES boundaries

Discussions on different approaches to determine the boundary between GES/sub-GES have been given dedicated attention at the CORESET project meetings. The HELCOM Secretariat and a number of experts who participate in the CORESET working teams also attended a 'Workshop on approaches to determining GES for biodiversity' that was held In November 2010 by the OSPAR ICG-COBAM group who coordinate biodiversity aspects of the MSFD within OSPAR. The approaches presented below draw on the discussions and conclusions of these meetings.

The approaches setting GES boundaries that have been discussed can be divided into six main categories, of which the five former focus on setting the GES boundary for biodiversity indicators.

4.3.1 Approach 1: Based on an acceptable deviation from a reference condition

In the HELCOM integrated assessment of eutrophication (HELCOM 2009a), the predominant approach to determine good status was to first define a reference condition and second an acceptable deviation from the reference condition which defines the boundary of good/below-good status. This approach is similar to the methods used in the implementation of the WFD that required the establishment of type-specific reference conditions (**Figure 4.2**).

Ideally, the reference condition should reflect the environmental condition when there is a lack of human pressure or it is very low. The reference condition can be based on, for example:

a) existing reference sites or populations that are considered as unimpacted by human pressures;
b) historical records that date back to the time when human pressures are considered as being low or absent; or
c) the output of modelling to derive the unimpacted state (e.g. modelled by using related variables where the reference condition is known).

The main drawback with this approach is the lack of existing unimpacted sites in the Baltic Sea and

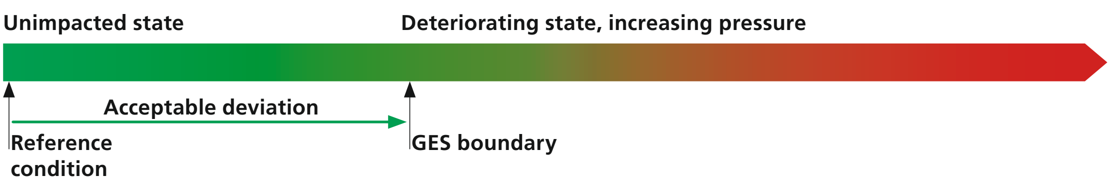


Figure 4.2. Target setting by a reference condition and an acceptable deviation. The unimpacted state is set on the basis of an existing unimpacted condition or a historic unimpacted condition or a modelled unimpacted condition.

historical data that date back to the prehuman impact period. During the COBAM GES workshop, this approach was considered as the most robust for target setting related to seabed habitats, while it was not considered an appropriate approach for mammals, fish, birds and pelagic habitats due the lack of historic data or unimpacted areas. Some old hydrographic datasets exist for the Baltic Sea which can, if appropriate, be used as a basis of modelling.

4.3.2 Approach 2: Based on an acceptable deviation from a fixed reference point/period

When it is not feasible to establish a reference condition, the state at a fixed time point or time period can be defined as a reference state to which future assessments should be related to, for example:

a) to establish a reference period based on the first years or a selected time period in the existing data series; or

b) to establish a reference point based on the current state.

As in approach 1, the GES boundary can be derived by defining a certain acceptable deviation from the reference period/point (**Figure 4.3**). Since the reference period/point typically stems from a time period when human pressures were already present, the acceptable deviation can be expected to be smaller than when using a reference condition as the starting point.

An inherent problem with this approach is that the length of the data series typically varies between organism groups, for example. This may not be a problem when assessing the state of a specific organism group or habitat over time. However, when reference states are derived from different time periods, the GES boundaries for different organism groups and habitats may be incompatible with each other. Nevertheless, the establishment of a reference state at a fixed time point/period was the most commonly used practice in the previous HELCOM pilot studies of biodiversity since relatively long data series (decades) exist for several organism groups.

Defining the reference state as the current state is a practical approach; however, it masks previous deteriorations in the range, extent and condition of habitats and species. Therefore, this approach should preferentially be accompanied with other approaches such as the use of other variables extending farther back in time, modelling, or expert judgment. In such a case, the target should be for no further deterioration and, where appropriate and possible, for improvement in the state. However, as some parameters may show improved environmental status at present (e.g. seal health), this approach may be very appropriate.

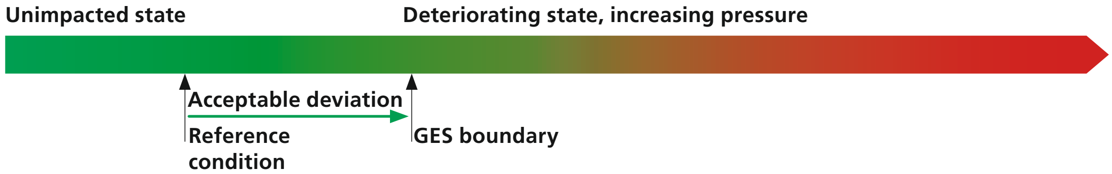


Figure 4.3. Target setting by a reference point/period. The reference point is set as the first point in a data series or as the current time.

4.3.3 Approach 3: Based on an acceptable deviation from a potential state

This type of reference state can be used when an ecological condition, which is required to sustain a certain species or population, is known (**Figure 4.4**). The reference state can be based on, for example:

a) the potential distribution or range, based on physical and ecological conditions and knowledge of the habitat requirements for the species in question; or

b) the potential population size, based on the knowledge of the carrying capacity of the system.

The use of the potential range, population, etc. is one of the recommended approaches for establishing reference values as required by the Habitats Directive. For example, a habitat distribution may increase, if existing pressures are reduced or removed. As for approaches 1 and 2, the target (favourable reference value in the Habitats Directive) is established by defining an acceptable deviation from the potential state.

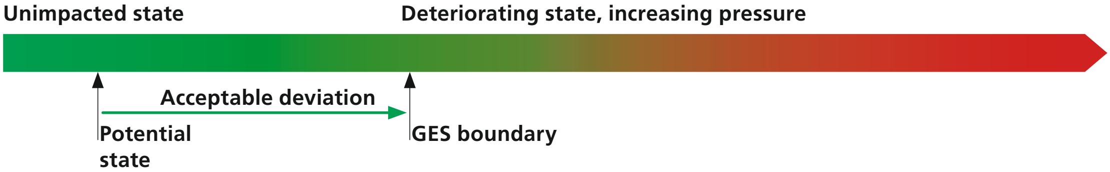


Figure 4.4. Target setting by a potential state. The potential is based on, for example, the physical and ecological conditions and knowledge of habitat requirements or carrying capacity.

4.3.4 Approach 4: Based on the knowledge of physiological- or population-related limitations

When using indicators that are related to the health of a population or the population size, the targets can potentially be set at known limitations related to these features, for example:

a) the average reproduction rate based on the knowledge of healthy populations;
b) population size limitations based on the knowledge of sustainable recruitment levels; or
c) physiological limits to certain physic-chemical conditions such as hypoxia.

This category of targets can be set based on existing knowledge or the modelling of conditions in the absence of significant pressures without defining a reference condition or reference point. This type of target setting has not been widely used in the previous HELCOM assessments. The GES criteria for the Biodiversity descriptor can include targets related to physiology, for example, by including 'condition' among the aspects to be reflected in the indicators (Anon. 2010). The MSFD definition of GES, as linked to sustainable use, also contains the possibility to consider safe biological or precautionary approach limits, for example, as GES boundaries without reference to historic conditions.

4.3.5 Approach 5: Targets based on temporal trends

In many cases, it may be feasible to develop indicators that reflect a change in the environment over a time period; if so, the target may reflect the direction and/or amount of change. As in the previous approaches, the target can be a fixed value (i.e. slope of the change) or a range of values (i.e. a variation of the slope). The advantage of this approach is that 'trend indicators' may be easier to develop and a certain slope of change can be set as a GES boundary on the basis of ecological reasons, political decisions (e.g. the year when GES should be achieved) or for predefined shorter periods (after which the slope will be re-evaluated) such as the MSFD's six-year implementation cycle. The trend-based GES boundaries can also serve as an intermediate approach before exact GES boundaries have been identified and validated.

There are, however, at least three disadvantages which should be considered before applying this approach: 1) in order to set a slope, a target point must be set at the end of the temporal scale (see **Figure 4.5**); 2) the slope target can only be an intermediate target since the change cannot continue forever; and 3) the slope does not explicitly define GES but rather a desired direction towards GES.

A practical solution would be to set an intermediate target that could be used to set the slope of the change.

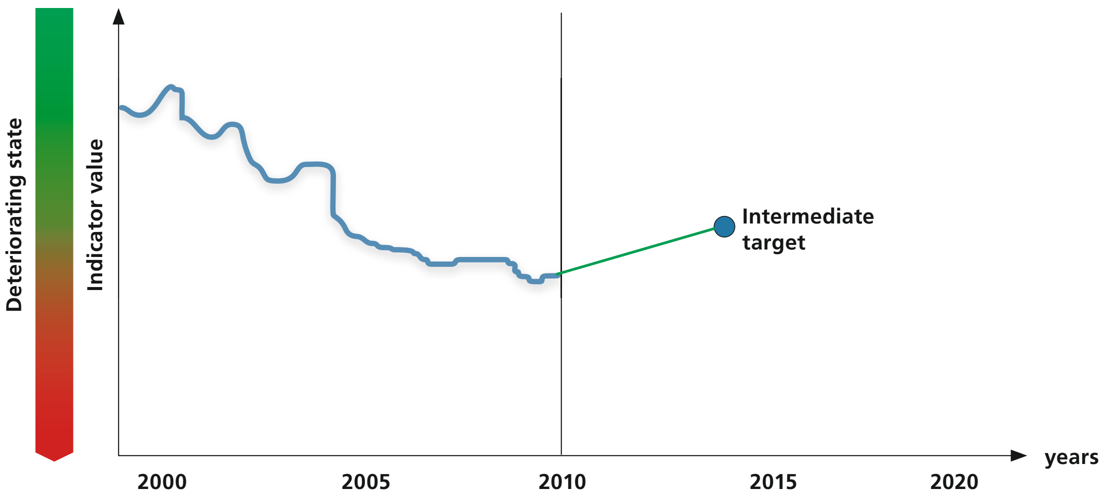


Figure 4.5. Target setting by using slopes of temporal trend curves. The green line reflects progress towards GES; trends below the slope would thus indicate sub-GES and vice versa.

4.3.6 Approach 6: Biological effects on the condition of an organism

GES boundaries can be directly set on the basis of adverse effects of a pressure on individual organisms without using reference conditions and acceptable deviations from it. Although the measurements are made at the organism level, the aim is to follow population-level impacts; for this reason, the approach is highly relevant for target setting in environmental assessments. Even though it is mainly restricted to measure the impacts of hazardous substances, this approach is also applicable to the impacts of noise, marine litter and even changes in the abiotic environment (hydrographical changes, oxygen levels, etc) (**Figure 4.6**).

The target levels in the assessments of hazardous substances follow this approach exclusively. They are based on field and laboratory measurements on the effects of specific substances on viability, reduced reproductive output or other reduced condition of organisms. Such targets include Environmental Quality Standards; specific Quality Standards; Environmental Assessment Criteria; Background Assessment Criteria; and Effect Range Low.

This approach also includes targets for indicators that measure the biological effects of hazardous substances. These indicators, however, do not measure the levels of specific substances; rather, they measure the impacts of a substance, substance group or a mixture of substances on an organism. The effects are measured at the enzymatic, sub-cellular, cellular, tissue, organism or population levels. The organism- and population-level measurements mainly focus on reproductive failures.

4.3.7 GES boundary depends on the type of the pressure response

The previous approaches in this section focused on the linear responses of an indicator to anthropogenic pressures; however, in the environment, a linear response is only one potential response among several others (e.g. unimodal, exponential and S-type). Furthermore, the use of a single target and thus two status classes is based on an assumption of a unidirectional response. However, 'good status' is not necessarily located at one end of a numeric scale. For sprat (*Sprattus sprattus*), for example, a small population size may be a sign of intensive fishing, whereas a large population size may be a sign of low predation by cod - also a bad sign from the ecosystem perspective (**Figure 4.7**). In this case, GES could be defined as a range with sub-GES located at two ends of the numeric scale. This is potentially relevant for a number of indicators - such as population size, biomass and productivity - that are influenced by both bottom-up and top-down processes.

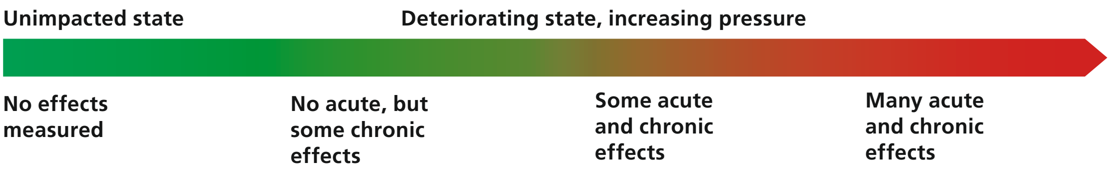


Figure 4.6. Target setting by measuring the effects of a pressure on the condition of an organism. Several of the existing environmental targets have been placed at the level where acute effects do not occur and only few chronic effects are found. The targets are also often set on the basis of their biomagnification in the food chain.

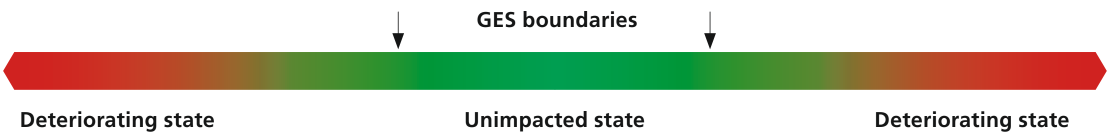


Figure 4.7. Bidirectional response of an indicator to environmental pressures.

4.4 Some general comments on target-setting approaches

It should be noted that when the above-mentioned approaches have been applied, for example in the implementation of the WFD, a combination of approaches were used based on a combination of historic data, statistical approaches and modelling. In addition, an element of expert judgement is usually a component in all approaches. A conclusion from the OSPAR ICG-COBAM GES workshop was that expert judgement plays a valuable and useful role in target setting - although care should be taken to make the process transparent. The latter was also emphasized by the CORESET Joint Advisory Board.

For the three first approaches, it should be noted that while the use of a reference condition, reference point/periods and potential states are useful when establishing the optimal state under given conditions, it is the acceptable deviation that is the pivotal definition. This is because it is this value that determines the GES boundary, taking into account the natural variability of the parameter while allowing for a 'sustainable use of the marine environment', as given in the MSFD.

One of the principles for the core indicators is that HELCOM's core indicators respond to anthropogenic pressures (**Table 2.1**). Ideally, therefore, each indicator should have a specific response gradient to a pressure or a mixture of pressures. On this response gradient, a threshold may exist which can be proposed as the boundary between GES and sub-GES. However, in many cases such thresholds cannot be detected and all too often the relation between the pressures and state indicators is not well established. Therefore, more theoretical approaches need to be used in order to find the boundary for GES. When long-term data sets have been available, a statistical approach - taking natural variation into account - has often been used to determine the boundary between good/below-good status, as in the implementation of the WFD and the recent HELCOM assessments.

4.5 Decisions on GES boundaries by the biodiversity expert group

4.5.1 GES boundaries should not be in conflict with existing policy decisions

The CORESET project has concluded that it is important that GES boundaries are not in conflict with the existing policy decisions. Of direct relevance for biodiversity is the decision in the Baltic Sea Action Plan (BSAP, HELCOM 2007) where the Contracting Parties to HELCOM have provisionally agreed on nutrient load reduction targets that are linked to an agreement on desirable water transparencies in the different sub-basins of the Baltic Sea. The agreed water transparencies can thus be viewed as the target for GES as regards this parameter/indicator. Good status of water transparency was last met in the Baltic Sea during the 1970s and 1980s. In some sub-basins like the Bothnian Sea and Bothnian Bay, water transparency is at good status even today; for this reason, no BSAP nutrient reduction requirements are targeted to them. In the thematic assessment of eutrophication (HELCOM 2009 a), GES for chlorophyll a and inorganic nutrient concentrations have been specifically defined for the sub-basins.

These already agreed definitions of GES may affect several of the indicators discussed in the project, such as the lower depth distribution of macrophytes; the biomass ratio of perennial/opportunistic macrophytes; indicators related to phytoplankton community composition; herbivorous zooplankton; and macrozoobenthic communities.

Biomass targets for spawning stock biomass (SSB) of commercially exploited fish species have been set to safeguard a viable population of a fish population, taking into account annual reproductive and growth parameters. The targets for the maximum sustainable yield (MSY) include the aspect of allowable fishing mortality. These policy advice targets for SSB or MSY will influence large zooplankton biomass/abundance and food web related fish indicators, for example.

The EU Habitats Directive (HD) (Anon. 1992) requires an assessment of favourable conservation status (FCS) of habitats given in the directive. The

GES boundaries of core indicators should not be in conflict with FCS thresholds.

The EU Birds Directive (Anon. 2009) gives objectives for a number of breeding birds in Special Protection Areas (SPAs). Its assessment scale is currently under preparation and will possibly be in-line with the HD-classification system. The Birds Directive does not define GES - it defines the target to maintain all wild living bird species. Adverse effects from human activities shall be avoided and will be part of programmes of measure.

4.5.2 GES boundaries should consider interlinkages between the proposed core indicators

Several of the proposed core indicators within the CORESET project are interlinked with each other, especially those that are related to abundance, biomass or the productivity of species (**Figure 4.8**). For these indicators, it is necessary to analyse whether the proposed definitions of GES are compatible with each other. Ultimately, while the proposed indicators are all linked to each other, examples of obvious interlinkages between indicators discussed during the course of the project are:

- Zooplankton biomass - affected, for example, by chlorophyll a and size of fish stocks consuming zooplankton;
- Relative abundance of cyprinids - affected by chlorophyll a and macrozoobenthos abundance/biomass;
- Relative abundance of piscivorous fish - affected by the population size of prey stocks and seals and predatory seabirds;
- Growth rate of populations of marine mammals - affected by the size and quality of fish stocks; and
- Population abundance of seabirds - affected by the biomass of fish, macrozoobenthos and plants.

Eventually, GES of all the core indicators must be 'calibrated' to ensure that they are compatible with each other. At this time point, such evaluation can only be made based on expert evaluation while, optimally, a dedicated modelling effort should be used to address the compatibility between the GES of different indicators.

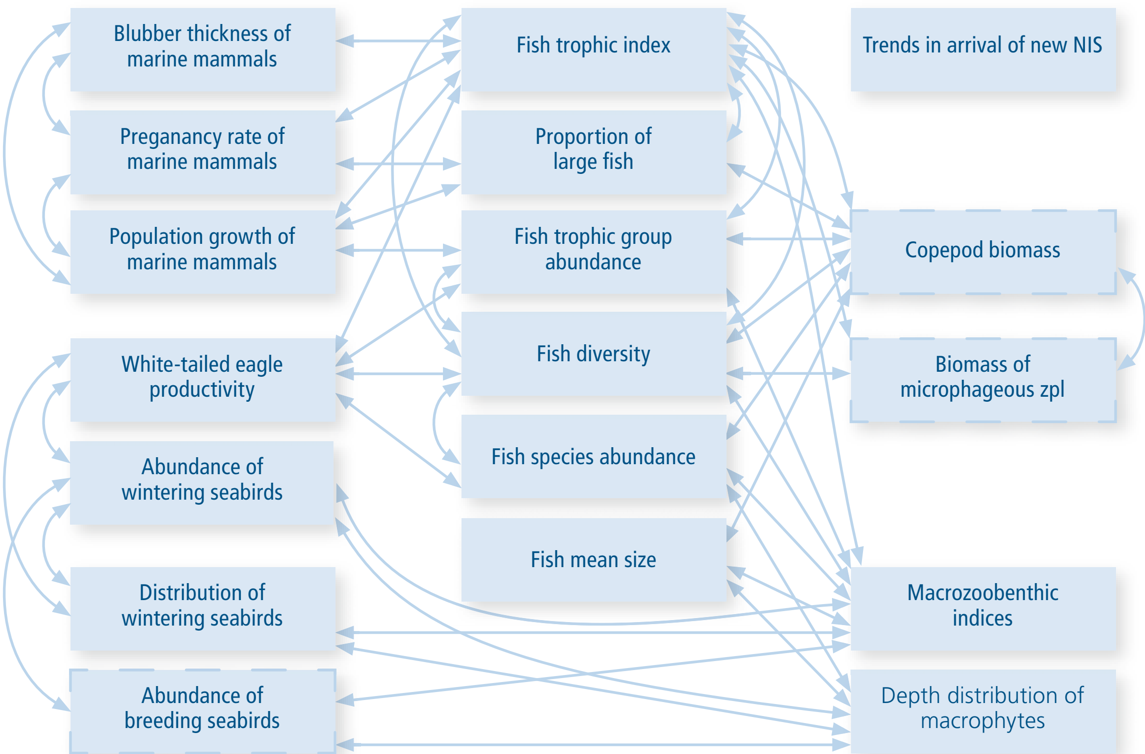


Figure 4.8. **Interlinkages of core indicators, particularly trophic relationships and interlinkages between GES boundaries. Selected candidate indicators have been included (dashed boxes). Although the indicators for non-indigenous species have obvious links to many other indicators, they do not have consequences to GES boundaries.**

4.5.3 GES boundaries are affected by regime shifts

Several studies have indicated pronounced regime shifts in the Baltic Sea ecosystem, i.e. relatively sudden changes in the structure and function of the system (Österblom et al. 2007, Möllmann et al. 2008). Some of these shifts have been linked to human pressures such as eutrophication, fishing and hunting, whereas some are also linked to changes in the climate. If using historical data as a basis for defining GES, data series of different lengths will thus cover different regimes in the Baltic Sea.

The ICES Working Group on Integrated Assessment of the Baltic Sea (WGIAB) has analysed long-term data sets from the Baltic Sea and detected a particularly strong period of reorganisation - detectable in all major basins of the Baltic Sea - between 1987 and 1989 (ICES 2011 a). This change has primarily been linked to increases in temperature and decreases in salinity caused by climate-driven changes. These changes have definite implications for biodiversity since the variation in climate affects the intrinsic properties of the sea and thus changes the conditions for proliferation of species and habitats. In this context, it should also be noted that the objective of Descriptor 1 is that "*the quality and occurrence of habitats and the distribution and abundance of species are in line with the prevailing physiographic, geographic and climate conditions*"._

To avoid this particular problem of non-comparable GES boundaries, the CORESET biodiversity expert group discussed whether it would be possible to determine GES as being set to a specific time period for all indicators (see **Section 5.3.2**). However, this option was discarded because: 1) the approach would limit use of historical data to the length of the shortest data series, which only dates back to the 1980s for some of the proposed core indicators; 2) different organism groups respond at different temporal and spatial scales, at times with considerable lag; and 3) the impact of different anthropogenic pressures on different components has varied over time.

The project discussed the use of a pragmatic approach for taking eventual regime shifts in to account by conditioning the GES boundaries, i.e. to define under which circumstances the proposed GES boundaries are applicable. For example, if the physiological limitation as regards salinity is known for a certain species, the GES can be conditioned by defining within which salinity range the GES applies.

4.5.4 Taking natural fluctuation into account when determining GES boundaries

When determining GES, natural variation has to be taken into account. In the current HELCOM assessment tools, this was considered when setting the 'acceptable deviation' from the defined reference condition. The acceptable deviation is ideally based on dose-response relationships when being set for nutrients and primary producers, for example. As stated, however, the determination of GES is not limited to the use of reference conditions and acceptable deviation - a GES boundary can also be set directly. In fact, for hazardous substances, targets have been set on the basis of various 'no-effect concentrations'. Setting aside the acceptable deviation in setting the GES boundary does not mean, however, that natural variation can be neglected. While a harmonized method to address natural variation should be strived for, it was not possible to explore and conclude this matter during the time course of the CORESET project. The assessment cycles of the BSAP and MSFD should be used to check and, if necessary, re-adjust the GES boundaries with new information on natural variation within the indicator (see **Section 4.5.3** on regime shifts).

4.5.5 Concluding discussions on GES boundaries by the biodiversity expert group

In summary, the most important issues discussed and concluded during the CORESET biodiversity expert group meeting were:

– that it is not possible to decide on one approach for defining boundaries for GES for all core indicators - the approaches will differ between indicators and this is warranted based on both ecological as well as practical considerations;
– there is a need to consider natural variability when defining the GES boundary;
– there is a need to consider defining GES as a range rather than a boundary when the response to deteriorating conditions may be bi-directional;

– there is a need to align GES boundaries between core indicators to avoid GES conflicts (including ensuring the equivalence of acceptable deviation values across indicators);
– there is a need to consider regional and temporal differences within an indicator;
– the GES boundaries should heed and, if suitable, be anchored in existing policy decisions, for example water transparency as agreed in the BSAP or habitat extent as given by the Habitats Directive; and
– when relevant, it should be considered to condition the GES boundaries, i.e. to re-evaluate them if the intrinsic conditions (e.g. salinity) change above given limits;

The proposed GES boundaries for the biodiversity core indicators are presented in **Chapter 6; Annex 2;** and **Part B** of this report (HELCOM 2012 a).

4.6 Decisions concerning GES boundaries in the hazardous substances expert group

The hazardous substances expert group decided already in the first meeting that it is beyond the capacity of the group to develop new GES boundaries. Instead, the group concentrated on finding existing targets such as Environmental Quality Standards (EQS) or specific Quality Standards (QS) of the WFD, OSPAR Environmental Assessment Criteria (EAC) or Background Assessment Criteria (BAC) and the US Effect Range - Low values (ER-L). Some substances that are relevant for the marine ecosystem do not have EQS targets for preferred matrices (biota and sediment) given by the Priority Substance Directive. In such cases, there are other quantitative targets available. EAC and BAC are quantitative targets developed by OSPAR. Other quantitative targets, for example those used in US EPA and NOAA for marine, coastal or freshwaters (Effect Range - Low), can also be used; however, it should be further studied how applicable they are to the Baltic Sea conditions. The EAC and the US values are based on the lethal doses of hazardous substances for sensitive benthic invertebrates and the use of the precautionary principle. The EQS values are often lower for seawaters than for freshwaters because of a cautionary factor which was applied if there are too few impact studies in marine environment.

The group acknowledged the different objectives of the BSAP ecological objective *Concentrations of hazardous substances at natural levels* and the EU target in the MSFD, which aims at 'levels not causing pollution effects'. It was decided to follow the EU objective since most of the target levels have been developed according to this principle (except BAC). The group established that although the HELCOM BSAP objective is the ultimate aim, they noted that it may be more relevant for metals (natural elements) than for synthetic substances which should have the ultimate level of zero in the environment.

When deciding the different targets, the group gave priority to those EQSs that are specifically mentioned in the MSFD and have a legally binding role in the region. The specific Quality Standards (QS), which are equivalent targets in all other matrices except that of an EQS but are not legally binding, were used with a similar preference. Both are currently being developed for many priority substances under the WFD WG-E.

The group also closely followed the revision of the list of priority substances in the WFD WG E because some of the selected core indicators were not among the agreed EU priority substances, even though there is a draft revision list of them (see **Chapter 5** for further discussion). For these substances, it was decided that the draft EQS/QS targets will be proposed as provisional GES boundaries, albeit they were not yet agreed in the EU. These will need to be revisited in light of the progress in the EU on developing these EQS/QS and experience gained in their application in the marine environment.

There are substances that are highly relevant to the Baltic environment but are not the EU Priority substances list (or on the revision list), such as some polyaromatic hydrocarbons (PAH) and cesium-137. Moreover, because some substances are only water targets available in the current or proposed EQS scheme, EAC or ER-L targets had to be chosen (e.g. DDE in sediment and biota).

The selected GES boundaries for the hazardous substances core indicators are presented in **Chapter 7**.

5 The HELCOM CORESET approach for selecting core indicators

The selection of the set of core indicators for biodiversity and hazardous substances in the HELCOM CORESET project was a structured process that was initiated by HELCOM Heads of Delegation, coordinated by the Secretariat and carried out by experts working on different indicators. In this section, the structure of the project expert group and the process of selecting the core indicators for the two themes are discussed.

5.1 Structure of the CORESET project

The CORESET project was divided into two work packages: biodiversity and hazardous substances (**Figure 5.1**, **Table 5.1**). The HELCOM Contracting Parties nominated experts to both packages to form two expert groups. The task of the hazardous substances group was more straightforward and thus no division into smaller teams was necessary; for biodiversity, however, further grouping was necessary due to the wide scope of the issue.

The biodiversity group decided that the development of indicators should be carried out by six teams who would each focus on:

1. Mammals
2. Birds
3. Fish
4. Pelagic habitats (including associated communities)
5. Seabed habitats (including associated communities)
6. Non-indigenous species

The reason for organising the biodiversity teams by organism groups and habitats according to Annex III Table 1 (MSFD) rather than the MSFD descriptors is the apparent overlap between several of the MSFD descriptors (see **Chapter 3**). This structure was therefore considered to provide synergetic effects. It was decided that the teams' work should result in a list of candidate indicators to be further discussed during the meetings of the biodiversity expert group. It was also decided that 'key species' and 'key trophic groups' should be defined by the working teams to facilitate the development of indicators, particularly for Descriptor 4 (Food webs), in which several of the proposed criteria and indicators are related to these concepts. Although no separate working team was established for food web indicators, experts from several teams joined in cross-sectoral discussions related to Descriptor 4 during the workshops.

The CORESET work was steered by the HELCOM Joint Advisory Board of the CORESET and TARGREV Projects (JAB). HELCOM JAB also functioned as the coordination platform of the regional implementation of the MSFD in the Baltic Sea. At the higher level, the HELCOM Monitoring and Assessment Group (MONAS) and the HELCOM Heads of Delegation (HOD) followed the work and steered or accepted the critical steps of the process.

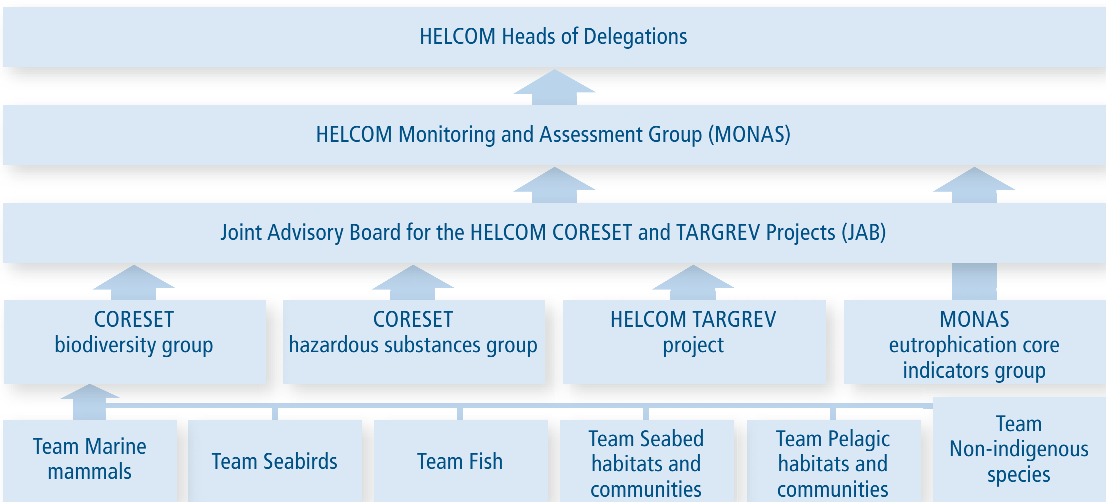


Figure 5.1. Structure of the HELCOM CORESET project and their relation to other HELCOM bodies.

Table 5.1. Number of experts in the HELCOM CORESET expert groups on the basis of the participation on meetings.

	DEN	EC	EST	FIN	GER	LAT	LIT	POL	RUS	SWE	Other	Total
Hazardous substances group	1			3	7	1	3	4	1	4	3	27
Biodiversity group	7	1	1	6	9	3	4	5	1	21	7	65

Coordination with the eutrophication experts developing the core indicators under the HELCOM MONAS was assured by regular information exchange between the two processes. As eutrophication core indicators are in a more advanced stage, the CORESET groups followed their good experience in many cases. The project also followed the scientific work carried out in the HELCOM TARGREV project, which reviews and possibly revises the GES boundaries for the Baltic eutrophication core indicators.

The CORESET project also followed the work being carried out in OSPAR ICG-COBAM, OSPAR CEMP and ICES (e.g. WGIAB and SGEH) as well as coordinated discussions of EU Member States in the interpretation of the MSFD (e.g. the document "Common understanding of (Initial) Assessment, Determination of Good Environmental Status (GES) & Establishment of Environmental Targets").

In addition, members of the HELCOM ZEN QAI and HELCOM FISH-PRO projects as well as HELCOM SEAL EG have also contributed to the biodiversity groups.

5.2 Project workshops, meetings and documents

Although the CORESET project has mainly worked intersessionally, the expert groups had held seven workshops by autumn 2011 (**Table 5.2**). The hazardous substances group met three times during 2010-2011 and a fourth workshop was scheduled for January 2012 to ensure the operationalisation of the core indicators. The biodiversity group organised four workshops during the same period. The focus teams had no obligation to meet separately since many of the participating experts did not have the resources to travel. However, the teams communicated via email and met unofficially to exchange views. HELCOM JAB met four times during the indicator development period in 2010-2011. The second phase of the project, starting in autumn 2011, will have another series of workshops.

One of the key elements in the success of the indicator development was the project documents developed by the project's staff and national experts. Their development was guided by HELCOM JAB and MONAS with the experts providing input both intersessionally and during the workshops. The guidelines and other project documents ensured that the tasks were clear and the products comparable. They also allowed HELCOM JAB, other HELCOM bodies, experts outside the region as well as other interested parties to follow the process and provided material for this report.

Table 5.2. Meetings of the HELCOM CORESET project.

Time and place	Meeting
20-21 September 2010, Stockholm	HELCOM JAB 1/2010
20-21 October 2010, Hamburg	HELCOM CORESET HS 1/2010
3-4 November 2010, Helsinki	HELCOM CORESET BD 1/2010
2-3 February 2011, Helsinki	HELCOM CORESET HS 2/2011
16-18 February 2011, Gothenburg	HELCOM CORESET BD 2/2011
21-22 March 2011, Berlin	HELCOM JAB 2/2011
31 May – 1 June 2011, Klaipeda	HELCOM CORESET HS 3/2011
15-17 June 2011, Riga	HELCOM CORESET BD 3/2011
27-28 June 2011, Warsaw	HELCOM JAB 3/2011
12-13 September 2011, Copenhagen	HELCOM CORESET BD 4/2011
4 October 2011, Vilnius	HELCOM JAB 4/2011

5.3 The process for the selection of biodiversity core indicators

The identification of a set of core indicators for the Baltic biodiversity followed a coherent and structured process, as agreed during the first expert workshop of the biodiversity expert group. Biodiversity being an object of huge complexity – even in the species-poor Baltic Sea – was considered a challenging subject. The group based its work on the reports of the MSFD GES Task Groups 1, 2, 4 and 6 (Cochrane et al. 2010, Olenin et al. 2010, Rogers et al. 2010, Rice et al. 2010), the HELCOM common principles of core indicators (see **Section 2.3**) and the EC decision document (Anon. 2010). They approached the selection of indicators from three aspects:
– functional groups and predominant habitats, including key species;
– impacts of anthropogenic pressures on the functional groups and predominant habitats; and
– the availability of monitoring.

5.3.1 The functional groups, predominant habitats and key species

The functional groups and predominant habitats were first based on the proposals present in the report of the EU MSFD GES Task Group 1 (Cochrane et al. 2010) and then adapted to Baltic conditions by the biodiversity group (**Tables 5.4 and 5.5)**. These functional groups and predominant habitats should form the basis of the monitoring and assessment of the status of biodiversity as they are intended to cover the range of biodiversity in the marine regions of the EU member states. The aim is that there should be indicators that can be used to assess the status of each functional group and predominant habitat, and should adequately reflect the relevant GES criteria and the pressures to which they are subject. However, with the limited time of the project, it has not been possible to fully define the range of indicators needed. Nevertheless, in a few cases, single indicators can be applied to several functional groups or habitat types.

According to the Commission Decision (Anon. 2010), individual species of fish, mammals and birds are to be assessed at the species or population level, while other biodiversity components should be assessed at the community level in association with their habitat. The latter category includes fish (when strongly associated with seabed habitats), phytoplankton, zooplankton, angiosperms, macroalgae and the invertebrate benthic fauna (*cf.* MSFD, Table 1 Annex III). The functional groups of fish, mammals and birds can be assessed by using the community criterion (i.e. considering species composition and relative abundance issues within the functional group).

The predominant habitats should first be divided into seabed and water column habitats. For the seabed habitats, the TG 1 report (Cochrane et al. 2010) proposes to use coarsely-defined habitat classes which are correlated to the high-level habitat classes of the European EUNIS classification scheme. In the Baltic Sea, the current EUNIS classification is considered unsuitable for MSFD purposes. However, the EUSeaMap project, in collaboration with biotope experts of the Project for Completing the HELCOM Red List of Species and Habitats/Biotopes, has developed a proposal for a Baltic Sea EUNIS classification. The coarse habitat classes from this proposal, which are proposed as the predominant habitat types for MSFD purposes, are shown in **Table 5.5** and have been used in the CORESET project. This does not exclude the possibility to further specify more detailed habitat types. The directive has the provision to also assess and report on 'special habitats' such as those on the HELCOM Red List.

The pelagic (water column) habitats are simply divided into coastal and offshore waters, using the 1 nautical mile delineation of the WFD to separate the two water types. This simple division is crude and thus a further classification for the Baltic Sea water column should be considered. One possibility is to divide the pelagic realm into 'photic' and 'non-photic' zones or a distinction between 'above' and 'below' the halocline. A further defini-

tion of pelagic habitats has not been completed within the project.

In addition to the identification of functional groups and predominant habitats, Baltic key species were identified. This was seen as significant for two reasons: to select appropriate indicator species for the functional groups and to identify indicator species for Descriptor 4 (Food webs), which particularly calls for such species. The preparation of such a list is also an explicit demand of the GES criteria document (Anon. 2010) which states for Descriptor 1: "*For each region, subregion or subdivision, taking into account the different species and communities…contained in the indicative list in Table 1 of Annex III to Directive 2008/56/EC, it is necessary to draw up a set of relevant species and functional groups.*" The list of key species, identified in the project, is presented in **Table 5.6**. The criteria used to assemble the list were: "*Species and/or groups important to the Baltic Sea ecosystem structure and function in terms of biomass, abundance, productivity, or functional role*" with emphasis on species/groups with important functional roles. Thus, it is not intended to be a full list of Baltic Sea species but should consider only the most important species/groups that adhere to these criteria. The list is sorted according to 'suitable groups' as outlined in Descriptor 4, indicator 4.3.1 (Anon. 2010 and **Table 3.4**). The list is a living document subject to further development. The expert group, however, is aware that at present the list does not properly cover key species in the Kattegat.

The GES criteria document also requires that lists of species and functional groups specified in existing community legislation, such as the Birds and Habitats Directive, as well as other 'listed' species should be prepared. Here, the CORESET project refers to the existing HELCOM red list of threatened and/or declining species and biotopes/habitats in the Baltic Sea area (HELCOM 2007 b); the HELCOM red list of threatened and declining species of lampreys and fishes of the Baltic Sea (HELCOM 2007 c); and the HELCOM red list of marine and coastal biotopes and biotopes complexes of the Baltic Sea, Belt Sea and Kattegat (HELCOM 1998). An update of the red lists of species and biotopes is expected to be finalised in the HELCOM REDLIST project by 2015.

In the CORESET project, core indicator work focused on key elements of the ecosystem - no indicator was developed for threatened or rare species or biotopes. However, some indicators may be applied to these species and habitats in order to assess their status.

Table 5.4. The functional groups in the Baltic Sea which were used as basis for indicator selection.

Species groups	Functional groups
Birds	Coastal pelagic fish feeder
	Offshore pelagic fish feeder
	Subtidal offshore benthic feeder
	Subtidal coastal benthic feeder
	Subtidal coastal herbivorous feeder
	Intertidal benthic feeding birds
	Coastal top predators
Mammals	Toothed whales
	Seals
Fish	Pelagic fish
	Demersal fish
	Elasmobranchs
	Coastal fish
	Anadromous/catadromous fish

Table 5.5. Predominant habitats of the Baltic Sea. Habitats are based on a preliminary EUNIS classification developed within the EUSeaMap project in collaboration with biotope experts of the Project for Completing the HELCOM Red List of Species and Habitats/Biotopes. The classification of pelagic habitats was based on Cochrane et al. (2010) and modified for the Baltic Sea environment.

Habitat groups	Final predominant habitats
Seabed habitats	Baltic hydrolittoral rock and other hard substrata
	Baltic hydrolittoral sediment [a]
	Baltic infralittoral rock and other hard substrata
	Baltic infralittoral sediment [a]
	Baltic circalittoral rock and other hard substrata
	Baltic circalittoral sediment
	Baltic deep sea rock and other hard substrata
	Baltic deep sea sediment [a]
Pelagic (water column) habitats	Estuarine water
	Coastal water
	Offshore water[5]
Ice-associated marine habitats	

a) The soft sediment can be further divided into sands and muds, for example.

5 In the TG1 report, the off-the-coast pelagic habitats were defined as 'Shelf water' and further as 'Oceanic water'. A class of 'Low salinity water' for the Baltic Sea was also proposed but the meaning of this term is unclear.

Table 5.6. Key species and functional groups in the Baltic Sea based on criteria specified in Section 6.3.1. The content of the list is sorted according to the 'suitable groups' as outlined in Descriptor 4, indicator 4.3.1 (Anon. 2010).			
D4 4.3.1 criteria: TOP PREDATORS			
Sub-group: Piscivorous fish			
Taxon	**Functional group in the pressure matrix**	**Comment**	**Link to GES criteria (2010/477/EU)**
Cod, Turbot	Marine demersal	TAC regulated fisheries	1.1-1.5, 3.1.1, 3.2.1, 4.1, 4.2.1, 4.3.1
Perch, Pike, Pikeperch	Coastal demersal		1.1-1.6
Salmon, Sea trout	Anadromous	TAC regulated fisheries, Listed in HD	1.1-1.3, 4.2.1, 4.3.1
Sub-group: Mammals			
Harbour porpoise	Toothed whales	Listed in HD, subject of by-catch	1.1-1.3, 4.1.1, 4.3.1
Grey seal, Ringed seal, Harbour seal	Seals	Listed in HD, subject of by-catch	1.1-1.3, 4.1.1, 4.3.1
Sub-group: Fish feeding birds			
Great black-backed gull, Herring gull, Lesser-black-backed gull, Common gull	Inshore surface feeder/ scavengers		1.1-1.3, 4.3.1
Black-headed gull, Common tern, Arctic tern	Inshore surface feeder	Terns listed in Annex I, BD	1.1-1.3, 4.3.1
Black-throated diver (winter), Red-throated diver (winter), Great crested grebe, Goosander, Razorbill, Common guillemot, Slavonian Grebe (winter)	Offshore pelagic feeder	Divers listed in Annex I, BD	1.1-1.3, 4.3.1
Black guillemot, Cormorant, Great crested Grebe (winter)	Inshore pelagic feeder		1.1-1.3, 4.3.1
White-tailed eagle	Coastal fish feeder	Listed in Annex I, BD	1.1-1.3, 4.1.1, 4.3.1

Table 5.6 continues...			
D4 4.3.1 criteria: GROUPS/SPECIES THAT ARE TIGHTLY LINKED TO SPECIFIC GROUPS/SPECIES AT ANOTHER TROPHIC LEVEL			
Sub-group: Young fish age groups consuming zooplankton			
Taxon	**Functional group or habitat in the pressure matrix**	**Comments**	**Link to GES criteria (2010/477/EU)**
Perch, Pikeperch	Coastal demersal		1.1-1.3, 1.5, 1.6, 4.3.1
Cyprinids	Coastal benthopelagic		1.3-1.7, 4.3.1
Cod	Marine pelagic	TAC regulated fisheries	1.1-1.3, 1.5, 3.1.1, 3.2.1, 4.1, 4.2.1, 4.3.1
Flounder	Marine demersal	TAC regulated fisheries	1.1-1.3, 4.2.1, 4.3.1
Herring, Sprat	Marine pelagic	TAC regulated fisheries	1.1-1.3, 4.2.1, 4.3.1, 3.1.1, 3.2.1, 4.1
Sub-group: Adult fish consuming zooplankton			
Herring, Sprat	Marine pelagic	TAC regulated fisheries	1.1-1.3, 3.1.1, 3.2.1, 4.1, 4.2.1, 4.3.1,
Sticklebacks	Marine pelagic and coastal demersal		1.1, 1.2, 1.3, 1.7
Sub-group: Benthic feeders			
Cyprinids	Coastal benthopelagic		1.3-1.7, 4.3.1
Herring	Marine and coastal benthopelagic		1.1-1.3, 3.1.1, 3.2.1, 4.1, 4.2.1, 4.3.1
Velvet scoter, Common scoter, Long-tailed duck, Eider, Tufted duck, Greater scaup	Subtidal benthic feeder		1.1, 1.2, 1.3, 4.3.1

Sub-group: Prey of benthic feeding fish and birds (soft bottom)			
Macoma balthica, Monoporeia affinis, Scoloplos armiger, Mytilus spp., *Mya arenalis, Hydrobia* spp., *Cerastoderma* spp.	Circalittoral sediments and sediments below halocline		1.1-1.3, 4.3.1
Bylgides sarsi	Sediments below halocline		1.1-1.3, 4.3.1
Bathyporeia pilosa	Infralittoral sand		1.1-1.3, 4.3.1

Table 5.6 continues...			
D4 4.3.1 criteria: HABITAT DEFINING GROUPS			
Taxon	**Predominat habitat type in the pressure matrix**	**Comments**	**Link to GES criteria (2010/477/EU)**
Sub-group: Benthic primary producers			
Seaweeds	Infralittoral rock and other hard substrates	e.g. *Fucus*, *Furcellaria*, *Laminaria*	1.1-1.6, 4.3.1
Eelgrass, Stoneworts, Pondweed	Infralittoral sediments	e.g. *Zostera*, *Potamogeton*	1.1-1.6., 4.3.1
Sub-group: Filters feeders			
Blue mussel	Infralittoral and circalittoral rock and sand	also Biogenic reefs	1.1-1.6, 4.3.1

Table 5.6 continues...			
D4 4.3.1 criteria: GROUPS WITH FAST TURNOVER TIMES			
Taxon	**Functional group in pressure matrix**	**Comments**	**Link to GES criteria (2010/477/EU)**
Sub-group: Carnivorous plankton			
Selected Cladocerans, Adult Cyclopoida, Jellyfish > 2mm	Zooplankton	e.g. *Cercopagis pengoi*, *Leptodora kindtii* and *Bythotrephes longimanus*	1.6.1, 1.6.2, 4.3.1
Sub-group: Herbivorous plankton			
Selected Cladocerans, Calanoida, Rotifers	Zooplankton	e.g. Bosminidae, Daphniidae, Podonidae	1.6.1, 1.6.2, 4.3.1
Sub-group: Bacterivorous plankton			
Appendicularia, Rotifers, Juvenile copepods, Small ctenophores	Zooplankton	e.g. all stages of *Mertensia ovum*, cydippid stage of *Mnemiopsis leidyi*	1.6.1, 1.6.2, 4.3.1
Sub-group: Pelagic primary producers			
Cyanobacteria, (nitrogen fixing), Diatoms, Dinoflagellates	Phytoplankton		1.6.1, 1.6.2, 4.3.1
Flagellates	Phytoplankton		1.6.1, 1.6.2, 4.3.1
Cyanobacteria, potent. toxic	Phytoplankton	e.g. *Nodularia spumigena, Chrysochromulina polylepis, Prorocentrum minimum, Pseudochattonella farcimen, Karenia mikimotoi, Anabaena lemmermanni, Aphanizomenon flos-aque*	1.6.1, 1.6.2, 4.3.1
Sub-group: Bacterioplankton			
Whole community			4.3.1

5.3.2 Use of anthropogenic pressures in the selection of the indicators

The second criterion for the process was to identify the anthropogenic pressures on the functional groups and predominant habitats. The linkage of a core indicator to a pressure(s) was considered essential, as a principal objective of the core indicators is to measure the effect of human pressures (or mitigation of them) on the ecosystem (see principles in **Section 2.3**). The use of the pressure-impact relationship to guide indicator selection draws on the proposals by the MSFD TG1 report (Cochrane et al. 2010); the ICES WGECO report (ICES 2010); and concepts laid down in the HELCOM HOLAS report (HELCOM 2010 a, c). The summary of the pressure-impact matrix is presented in **Annex 1**.

The evaluation of impacts of pressures on Baltic Sea functional groups and predominant habitat types was carried out in the six working teams (see project structure in **Section 5.1**). A specific guiding document for the selection of indicators was produced, which took into account the MSFD GES criteria as well as the common principles of the HELCOM core indicators. Experts were given a list of anthropogenic pressures, sorted according to Annex III, Table 2, of the MSFD, and asked to score the impact of each pressure on each functional group or habitat by a three-level score - low, intermediate, high - and distinguish direct impacts from indirect ones. The pressures perceived as having the highest impacts were identified and the selection of indicator parameters guided by the results of the evaluation. It can be noted that although the expert evaluation of the severity of impacts varied somewhat considerably, when all expert judgements were compared it was still possible for the teams to identify a limited number of pressures as the most severe ones (see **Chapter 6**). The fish team, which is based on the existing HELCOM FISH PRO project, used a statistical approach to identify the predominant pressures (HELCOM 2012 b).

By using a pressure-based approach, the indicators - while primarily describing the state of different ecosystem components - also indicate the impact of pressures on the ecosystem. With a clear link to pressure, they can thus also serve the purpose as indicators to follow up management actions to mitigate the impact of human pressures. With this in mind, the indicator selection focused on identifying indicators that respond to one or a limited number of pressures. However, considering the multiple pressures present in the Baltic Sea and their combined impacts, this ambition has not been possible to follow through for all indicators; as some proposed core indicators have multiple weak underlying pressures, the impacts of some pressures are not adequately measured by any one core indicator (see **Chapter 6**).

5.3.3 The influence of monitoring data on indicator selection

One prerequisite of the core indicators, according to the HELCOM common principles, is that they should be frequently monitored using harmonised methods. For this purpose, the project gathered information on existing monitoring in all Contracting Parties (**Chapter 9**). However, the existing HELCOM monitoring programmes, such as COMBINE, are mainly directed towards monitoring the effects of eutrophication and contaminants. Thus, there is no existing dedicated monitoring programme that widely addresses all components of or all pressures on biodiversity. The availability of the monitoring data was therefore not a ruling criterion in the development of the core indicators for biodiversity. Instead, the principle was interpreted to apply to the operational core indicators after the monitoring programmes had been revised according to the proposed core indicators. Hence, suggestions for the monitoring of the identified core indicators were given, where appropriate.

Existing monitoring on certain variables was, however, used to guide the selection process. An example is the proposed indicators for coastal fish, where harmonised monitoring is currently conducted by Estonia, Finland, Latvia, Lithuania and Sweden while being conducted using other methods in the other CPs. The working teams were also given the liberty to develop indicators where there is currently a lack of monitoring if the proposed indicators are considered as central for assessing the state of the biodiversity in the Baltic Sea. The expert group was aware that HELCOM is starting to revise the joint monitoring programme and wanted to be proactive in this matter. The teams were, however, asked to be realistic in their work - if they proposed new monitoring they should also outline a proposal for the revision process.

5.3.4 Categorisation of the biodiversity indicators

The process to develop core indicators generated an initial list of 45 candidates. The list was presented and discussed during the project's second workshop. At this stage, they were all labelled 'candidate indicators' and thus the teams were encouraged to continue developing almost all of them. The third biodiversity workshop categorised the indicators into candidate and core indicators and also identified a number of 'supplementary indicators'.

The following criteria were used to categorise indicators as core indicators:

– the indicator should clearly represent a GES criterion and the HELCOM common principles for indicators (e.g. link to anthropogenic pressures);
– the indicator should be well-established or, if new, be tested and documented in a way that allows an external review of the proposal;
– include proposed GES boundary/boundaries; and
– monitoring should be in place or a proposal for future monitoring should be formulated.

What remained as 'candidate indicators' after this process were considered 'promising' yet 'not possible to operationalise' within the first phase of the CORESET project. It was anticipated, however, that some of the remaining candidate indicators would be reclassified during the second phase of the project and the development work will continue in HELCOM working groups and external projects until and beyond the finalisation of the present report.

Indicators which clearly did not fit to the core indicator concept were categorised as 'supplementary indicators'. These were not considered as core indicators but were seen as useful support material for them since they provide data on climatic and hydrographic changes, fluctuations of populations and changes in parameters which reflect human activities.

5.3.5 The process to develop GES boundaries

The final step in the development work was to identify a boundary or range where each indicator is in GES. Different approaches to target setting were described in **Chapter 4**. Based on discussions and the conclusion in the project, the working teams were given freedom to choose the target setting

approach which best suited the available data and type of indicator. As the target setting process varied among the core indicators, it was decided that each core indicator should be substantiated by a background document, including a description of how GES boundaries were established (see Part B of this report (HELCOM 2012a)).

During the CORESET process of defining GES boundaries for core indicators, it was also decided to produce qualitative (i.e. narrative) GES boundaries for each core indicator. The benefit of the approach was twofold: 1) to explain the reasoning behind the numeric value to a non-expert; and 2) to facilitate the development of the numeric value. The qualitative GES descriptions are given in **Annex 2**.

5.4 Selection of core indicators for hazardous substances

5.4.1 The selection process of the hazardous substances core indicators

The hazardous substances expert group began its first workshop by agreeing on criteria for the selection of indicators. The group agreed that the selection criteria should be based on needs - at least during the first phase - and not be biased by data availability or solely by existing priority lists. It was also noted that the revision of the HELCOM monitoring programmes was at hand and the selection of core indicators can have a proactive effect on that process. The group based its work on the principles of core indicators (see **Section 2.3**).

The selection criteria for the hazardous substances core indicators were:
– an alarming /increasing levels of the substance in the Baltic;
– PBT properties (persistence, bioaccumulation, toxicity);
– management status (banned, regulated, not banned);
– policy relevance (existing priority lists);
– the availability of targets; and
– monitoring status.

The expert group screened the list in all the three workshops and eliminated or added indicators as new information became available.

In particular, the group discussed the policy relevance of the substances that have been suggested by the WFD WG E to be added to the revision list of the Priority Substances; to date, however, the final decision at the EU level on their inclusion has not been yet made. Nevertheless, the expert group decided that there is no reason not to include them in the core set provided other selection criteria are fulfilled. Except for the two pharmaceutical substances, all the other substances are included in other 'priority lists' as well as the list of EU Priority Substances.

Commonly known hazardous substances often consist of several congeners (e.g. PCBs, or PBDEs) or separate substances (e.g. PAHs). As a laboratory's chemical analysis package frequently contains parallel analyses of several congeners or substances at no extra cost, the expert group considered it expedient to include several parameters (i.e. congeners or substances) for a single core indicator. Moreover, the congeners (or closely-related substances) often represent different pollution sources and, hence, provide important extra information to the indicator. Most of the individual substances of a group (e.g. PAH) should be assessed against substance-specific targets; however, there are some substance groups for which one target can be used collectively (e.g. dioxins and furans as well as PBDEs). For PCBs, it was agreed that as the congeners 118 and 153 represent the majority of the congeners, the core indicator will be primarily assessed by these two congeners (although concentrations of the ICES 7 congeners (CBs 28, 52, 101, 118, 138, 153, 180) will be shown).

HELCOM JAB also tasked the group to include indicators of the effects of hazardous substances in its working programme. The group invited the BONUS+ project BEAST to contribute to the work, and welcomed their offer to choose up to four key indicators with targets and background material. All of the selected core indicators for biological effects had established methods recommended by ICES SGIMC[6] and ICES WGBEC[7]. They are already included in other regional monitoring programmes such as OSPAR (on a voluntary basis) or MEDPOL, or used in the national monitoring programmes of

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Denmark, Germany and/or Sweden. The following information applies to all listed indicators:

- sufficient research or monitoring data was available, covering different Baltic Sea sub-regions;
- Baltic Sea specific Background Assessment Criteria (BAC) have been established for a range of Baltic Sea indicator species (note that BACs for biological effects and for substance concentrations are based on different procedures);
- biological effects can be assessed against Environment Assessment Criteria (EAC) of response that are indicative of significant harm to the species under investigation (note that BACs for biological effects and for substance concentrations are based on different procedures);
- monitoring guidelines, including published Standard Operation Protocols (SOPs, e.g. in the ICES TIMES series), are available and widely applied;
- the costs of analyses are low and samples can be collected during the same sampling campaigns as for the contaminant analyses (mostly using the same target species, size classes, etc.).

The impact relationships of organisms or species populations and contaminants are described separately in the core indicator documentation (see **Part B** of this report, HELCOM 2012 a). Generally, the expert group aimed to cover different contaminant groups by these core indicators; different response levels in organisms; and most mature indicators scientifically. The choice to include the biological effects indicators as core indicators under the hazardous substances group originated from the MSFD and BSAP terminology, although they are very close to the biodiversity indicators in many cases, thereby creating synergies between these two groups of indicators.

The expert group also discussed the effects of hazardous substances on top predators (marine mammals and white-tailed eagle) and considered a specific core indicator for these. Although there is extensive material available on this subject, the group decided not to create specific core indicators for top predators since the same substances were already covered by separate indicators in fish, mussels, sediment and water, as it would be difficult to choose which substances should be measured in top predators. It was decided, therefore, that the concentrations of selected substances in top predators will, if available, be shown as supplementary information in the core indicator reports. Moreover, the biodiversity group included the general health indicator of marine mammals in their working programme.

5.4.2 Decisions on sampling and data conversions for hazardous substances core indicators

Monitoring programmes include measurements of hazardous substances from water, sediment, mussels, fish, bird eggs and marine mammals. The multiplity of the sample matrices creates a challenge of compatibility among the data sets and coherence of an indicator. There are probably several reasons for this current situation including chemical properties, historical institutional practices and work sharing, the continuation of long-term data series, preferences of individual scientists and legal obligations. In general, the group was of the opinion that water is unsuitable as a sampling matrix for most of the selected indicator substances. The group also concluded that sediment sampling gives a different message than measurements in biota - the former assesses the state of benthic environment (and hence only a risk for organisms) while the latter assesses the actual concentrations in living organisms. However, since the relevance of the sampling matrix depends on the chemical properties of a compound, sediment sampling can be appropriate for some substances.

In order to aim at maximal coherence among countries, marine areas and data sets, the group decided to give priority matrices for the selected substances (**Table 5.7**). Other matrices can be sampled if no other data is available. The group also wanted to give a message for sampling coherence to the forthcoming revision of the HELCOM monitoring programmes. According to **Table 5.7**, most substances are to be primarily monitored from biota (or sediment); however, the primary matrix of the pharmaceutical compound EE2 was judged to be water and for the alkylphenols water or sediment. Polyaromatic hydrocarbons cannot be measured from vertebrates (like fish) as they are efficiently degraded; instead, the PAH-metabolite indicator can be used for those compounds in vertebrates.

The monitoring of very persistent substances in sediments, in addition to biota, gives additional information to the assessments of hazardous substances and their effects since sediments, which are generally sinks for many persistent substances, may also act as internal sources to the ecosystem long after the external inputs have ceased.

Another discussion point during the process was the sample tissue (in fish samples) and its suitability for assessments against targets. The group acknowledged that as the targets were environmental targets being calculated to prevent the poisoning of higher trophic levels, the targets applied to whole fish. The samples, however, were not taken from homogenised whole fish but from muscle, liver and sometimes bile. The group decided that a pilot study, including a literature review and laboratory experiments, needs to be conducted and the results evaluated in a workshop in 2012. The group will produce conversion factors for the data in order to enable coherent assessments with the core indicators. Target setting should be reviewed in light of the workshop results, progress in the EU on developing EQS for biota and sediments and experience gained in the application of those targets in the marine environment.

Table 5.7. Sampling matrices to be preferred for core indicator substances.

Sampling matrix	Substance
Water	17-alpha-ethinylestradiol
Sediment	PAHs, (PBDE, HBCDD, PFOS, PCB, Dioxins)
Fish	PBDE, HBCDD, PFOS, PCB, Dioxins, PAH metabolites, metals, cesium-137, diclofenac
Mussel/bivalve	PBDE, HBCDD, PFOS, PCB, Dioxins, PAHs, metals, cesium-137

5.4.3 Core indicators for seafood safety

As the CORESET expert group had only limited expertise on seafood safety, the development of core indicators for the BSAP ecological objective of safe seafood and the MSFD GES Descriptor 9 was considered incomplete. It was decided that this report will present safety limits from the EU legislation (Anon. 2006) for the selected chemicals as core indicators.

The group discussed that it would be cost-efficient to aim at shared monitoring programmes for both indicators of Descriptors 8 and 9. Currently, monitoring is often carried out by different institutes separately. Depending on countries, alignment of the two monitoring approaches may, however, be difficult or not possible due to different requirements under food legislation (sampling of market fish), environmental monitoring (fish from identified sampling/catch location) and different sampling matrices (whole fish, muscle or liver). In such cases, chemical analyses for environment monitoring could be expanded to assess environmental concentrations against food standards.

5.5 Geographical scales of the core indicators

Early in the process during the development of core indicators, both expert groups considered geographical scales of the assessment units for the indicators, GES boundaries and integrated assessments. It was apparent that both the size of the assessment units and the scale for which GES boundaries should apply are parameter dependent. For example, highly mobile species (e.g. seals) have a similar GES boundary over the entire sea area for a given parameter; the GES of benthic invertebrate communities, on the other hand, vary along several environmental gradients. It was also agreed that the assessment units for integrated assessments need to be considered already at this stage of the project, even though the assessment methodologies are still not developed.

The biodiversity expert group decided that each team should agree on the geographical variability of GES for each core indicator and suggested a relevant size of assessment units for them. The following aspects were to be considered when defining the assessment units for the indicators:

– a suitable assessment unit for an indicator, based on ecological relevance, i.e. scales of variability in ecosystem components;
– suitable geographical boundaries within which GES applies to an indicator; and
– an assessment unit for an integrated assessment.

The expert groups noted that the same GES boundary may apply across multiple assessment units. While an indicator can have the same GES boundary for a large area (e.g. a sub-basin), it may, depending on area specific exposures to pressures for instance, be relevant to assess the status of the indicator in smaller areas (e.g. a water type).

In order to avoid boundary conflicts among the indicators in the integration phase when producing the assessments, it was decided that the assessment units need to be '**nested**'. In order of hierarchy, the highest level (i.e. the largest scale) is the entire Baltic Sea, followed by the sub-basin level and then the levels for offshore and coastal waters of the sub-basins, WFD coastal water types and WFD coastal water bodies. In offshore waters, there is no proposal to divide the basins into smaller units (except for national borders, which should be visible on the assessment maps). This nested boundary setting includes a few hierarchical levels and facilitates the integration of the indicators. The appropriate level of integration would preferably be the smallest scale. **Figure 5.2** shows the four levels of the geographical scales nested within each other: the entire Baltic Sea (panel A), the sub-basin level division (panel B) and the division to offshore sea areas and coastal waters (panel C) and the WFD water types inside the 1 nm coastal water boundary (panel C).

The hazardous substances expert group has not yet made any decision on the size of the assessment units; however, they noticed that there are strong gradients from pollution sources and nearby sediment accumulation areas, which supports the differentiation of coastal and offshore waters as assessment units. It was clear, however, that in the integration phase of the hazardous substances core indicators, a decision of the assessment units should be made, otherwise there would be no objective rule of how to combine measurements from point-based sampling sites to an integrated assessment. One option would be to follow the example from the eutrophication core indicators, which are assessed in the coastal waters in the WFD water types (or even water bodies) and in the offshore areas in the offshore sub-basins.

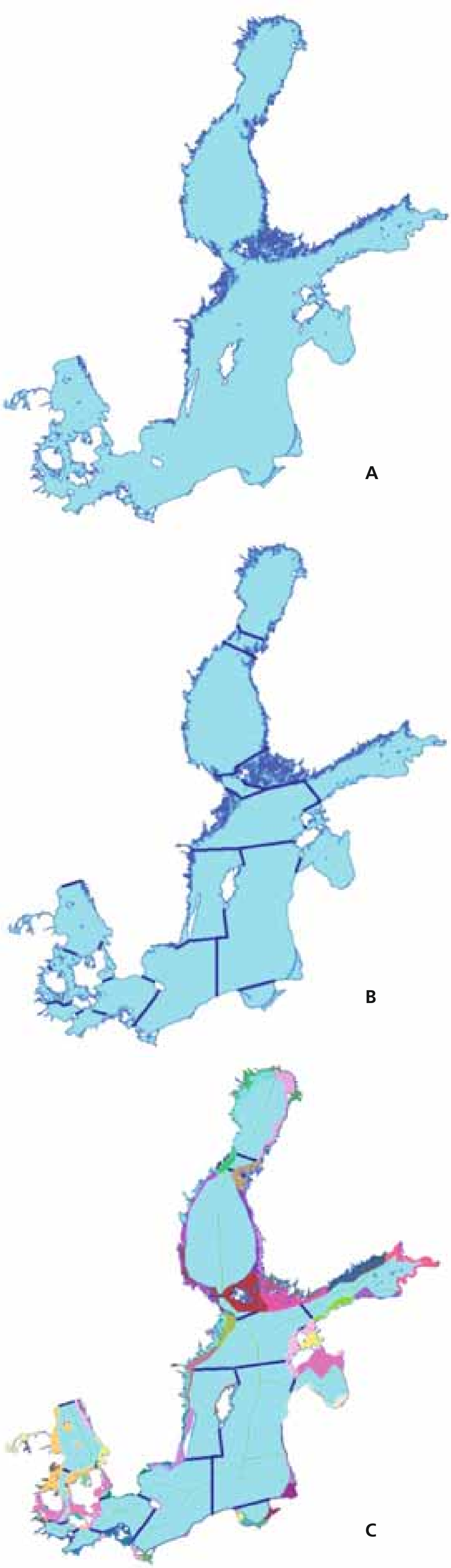


Figure 5.2. Assessment units for the whole Baltic Sea (A); 19 sub-basins (B); and water types of the WFD in coastal waters and 19 sub-basins in offshore waters (C). In panel C, the brown lines represent national borders of Exclusive Economic Zone (EEZ). Key: BBa=Bothnian Bay; Q=Quarck; BS=Bothnian Sea; ÅS=Åland Sea; AS=Archipelago Sea; NBP=Northern Baltic Proper; GF=Gulf of Finland; GR=Gulf of Riga; EBP=Eastern Baltic Proper; WGB=Western Gotland Basin; GG=Gulf of Gdansk; BBs=Bornholm Basin; AB=Arkona Basin; MB=Mecklenburg Bight; KB=Kiel Bight; S=Sound; GB=Great Belt; LB=Little Belt and K=Kattegat.

6 Biodiversity core indicators and targets

How can a limited set of indicators to assess marine biodiversity be developed – one that covers organisms from bacteria to seals, food web interactions on five levels, habitats from the shore to the deepest trenches and all impacted by an array of human activities? The primary limiting factor in such assessments is the available resources for monitoring activities, but also the scientific understanding of interspecific relationships and pressure-impact causalities complicate the development of many potential indicators.

The richness of species in the Baltic Sea is relatively low due to its brackish water environment, the young age of the sea basin and the food webs which are characterised by interactions of only a few predominant key species. Because the regional scientific collegium has cooperated for decades to characterise the Baltic biodiversity and human impact on it, the assessment work in the Baltic Sea can be perceived to be somewhat easier than in oceanic environments – but it is still a major challenge.

The previous chapters of this report described the process of identifying the core indicators for the Baltic Sea. **Chapter 2** presented the premises for the HELCOM core indicators while **Chapter 3** discussed their objectives - what they should measure. Potential approaches for the quantitative characterisation of good environmental status (GES) for each indicator were given in **Chapter 4** and the CORESET process of selecting and developing the core indicators was explained in **Chapter 5**.

This chapter presents the outcome of the HELCOM CORESET indicator development work with specific emphasis on those indicators that were identified as core indicators, i.e. indicators considered as reasonably validated and fully or nearly operational. The chapter also presents examples of numeric targets - the GES boundaries - for the core indicators. At this stage of the project, several of the identified indicators were still considered as 'candidates' because their relation to underlying pressures was still unclear, their applicability to measurement of GES was not proven, or for other reasons. For this reason, the classification of the core and candidate indicators should not be emphasised too much at this stage of the CORESET project.

6.1 Proposed core indicators for biodiversity

This section presents the biodiversity related core indicators developed in the HELCOM CORESET project. The proposed indicators are interim expert products that require further development; for example, methodological details and their adjustment to sub-regional conditions. The proposed GES boundaries should be seen as examples provided by the current scientific understanding.

The biodiversity core indicators assess the HELCOM BSAP policy goal *Favourable conservation status of Baltic Sea biodiversity* and the MSFD GES

Table 6.1. The proposed core indicators and their potential use as indicators for Descriptors 1, 2, 4 and 6 of the MSFD. The table also presents the primary pressure(s) for these state indicators.

Proposed core indicator	D1	D2	D4	D6	Primary pressure/driver(s)
1 Blubber thickness of marine mammals	X				Hazardous substances, disease, removal of prey
2 Pregnancy rates of marine mammals	X				Hazardous substances
3 Population growth rates of the populations of marine mammals	X		X		Hazardous substances, hunting, disease
4 White-tailed eagle productivity	X		X		Hazardous substances, persecution
5 Abundance of wintering populations of seabirds	X		X		Species dependent, mainly linked to eutrophication, habitat and prey loss, oil contamination and by-catch
6 Distribution of wintering populations of seabirds	X				Species dependent, mainly linked to eutrophication, habitat and prey loss, oil contamination and by-catch
7 Fish population abundance	X		X[A]		Functional group dependent, mainly linked to eutrophication or fishing
8 Proportion of large fish in the community	X		X		Fishing
9 Mean metric length of key fish species	X				Species dependent, mainly linked to fishing
10 Fish community diversity	X				Eutrophication, fishing, habitat loss
11 Fish community trophic index	X		X		Fishing, eutrophication
12 Abundance of fish key trophic groups	X		X[A]		Functional group dependent, mainly linked to eutrophication or fishing
13 Multimetric macrozoobenthic indices	X			X	Physical disturbance, hypoxia, eutrophication
14 Lower depth distribution limit of macrophyte species	X			X	Eutrophication
15 Trends in arrival of new non-indigenous species		X			Reflects the efficiency of management actions to reduce new introductions

[A] The proportion of piscivorous, non-piscivorous fish and cyprinids that can be derived from the core indicator.

Table 6.2. Summary of the anthropogenic pressures with the highest impact on the Baltic Sea biodiversity according to evaluations by the CORESET biodiversity working teams. The success of the HELCOM CORESET project in covering functional groups and main anthropogenic pressures by core indicators is shown by the colouring: green = core indicator(s); orange = candidate indicator(s); red = no indicator. Key: I = State indicator responding to a pressure and displaying its impact; P = Pressure indicator

Major functional groups and habitat types	Predominant pressures								
	Input of nutrients	Input of synthetic and non-synthetic substances	Fishing – targeted catches	Fishing – by-catch	Hunting	Noise	Oils spills	Introduction of non-indigenous species	Physical disturbance of the seabed
Mammals		(I)		(I)	(I)	(I)			
Birds		(I)		(P)		(I)	(I)		
Offshore fish			(I)						
Coastal fish	(I)		(I)						(I)
Seabed and communities	(I)							(I/P)	(I)
Pelagial and communities	(I)	*	*					(I/P)	

* Impacts are indirect and difficult to assess through indicators.

descriptors for biodiversity, non-indigenous species, food webs and sea-floor integrity. The descriptions and background documentation of all the core indicators are given in **Part B** of this report (HELCOM 2012 a). **Table 6.1** provides a simple overview of the proposed core indicators and how they can be used to assess the different descriptors covered in the project. Even if the redundancy of core indicators between Descriptors 1 and 4, in particular, must be omitted, there are a sufficient number of core indicators to cover most of the GES criteria for both descriptors.

The proposed core indicators do not cover the responses of all functional groups or predominant habitats (including associated communities) to the main anthropogenic pressures. **Table 6.2** summarises how the indicators, representing different functional groups, are linked to the main pressures identified in the project. In many cases, the indicator development was not finalised as seen by the number of candidate indicators (orange). The table also shows which pressures in the selection process were identified as causing significant impacts but which still lack an indicator at this stage of the project (red).

6.1.1 Core indicators for Descriptor 1 (biodiversity)

The core indicators for Descriptor 1, which describes the biological diversity of the marine ecosystem at the species, habitat and ecosystem levels, are presented in **Tables 6.3 and 6.4**. Of the 14 core indicators, eight are related to the species level; five to the habitat level (incl. communities); and one to the ecosystem structure.

Despite the relatively high number of indicators, the habitat distribution criterion (1.4) lacks a core indicator (**Tables 6.3 and 6.4**). This gap will be revisited during the second phase of the project in 2012. Further, the genetic structure of populations and habitat distribution patterns are not covered by the set of core indicators – mainly due to a lack of information and monitoring. The species distributions are assessed by only one seabird indicator, even though distributional ranges and patterns of several other species should be available. Moreover, the ecosystem structure is only addressed by the trophic index of the coastal fish community - other indicators measuring the ecosystem structure would thus be desirable.

From the perspective of major organism groups, mammals, birds and fish are relatively well represented in the set of core indicators (compare to

Table 6.3. Proposed core indicators for Descriptor 1 at the species level. The core indicators are shown in their relation to MSFD GES criteria and indicators (EC Decision 477/2010/EU).

GES criteria	GES indicator	Proposed core indicators
1.1 Species distribution	1.1.1 Distributional range	**Birds:** Distribution of wintering seabird populations
	1.1.2 Distribution pattern within the latter	No indicator
	1.1.3 Area covered by sessile/benthic species	No indicator
1.2 Population size	1.2.1 Abundance and/or biomass	**Mammals:** Population growth rate of marine mammals
		Fish: Fish population abundance
		Birds: Abundance of wintering populations of seabirds
1.3 Population condition	1.3.1 Population demographic characteristics: (body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)	**Mammals:** Blubber thickness of marine mammals Pregnancy rate of marine mammals
		Birds: White-tailed eagle productivity
		Fish: Mean metric length of key fish species
	1.3.2 Population genetic structure	No indicator

Table 6.4. Proposed core indicators for the Descriptor 1, habitat level (including associated communities) and ecosystem level. The core indicators are shown in their relation to MSFD GES criteria and indicators (EC Decision 477/2010/EU).

GES criteria	GES indicator	Proposed core indicators
1.4 Habitat distribution	1.4.1 Distributional range	No indicator
	1.4.2 Distributional pattern	No indicator
1.5 Habitat extent	1.5.1 Habitat area 1.5.2 Habitat volume	**Seabed communities:** Lower depth distribution limit of macrophyte species
1.6 Habitat condition	1.6.1 Condition of the typical species and communities	**Seabed communities:** Multimetric macrozoobenthic indices (e.g. BQI, MarBIT, DKI, BBI)
		Fish: Proportion of large fish in the community Fish community diversity
	1.6.2 Relative abundance and/or biomass	**Fish:** Abundance of fish key trophic groups
	1.6.3 Physical, hydrological and chemical conditions	Water transparency Inorganic N Inorganic P Chl a
1.7 Ecosystem structure	1.7.1 Composition and relative proportions of ecosystem components	Fish community trophic index

Table 5.4). Although the offshore fish populations were not yet adequately covered by this project, they are currently being developed in the project and ICES workshops, for example, and will be the focus (fish indicators) during the second phase of HELCOM CORESET. However, the set still lacks core indicators for breeding seabirds and zooplankton – even though they are identified as well-developed candidate indicators (see **Section 6.2**).

Although the core indicators for seabed habitats adequately cover the sediment bottoms at all depth categories, the rocky and hard substrata bottoms (**Table 5.5**) are only covered in the infralittoral zone with the macrophyte indicator (**Table 6.4).** The offshore and coastal pelagic habitats currently lack a core indicator. Despite the adequate coverage of MSFD GES criteria, **Table 6.2** shows that candidate indicators would fill significant gaps with regard to organism groups and the major pressures that impact them.

Blubber thickness of marine mammals

The blubber thickness of marine mammals indicates the nutritional status and reflects the health condition of the animals. The specific pressures behind the decreased blubber thickness have not been resolved and may involve the synergistic effects of hazardous substances, disease as well as the quality and quantity of available food (fish stocks). Currently, only the blubber thickness of the grey seal has been included as an indicator. Measured in millimetres, the parameter is regularly monitored in Sweden, Finland, Germany and, to some extent, in Poland.

The proposed quantitative boundaries for GES have been based on data available at the Swedish Museum of Natural History; the Institute of Marine Research (Norway); the Institute of Zoology, the Zoological Society of London (United Kingdom); and on information gathered through literature reviews. GES is proposed to be the lower 95% CI of the geometric mean of values in the reference period 1999-2004, i.e. GES is based on what is expected to represent healthy populations while taking natural variation into account. Different GES boundaries are proposed for female, male and immature seals.

The status assessments should only be based on the data collected during the reproductive season, with hunted or by-caught animals being included but treated separately in the analysis. The geographic scales of assessments should adhere to the management unit for seals as agreed in HELCOM recommendation 27-28/2.

Pregnancy rates of marine mammals

The pregnancy rate describes the reproductive capacity and reflects the health condition of the animals. The decrease in pregnancy rate is mainly linked to the impacts of hazardous substances but could also be linked to infectious agents or starvation. The presence/absence of a foetus or embryo is noted during the pregnancy period of mature females and expressed as a percentage. Currently, only the pregnancy rate of the grey seal has been included. The parameter is regularly monitored in Sweden, Finland, Germany and, to some extent, in Poland.

The proposed quantitative boundaries are based on a time-series analysis of the pregnancy rates of grey seals in the Baltic Sea area. After a severe decrease in the pregnancy rates during the 1970s-1990s, the grey seal population currently shows no uterine obstructions with pregnancy rates reaching 88% in 4-20 year-old females in 2008-2009. The GES boundary is proposed to be set at the lower 95% CI of the 2008-2009 period. GES is thus based on the status of what is expected to represent healthy populations as regards pregnancy rates.

Only hunted or by-caught animals should be included in the analysis for the status assessments and the geographic scales should adhere to the management unit for seals as agreed in the HELCOM recommendation 27-28/2.

Population growth rate of marine mammals

The growth rate of the population describes the status of the population's condition. In the case of the Baltic seals and harbour porpoises, a growth rate lower than the intrinsic rate of increase [8] is indicative of the impacts of hazardous substances, hunting, excessive by-catch or disease when the population is far from the carrying capacity. Populations near the carrying capacity will show decreased growth rates due to density dependence in the populations and are then estimated by other means (see below). The indicator is expressed as a % increase of the population per year. The abundance of all seal species is monitored annually in the entire Baltic while data is currently inadequate for harbour porpoises.

The proposed quantitative boundaries are based on a theoretical analysis of biological constraints and empirical analyses of the growth rates of seals and harbour porpoise populations that have been depleted by hunting. GES boundaries are proposed to be based on two different conditions: 1) When a population is far from the carrying capacity, i.e. the maximum population size of the species that the environment can sustain indefinitely with the available resources, the status should not deviate significantly from its intrinsic rate of increase: the GES boundary is proposed to be set at 4% for harbour porpoises; 10% for grey and ringed seals;

8 he rate at which a population increases in size if there are no density-dependent forces regulating the population is known as the *intrinsic rate of increase*. (Wikipedia)

and 12% for harbour seals. 2) When a population is close to its carrying capacity, GES is proposed to be considered as being met if the decrease of the population is less than 10% over a period of 10 years (similarly to the OSPAR convention EcoQO for seals). The geographic scales of assessments should adhere to the management units for seals as agreed in HELCOM recommendation 27-28/2. The geographic scale for harbour porpoise is the distribution range of each of the separate populations.

White-tailed eagle productivity

The proposed indicator of the white-tailed eagle population reflects the health status of the population and is based on the brood size (number of eggs per breeding pair) and the breeding success (% successful reproduction of all pairs). Productivity mainly decreases as a response to hazardous substances (for both brood size and breeding success) and persecution and other disturbances (for the breeding success). Productivity is measured as the mean number of nestlings out of all occupied nests.

The proposed GES boundary is based on pre-1950s data from Sweden, i.e. based on a time period when the impacts of hazardous substances on the population are perceived as being low. The GES boundary is set at the lower 95% confidence level of the pre-1950s data. The proposed GES boundary for breeding success is 60%, for brood size 1.64 nestlings, and for productivity >1.0 nestlings; the parameters are monitored in all the Baltic Sea countries. The assessment units of the core indicator are the coastal strips (15 km inland) of the Baltic Sea's sub-basins.

Abundance of wintering populations of seabirds

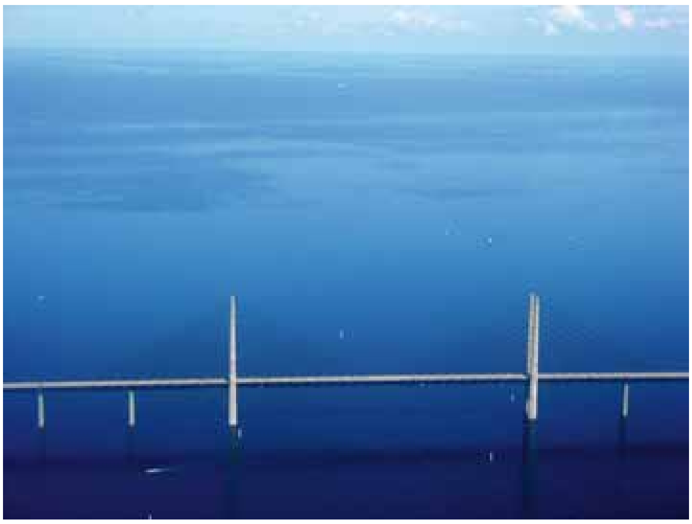
The core indicator for wintering seabird populations measures the abundance of selected species, which have been categorised into functional groups. The indicator can be used either for single species or as an integrated indicator for functional groups or all species. The impacts of pressures on the abundance are species specific; however, the main pressures are the oiling of birds; visual disturbances; altered food availability (i.e. deteriorated habitat conditions); loss of habitat; and by-catch in fisheries.

The proposed GES is tentatively defined as a percent deviation from the mean of the reference period. The current proposal is to use the reference period 1992-1993, which corresponds to the time period of the last coordinated survey and a deviation of 50%. This approach, however, needs to be revisited during the second phase of the CORESER project. Ultimately, GES should be set by modelling the population size based on the GES for eutrophication-related core indicators and empirical data on breeding success and survival rates of the species concerned. The assessment units are the sub-basins of the Baltic Sea.

Distribution of wintering populations of seabirds

The indicator follows changes in the main distribution area of selected bird species of high numerical and environmental importance, for which sufficient coverage by line transect data is available, such as the Common Eider, Velvet Scoter, Common Scoter and Long-tailed Duck. The distribution is determined from density surface models such as GAMs or GLMs, where the 75th percentile of all the sampled densities during the reference situation is used as the limit for distribution.

Time series data can provide information on changes over time and reveal reoccurring spatio-temporal patterns. Combined with data on anthropogenic pressures, naturally driven patterns can be distinguished from pressure-based changes. Pressure-based changes in distribution may occur due to changes in resource quality and availability, habitat loss and disturbances or barriers. The



distribution is assessed on the scale of the entire Baltic Sea. GES is proposed to be compared to the situation in 1992-1993; significant negative deviation from this distribution is proposed to reflect a sub-GES condition.

Fish population abundance

Under this core indicator, several fish stocks in the coastal and offshore waters can be assessed. The offshore stocks are proposed to be assessed by using the MSY B trigger values as GES boundaries; for coastal stocks, however, other GES boundaries need to be used. Currently, ICES has developed MSY B triggers in the Baltic Sea for the western cod stock and three herring stocks. New triggers are also being developed to facilitate the implementation of the EU MSFD.

The HELCOM FISH-PRO project has developed the **Coastal fish - Species Abundance Index** as a core indicator for population assessments. The index estimates the abundance of key fish species in Baltic Sea coastal areas, such as perch (*Perca fluviatilis*) - a freshwater species that commonly dominates (in terms of numbers) coastal fish communities. As such, areas of good ecological status generally have high populations of perch. The index reflects the integrated effects of recruitment and mortality. Recruitment success is expected to be mainly influenced by climate and the quality of recruitment habitats; mortality, on the other hand, is influenced by anthropogenic pressures, mainly fishing, but also by natural predation by apex predators such as seals, seabirds and fish. The index is currently based on data collected from fishery-independent sampling of coastal fish using passive gears and expressed as relative abundance. Harmonised monitoring is currently conducted in Estonia, Finland, Lithuania, Latvia, and Sweden. Additional data sources, such as commercial catch statistics based on the EU-data collection system and coastal echo sounding, could complement the data if they prove to be of high enough quality to assess the biodiversity of coastal fish communities (for additional fish indicators see **Part B** of this report, HELCOM 2012 a).

The proposed quantitative boundaries for the GES of coastal fish should be based on specific reference data from the sites and sampling methods. If reference data are missing, trends in available data and expert judgements are used to set the GES boundary. Since the temporal and spatial variation

of coastal fish communities in the Baltic Sea is substantial, the expected targets for GES are typically site specific, depending on the local properties of the ecosystem such as topography and geographical position. The geographic scales of assessment should therefore be within the region of the monitoring area.

Proportion of large fish in the community

This core indicator follows the community structure by computing the proportion of fish (biomass or individuals) that are large enough to contribute significantly to reproduction and predation. As fishing targets large individual fish, the size structure tends to be bias towards fewer large fish under a heavy fishing pressure. Although there is no established indicator for offshore communities to date, the development work is ongoing (see **Section 6.2**).

For the coastal fish communities, the HELCOM FISH-PRO project has developed the **Coastal fish – Community Size Index** indicator, which reflects the general size structure at the community level and is based on estimates of the abundance of large fish (measured as catch per unit effort). Generally, large piscivorous fish are abundant in coastal communities indicative of good ecological status in the Baltic Sea. The index is expected to mainly reflect changes in fishing mortality at the community level, where low values reflect increased fishing mortality. However, the value of the index may to some extent also be influenced by environmental conditions such as temperature and nutrient status. For monitoring, GES principles and geographical scale, see "Coastal Fish - Species Abundance Index".

Metric mean length of key fish species

The core indicator *mean length of the key species* is expected to reflect changes in recruitment success as well as in mortality. Low levels may signal the appearance of a strong year class of recruits, decreased top down control in the ecosystem, or high fishing mortality but potentially also density-dependent growth. High levels in the index may signal a high trophic state, but potentially also decreased recruitment success. Because of this, the indicator should be interpreted together with the Fish population abundance.

In the coastal community, **Coastal fish – Species Demographic Index** reflects the size structure of key fish species in Baltic Sea coastal areas, such as perch (*Perca fluviatilis*). The index is based on the metric *mean length of the key species*, but the metric *abundance of large key species* could be used as additional information or complement. For monitoring, GES principles and geographical scale, see "Coastal Fish - Species Abundance Index". There are no parameters currently developed for offshore fish species.

Fish community diversity

The indicator reflects biological diversity of fish at the community level and can be based on the Shannon Index. High values reflect high species richness and low dominance of single species, whereas low values reflect the opposite. The index has both an upper and a lower boundary since very high levels of the index potentially also may reflect a decrease in the abundance of a naturally dominating species.

In the coastal waters, **Coastal Fish Community Diversity Index** is based on the Shannon index and has been tested by the HELCOM FISH-PRO project. For monitoring, GES principles and geographical scale, see "Coastal Fish - Species Abundance Index".

Abundance of fish key trophic groups

The indicator measures abundances of trophic groups, being hence a wider estimate of fish abundance in the ecosystem than abundance of single species populations. The indicator has not been developed yet in the offshore waters in the CORESET project, but in the coastal waters the HELCOM FISH-PRO project has tested the **Coastal fish – Community Abundance Index.**

The coastal index is based on estimates of the abundance of two different species groups: *Abundance of cyprinids* and *abundance of piscivores*, and reflects the integrated effects of recruitment and mortality of the species included in each functional group. Recruitment success is expected to mainly be influenced by the quality and availability of recruitment habitats, climate and eutrophication. Mortality is influenced by fishing, but also natural predation from other animals, such as seals, seabirds and fish causes variation in the abundance. The two metrics included in the index are expected to differ in their responses to anthropogenic pressure factors; the a*bundance of cyprinids* is expected to show the strongest link to eutrophication and *abundance of piscivores* the strongest relationship to fishing pressure. Abundance of cyprinids should have an upper and lower boundary since to low levels may reflect a decreased abundance of some naturally dominating cyprinid species. For monitoring, GES principles and geographical scale, see "Coastal Fish - Species Abundance Index".

Fish community trophic index

The index reflects the general trophic structure at the community level and is based on estimates of the proportion of fish at different trophic levels. Alternatively, estimates of the proportion of piscivores in the fish community may be used. The index provides an integrated measure of changes in the trophic state of the fish community. Typically, very low values of the index may reflect high fishing pressure on piscivores and/or domination of species favoured by eutrophic conditions. Since high levels of the index also may reflect a decreased abundance of some naturally dominating non-piscivore species the index has both an upper and a lower boundary. The HELCOM FISH-PRO has tested the **Coastal Fish - Community Trophic Index** for coastal fish species. For monitoring, GES principles and geographical scale of that approach, see "Coastal Fish - Species Abundance Index".

Multimetric macrozoobenthic indices

In coastal waters, there are several national versions of multimetric macrozoobenthic indices that are used for the implementation of the WFD. All the indices are based on the Benthic Quality Index (BQI) and adapted to local conditions. For example, previous studies show the high dependency of biodiversity indices to the strong salinity gradient in offshore waters of the Baltic Sea (e.g. Zettler et al. 2007). The use of the BQI was ensured by the adjustment to the open sea and salinity conditions by Fleischer & Zettler (2009).

The CORESET project proposed to use the species richness indicator (Villnäs & Norkko 2011) in the offshore water areas, until the validity of Benthic Quality Index (BQI) can be ensured in the open sea conditions. This core indicator thereby includes a number of different indices, which are, however, generally based on abundance, sensitivity of species and taxonomic composition of the benthic invertebrate communities. The indicator is a unitless, general disturbance indicator that responds to multiple pressures. Intercalibration has been finalized for some countries in the WFD Baltic GIG (e.g. Carletti & Heiskanen 2009).

The GES boundary is the good/moderate boundary as defined in the implementation of the WFD. These boundaries have mainly been determined by first defining a reference condition based on reference sites, historic data or expert judgement. The assessment units in the coastal waters are the water types or water bodies defined in the WFD and, in the offshore waters, the offshore subbasins defined in the HELCOM thematic assessments (HELCOM 2009 a, b).

Lower depth distribution limit of macrophyte species

The macrophyte indicator reflects the depth distribution of macrophytes which is dependent on water transparency. The indicator value decreases mainly in response to eutrophication, but is also reduced by coastal shipping and other disturbances causing the resuspension of sediments. The indicator has been used in the implementation of the WFD by all Baltic Sea countries except Poland. Intercalibration has taken place in the WFD Baltic GIG. The CORESET project also applied the proposed macrophyte indicator to the offshore areas of the Baltic Sea, even though it only comprises a limited area of offshore reefs. This means that the GES boundaries in the offshore reefs still need to be established.

The GES boundary and the assessment units are as in the previous.

6.1.2 Core indicators for Descriptor 2 (non-indigenous species)

MSFD Descriptor 2 requires two kinds of indicators: trends in the abundance of non-indigenous species (NIS) and their impacts (already in the description of the descriptor). Only one core indicator was

Table 6.5. Proposed core indicators under Descriptor 2 (Non-indigenous species).		
GES criteria	**GES indicator**	**Proposed core indicators**
2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species	2.1.1 Trends in abundance	Trends in arrival of new non-indigenous species
2.2 Environmental impact of invasive non-indigenous species	2.2.1 Ratio of invasive non-indigenous and native species	No indicator
	2.2.2 Impacts	No indicator

proposed for non-indigenous species: trends in the arrival of new species (**Table 6.5**). The biopollution index that measures the impacts of non-indigenous species on the ecosystem is in its current form, however, considered as a supplementary indicator (**Section 6.3**). The proposed GES indicator 2.2.1 *Ratio of invasive non-indigenous and native species* is not covered by a core indicator.

Trends in the arrival of new non-indigenous species

This indicator follows the number of new species in assessment units during six-year assessment periods, and is thus directly related to the management success of the implementation of the IMO Ballast Water Convention and other relevant policies. The indicator reaches GES when no new non-indigenous species have been found in an assessment unit during the assessment period. The indicator is always 'nulled' after the assessment period; however, the cumulative number of new species in the assessment units over longer time periods can be shown as supplementary information. The assessment units of the indicator are the sub-basins divided by national borders and offshore-coastal water boundaries. Although the data of the non-indigenous species are taken from existing monitoring programmes and other sources of information, targeted survey activities are recommended in the vicinity of high-risk areas such as harbours, anchoring areas and intensive ship traffic.

6.1.3 Core indicators for Descriptor 4 (food webs)

As outlined earlier, several of the 'biodiversity' indicators under GES Descriptor 1 of the MSFD are also relevant for Descriptor 4, which describes a functional food web. The indicators related to criterion 4.3 *Abundance/distribution of key trophic groups and species*, in particular, have a clear overlap with the indicators under Descriptor 1. **Table 6.6** presents the proposed core indicators that can be used to assess GES for food webs. Because all these indicators can also be categorised under GES Descriptor 1, the descriptions are given in **Section 6.1.1**. Thus, no food-web specific indicator has been proposed by the project.

The proposed core indicators cover all the GES criteria and associated GES indicators for a food web. The indicators do not, however, represent the key species and trophic groups of the ecosystem at an adequate level (see key species in **Table 5.6**). The set of core indicators for this descriptor lacks benthic species, which play a key role in the food web as prey species, for example; and zooplankton, which would indicate the availability of prey for planktivorous fish. There are, however, candidate indicators suggested by the project, which describe, for

Table 6.6. Proposed core indicators for GES Descriptor 4 (Food webs). Note that all of the proposed indicators are also listed under Descriptor 1 (Biodiversity).		
GES criteria	**GES indicators**	**Proposed core indicators**
4.1 Productivity of key species or trophic groups	4.1.1 Performance of key predator species using their production per unit biomass.	White-tailed eagle productivity
		Population growth rate of marine mammals
4.2 Proportion of selected species at the top of food webs	4.2.1 Large fish (by weight).	Abundance of fish key trophic groups
		Fish community trophic index
4.3 Abundance/distribution of key trophic groups and species	4.3.1 Abundance trends of functionally important selected groups/species.	Abundance of wintering seabirds

example, the size distribution of benthic long-lived invertebrates and the abundance of zooplankton (see **Section 6.2**). The supplementary indicators for the ratios of different functional groups may also evolve into food web core indicators if further developed and properly tested (see **Section 6.3**).

6.1.4 Core indicators for Descriptor 6 (sea-floor integrity)

GES Descriptor 6 describes the condition and extent of benthic habitats and focuses both on the state as well as the impact on and pressure to the seafloor. Among the proposed core indicators, *Lower depth distribution limit of macrophyte species* and *Multimetric macrozoobenthic indices* address GES criterion 6.2 *Condition of the benthic community* (**Table 6.7**). Because these indicators can also be categorised under GES Descriptor 1, the descriptions are given in **Section 6.1.1**.

No core indicator was selected for GES criterion 6.1 *Physical damage, having regard to substrate characteristics*. This criterion has two GES indicators: the first describes the extent of biogenic substrates and the second the extent of significantly affected seabed. The CORESET project has, however, suggested a candidate indicator for the extent of seabed biotopes significantly affected by the anthropogenic cumulative impact (see **Section 6.2.2**). In addition, the HELCOM Initial Holistic Assessment contains a chapter that describes the extent of anthropogenic pressures and impacts in the Baltic Sea (HELCOM 2010 a, b); the data layers are published in the HELCOM Data and Map Service (http://maps.helcom.fi).

6.2 Candidate indicators for the assessments of biodiversity

Within the tight time schedule of the HELCOM CORESET project, it was not possible to finalise the selection of all the proposed indicators that had been identified as potentially important for the assessment of the environmental status of the Baltic Sea. These indicators were labelled in this report as *candidate indicators* and will be readdressed during the second phase of the project. Some of the candidate indicators lack GES boundaries, some have methodological challenges, while others need the data to be compiled and undergo further testing. The CORESET expert group for biodiversity considered it important to continue developing them towards operational core indicators.

This section presents the candidate indicators discussed during the CORESET project, while **Part B** of this report (HELCOM 2012a) contains more detailed descriptions of them.

6.2.1 Candidate state indicators for biodiversity

The candidate biodiversity indicators that could be used to measure the *state* of the marine biodiversity are listed in **Table 6.8**. Significant additions to the proposed set of core indicators would be the indicators related to distribution (GES criterion 1.1), breeding waterbirds, zooplankton and phytoplankton, anadromous fish, harbour porpoise and benthic communities.

Table 6.7. Proposed core indicators for Descriptor 6 (Sea floor integrity) in relation to the MSFD GES criteria and GES indicators.

GES criteria	GES indicator	Proposed core indicators
6.1 Physical damage, having regard to substrate characteristics	6.1.1 Type, abundance, biomass and areal extent of the relevant biogenic substrate.	No indicator
	6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types.	No indicator
6.2 Condition of the benthic community	6.2.1 Presence of particularly sensitive and/or tolerant species.	Lower depth distribution limit of specific perennial macrophyte species
	6.2.2 Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species.	Multimetric macrozoobenthos indicators (BQI, MarBIT, DKI, BBI, ZKI, B)
	6.2.3 Proportion of biomass or number of individuals in the macrobenthos above some specified length/size.	No indicator
	6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community.	No indicator

Table 6.8. Candidate state indicators for biodiversity. The indicators are related to the MSFD GES descriptors and criteria.	
MSFD GES descriptors and criteria	**Candidate state indicators**
Descriptor 1	
Criterion 1.1 Species distribution	Distribution of harbour porpoise
Criterion 1.2 Population size	Sea trout parr density, quality of spawning habitats (also criterion 1.6)
	Salmon smolt production capacity
	Offshore fish populations and communities
Criterion 1.5 Habitat extent	Blue mussel cover
Criterion 1.6 Habitat condition	Seasonal succession of functional phytoplankton group
	Phytoplankton diversity
	Zooplankton species diversity
	Cladophora length (also criterion 5.2)
	Population structure of long-lived macrozoobenthic species (also criterion 4.3)
Descriptor 4	
Criterion 4.1 Productivity of key species or trophic groups	Fatty-acid composition of seals as measure of food intake composition
Criterion 4.3 Abundance/distribution of key trophic groups and species	Biomass of copepods
	Biomass of microphagous mesozooplankton
	Mean zooplankton size
	Zooplankton-phytoplankton biomass ratio
	Abundance of breeding populations of seabirds
	Offshore fish populations and communities
Descriptor 6	
Criterion 6.2 Condition of the benthic community	Ratio of perennial and annual macrophytes (also criterion 1.6)

Although it may be premature to claim anything concrete regarding the process to finalise the candidate indicators, the salmon and sea trout indicators are currently being developed by ICES WGBAST [9] with several sub-parameters of the indicator already existing. For example, two of the zooplankton indicators are well developed, but their applicability needs to be validated in a wider area; further, the harbour porpoise indicator as well as the phytoplankton indicators are waiting for in-depth exploration of data for the GES boundaries. By contrast, there is not even enough background data to start the development work on the fatty-acid composition, the macrophyte ratio indicators or the mussel cover indicator (**Table 6.8**). The perspectives of the other candidate indicators rest somewhere between these extremes.

Distribution of harbour porpoise

The indicator is intended to measure the geographic distribution of harbour porpoise based on the frequency of registrations per area in a year (e.g. >10 registrations/1,000 km^2). There is regular monitoring for the distribution and abundance of harbour porpoise in the south-western Baltic Sea and the current project activities in the Baltic Proper can serve to operationalise the indicator in the near future. However, until a coordinated methodology for the calculation of the indicator is developed it cannot be proposed as a core indicator.

The Baltic Proper's harbour porpoise population is currently critically endangered. As an intermediate target, GES may be defined as a positive trend, i.e. an increase in the distribution of the porpoise population between assessment periods. Ultimately, GES is reached when the entire historical range in the Baltic Proper is recolonised. It should be noted, however, that since the abundance of the harbour porpoise in the Baltic Proper is very low at present, it is no longer reliably quantifiable. An indicator based on sightings and recordings of their presence is therefore recommended until the density has recovered sufficiently to allow a reliable estimation of their distribution.

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Fatty-acid composition of seals as a measure of food composition

The indicator measures the nutritional status of seals by fatty-acid composition. While there may be multiple pressures behind a change in fatty-acid composition, fishing, the deterioration of habitats of prey species and hazardous substances are perhaps the predominant pressures. However, for a population near its carrying capacity and thus competing for food, this indicator may not be reliable. GES could be estimated from historic data and literature surveys. The assessment unit is the entire Baltic Sea.

Abundance of breeding populations of seabirds

The indicator includes *apriori* selected seabird species, which have been categorised into functional groups. The indicator responds to multiple pressures, such as habitat loss, food availability and disturbance. The abundance can be measured on three levels: species, functional groups or all seabirds. In the case of the two latter, an integration method needs to be developed. Although data for the indicator exists, data compilation and the development of the GES boundary require more work. This indicator is predicted to be a very promising candidate for the set of core indicators.

Salmon smolt production capacity

Three parameters that can be combined into an index are proposed to assess the state of salmon: 1) the survival of smolts in the sea (%); 2) the number of smolts produced annually in a river; and 3) the trend in the number of salmon spawning rivers (%). The indicator responds to fishing pressure - target and non-target - and pressures degrading the quality of spawning habitats. The first two indicators are ready, in principle, for operational use and the results are available in the ICES WGBAST reports (ICES 2011 b). ICES WGBAST will further develop the third parameter, as well as consider ways of combining the three parameters into an index. The outcome of this work is expected to be operational by 2013. GES for the index has not been developed; however, HELCOM BSAP includes a target for riverine smolt production capacity of 80%.

Sea trout parr density and the quality of spawning habitats

Two parameters related to sea trout are proposed: 1) sea trout parr densities of sea trout rivers vs. their theoretical potential densities (%); and 2) the quality of the spawning habitats. The indicator thus responds to both fishing pressure as well as the pressures degrading the quality of spawning habitats. ICES WGBAST is further developing both the parameters. The first parameter is expected to be operational by 2012/2013 and the second by 2013/2014. WGBAST already estimates parr densities in rivers (ICES 2011 b).

Offshore fish communities and other fish indicators

The CORESET fish indicators have relied on the HELCOM FISH-PRO project, which assesses the status of coastal fish communities. The CORESET biodiversity expert group has, however, also identified additional indicators which are based on other sampling methods and followed the ICES workshops on Descriptor 3 indicators to facilitate the development of core indicators for commercially exploited fish stocks.

Offshore fish populations and communities were studied from the Baltic International Trawl Survey (BITS) data. The work will continue with other data sets to develop indicators which are compatible with the coastal fish indicators but comprise different species.

The core indicators 'Abundance of fish key trophic groups' and 'Fish population abundance' currently only include sampling by gill nets, where perch and some cyprinids (roach, white bream, etc.) typically form the bulk of the catch. Other data sources, such as coastal trawl surveys, can be used to obtain population level data from a wider group of species. The fish catch data collected under EU Data Collection Regulation 665/2008/EC is also a source which can be used for this indicator. One part of this data, e.g. sampling of predatory species from herring traps, covers all size classes and can be treated here as fishery independent data. The potential indicators from these data sources are 'Proportion of fish larger than the mean size of first sexual maturation' and 'Mean size at first sexual maturation'. These indicators are closely linked to the effects of fishing pressure on fish populations and on population level biodiversity. The testing of these indicators is being carried out in the LIFE+ MARMONI project. GES is anticipated to be based on fishery independent data sources and on the principle that each individual fish should have a chance to spawn at least once before they are targets for effective fishery.

Cyprinids, especially bream (*Abramis brama*), roach (*Rutilus rutilus*) and white bream (*Blicca bjoerkna*), have become increasingly abundant in large archipelago areas of the northern Baltic Sea (e.g. in the Gulf of Finland, the Archipelago Sea and the Åland archipelago), mainly due to coastal eutrophication. This indicator is complementary to the core indicator *Fish population abundance* as regards cyprinid species. It will use sampling methods which give a more reliable estimate of cyprinid abundance, such as horizontal echo-sounding (with trawl or seine samples of the fish) and commercial catches of cyprinids with trap nets and logbook data. The results of these sampling methods, however, would not be directly comparable with the existing gill net monitoring by HELCOM FISH-PRO. Targets could be set as expert judgements, for example a 30-40% reduction in cyprinid biomass in coastal regions where they are very abundant.

Ratio of opportunistic and perennial macrophytes

The ratio between opportunistic and perennial macrophytes reflects the relative abundance of functionally important groups, with the perennial species often being habitat structuring and sensitive to water quality while the annual species are more tolerant of or even opportunistic in eutrophic conditions. The indicator is based on g dry weight m^{-2} and expressed as a percentage of the respective type. A shift to a higher percentage of annual macrophytes is primarily considered as a sign of both eutrophication and physical disturbance. The indicator is already applied in the implementation of the WFD in Estonia, Germany and Poland. Assessment units are the WFD water bodies and the GES boundaries that have been developed for specific water types.

Cladophora length

The length of the green seaweed *Cladophora glomerata* has been proposed as an indicator of seasonal nitrate availability. Although being primarily a eutrophication indicator, it still provides an easy measure of the condition of hard substratum habitats. It can also be used as an indirect estimate of the state of biodiversity since it also indicates the loss or decreased condition of perennial macroalgae that support diverse communities of associated species. Further validation of the response to nutrient enrichment is needed and is being conducted as part of the ongoing LIFE+ MARMONI project. The indicator is presumed to be low-cost as it is possible to measure from stationary buoys, for example. The GES boundaries can tentatively be based on the response of the length to the nitrate concentrations. Thus, GES boundaries for nitrate concentration will set the GES boundaries for this indicator.

Blue mussel cover

Blue mussel (*Mytilus edulis/trossulus*) is an important habitat-forming species in the Baltic Sea and is a food source for benthic feeding birds and fish. Depending on the definition of the methodology (distribution or extent), the indicator based on this species would fulfil GES criteria 1.1 (species distribution); 1.4 (habitat distribution); 1.5 habitat extent; and/or the GES indicator 6.1.1 (areal extent of biogenic substrate) - all of which are poorly covered by the currently proposed core indicators. At present, although there is no dedicated monitoring in place, the blue mussel cover in stationary monitoring transects has probably been assessed all around the Baltic Sea.

Size distribution of long-lived macrozoobenthic species

Long-lived species such as the bivalve molluscs *Mytilus edulis/trossulus, Cerastoderma glaucum, Arctica islandica* and *Macoma balthica*, the isopod crustacean *Saduria entomon or decapod crustacean species* are key species in the benthic community and reflect its condition. The population structure, measured as abundance per size class, is proposed to reflect physical disturbance as well as the indirect effects of eutrophication and selective extraction of species. Continued development of this indicator requires that the response to different pressures as well as the definition of the natural size spectrum be analysed. Although current monitoring in the Baltic Sea does not fully support this indicator, with slight modifications in the analyses the proportion of large individuals can be counted. Depending on the scale of the predominant pressure (hypoxia / bottom trawling / dredging), the assessment units can range from WFD water bodies to sub-basins.

Biomass of copepods

The biomass of copepods primarily reflects the quantity and quality of food for zooplanktivorous fish. As a primary food source for zooplanktivorous fish and efficient consumers of phytoplankton, copepods are central to the ecosystem functioning. The copepod biomass is negatively affected by eutrophication and fishing. The indicator is expressed as mg m^{-3} or as a percentage of the total mesozooplankton biomass. Monitoring is carried out in all the Baltic Sea countries, albeit with different frequencies and area coverage.

The approach for defining GES is based on reference data on zooplanktivorous fish and the identification of time periods when fish growth and population stocks were relatively high. A boundary for GES is set as a threshold mark between acceptable and unacceptable conditions. The geographic scale of assessments is proposed to be based on Baltic Sea sub-basins as defined by HELCOM.

Biomass of microphagous mesozooplankton

The indicator primarily reflects the trophic state of the ecosystem and increases with increasing eutrophication. It is expressed as mg m^{-3} or as a percentage of the total mesozooplankton biomass. An increase in the indicator value may also be linked to decreased food availability/quality for zooplanktivorous fish. The biomass of microphagous mesozooplankton is positively affected by eutrophication.

The approach for defining GES is based on the reference data of water transparency and/or chlorophyll a and the identification of time periods when these parameters were considered in GES. A boundary for GES is set as a threshold mark between acceptable and unacceptable conditions. The geographic scale of defining GES and conducting current status assessments is proposed to

be based on Baltic Sea sub-basins as defined by HELCOM and the WFD coastal water types.

Zooplankton diversity index

Initial testing of the zooplankton diversity index has been conducted. It is a biodiversity-based indicator displaying the ratio between the number of species actually observed in the area and the species number registered in the area in any given year (season), assuming that ratios less than 1 correspond to decreased diversity, and that ratios over 1 indicate an invasion or colonization from nearby areas. Tests showed that the ratio is consistently <1, has been increasing over the last three decades and that it shows a cyclic pattern. Further testing is needed to evaluate the applicability of the indicator.

Mean zooplankton size

The zooplankton species composition has changed in the Baltic Sea due to climatic fluctuations (e.g. salinity changes), an increase of hypoxic bottom waters (limiting vertical migration) and increased herring and sprat predation. As a general outcome of these changes, the zooplankton size has decreased. The decreased abundance of large-bodied species causes food depletion for predators like herring and sprat as well as for fish-feeding birds (Österblom et al. 2006). GES can be defined from old data series by using weight-at-age measurements of zooplankton-feeding fish species (herring and sprat). As the indicator measures very large-scale changes in the Baltic Sea, the assessment units can be sub-basins or even combining some of them to create larger units.

Ratio of zooplankton and phytoplankton biomasses

One way of measuring the state of the food web in the Baltic Sea is to follow the ratios of trophic levels. By comparing the zooplankton-phytoplankton biomass ratio with fish-related parameters (weight at age, spawning stock biomass, fishing mortality, etc.) over longer time spans, it may be possible to define a ratio where the food web appears to be in GES. As the indicator measures very large-scale changes in the Baltic Sea, the assessment units can be sub-basins or even combining some of them to create larger units.

Phytoplankton diversity or evenness

Initial testing of the biodiversity-based indicators have been conducted concentrating on the dominant phytoplankton species and their diversity, for example the proportion of the total biomass formed by the most dominant species; the number of species that make up the majority of the total biomass; and an applied Shannon's index based on the most abundant species that together make up >95% of the total biomass. The preliminary testing of the indicators show promise but needs further elaboration.

Seasonal succession of functional phytoplankton groups

Initial testing of an index based on the seasonal succession of phytoplankton functional groups has been conducted. The proposed index has previously been presented by Devlin et al. (2007) for UK waters. The method is based on first defining reference growth envelopes for functional groups of interest using long-term data or un-impacted sites. The present state is assessed by comparing the present seasonal distribution of each functional group to the reference by use of a normalized score. The index has been tested for diatoms and dinoflagellates in the Baltic Sea area. Further testing is needed to evaluate the appropriateness of the indicator.

6.2.2 Candidate pressure indicators for biodiversity

The GES descriptors for biodiversity, food web and sea floor integrity contain mainly criteria and indicators for the state or impacts on the ecosystem (Anon. 2010). The anthropogenic pressures affecting the state or impacts can be numerous yet only a few have been mentioned in the EC decision document (Anon. 2010). An assessment of individual pressures has, however, advantages which should be heeded. First, a pressure indicator may be easier to develop and monitor than an impact indicator; and second, a pressure indicator is linked to the need for management measures in order to improve the state of the environment. Pressure indicators are, however, always indirect indicators for GES because an increase or decrease of a pressure does not indicate whether GES has been reached for any biodiversity descriptor.

The process that was used to guide the indicator selection (see **Section 5.3.2**) resulted in an expert evaluation of the pressures perceived to have the highest negative impact on biodiversity. Those pressures identified as predominant are presented in **Table 6.2** while the detailed pressure matrices are presented in **Annex 1**.

Many of the pressures are already measured with the spatial accuracy required for developing pressure indicators. Indicators and targets related to inputs of nutrients already exist within HELCOM in the BSAP and are further refined within the HELCOM LOAD group based on the work of the HELCOM TARGREV project. Although indicators related to inputs of synthetic and non-synthetic substances do not currently exist, they are being discussed in other HELCOM working groups or projects (e.g. CORESET HS, COHIBA and HELCOM LOAD) while spatial data is available for some substances. Data on the hunting of seals (and birds) is collected at the national level while data on fishing in terms of catches and efforts of commercial fishery is collected at the EU level. However, there is no spatially-detailed fishing pressure indicator. Oil spills are being monitored in the Baltic Sea by aerial surveillance but the number of oiled birds, for example, is currently not monitored. Thus, the predominant pressures on biodiversity, which are not properly monitored and where indicators are missing, are primarily by-catch in fisheries, noise and the physical disturbance of the seabed (**Table 6.9**). These indicators were the focus for the development of pressure indicators in the biodiversity expert group.

By-catch of marine mammals and seabirds

The indicator directly reflects the impacts of fishing on marine mammals and seabirds. Fishing is considered as one of the main pressures on seabirds and most likely the most important pressure for harbour porpoises in the Baltic Sea area. The indicator is measured as numbers of individuals by-caught in fishing gear or as a proportion of the population killed annually. According to CORESET experts, the required monitoring to operationalise the indicator is not in place. However, this may be solved if CCTV (closed-circuit television) surveillance systems become mandatory on EU fishing vessels. In addition, the requirements of the MSFD criteria and associated indicators for Descriptors 1 and 4 should lead to additional monitoring efforts of by-catches carried out by the Member States (Anon. 2010). Acceptable by-catch rates must be determined for specific species and subpopulations. A proposed target was already stated in the BSAP - by-catch of harbour porpoise, seals and seabirds should be significantly reduced with the aim of reaching close-to-zero by-catch rates. The assessment units could be HELCOM sub-basins. The indicator can be widened to also include non-target fish and invertebrate species.

Impacts of anthropogenic underwater noise on marine mammals

The indicator directly reflects the single and cumulative impacts of anthropogenic underwater noise on marine mammals in the Baltic Sea area such as high-amplitude, low and mid frequency impulsive sounds introduced by different types of sonar, seismic activities, the construction of offshore wind farms or acoustic harassment devices. It also includes low frequency continuous noise generated from shipping, sand and gravel extraction or the operation of offshore wind farms. According to the HELCOM Initial Holistic Assessment, anthropogenic underwater noise is considered as a widespread pressure in the entire Baltic Sea. Underwater noise can be assessed by measurements and modelling based on appropriate propagation models and harmonised noise profiles of the relevant sources. Species-dependent impacts need to be specifically estimated and weighted. According to CORESET experts, the required monitoring to operationalise the indicator is not in place. The requirements of MSFD Descriptor 11 (Anon. 2010) should lead to the basic monitoring of impulsive and continuous sound sources in the marine waters of the Member States and serve as a basis for mapping noise to illustrate the entire soundscape of an area and associated impact zones for different biota of concern. Acceptable noise thresholds should be set to reflect he impact levelss to be avoided. Assessment units are to be determined but the rather quick attenuation of high frequencies should be considered. The indicator can be widened to include other affected marine organisms such as fish or invertebrates.

Oiled birds

The number of oiled birds is proposed as an indicator to reflect the pressure of oil spills on biota. The oiling of seabirds is a significant pressure on the breeding and particularly wintering populations of seabirds (HELCOM 2009 b). The first step is to identify what type and frequency of monitoring is needed to support the indicator. The indicator would most probably be based on the core indicator *Abundance of wintering populations of seabirds* - the monitoring effort of the indicator would also produce data for oiled birds. The proportion of oiled birds in the populations would be followed over time and GES would be based on an acceptable mortality rate for the population.

Cumulative impacts on benthic habitats

The indicator for the anthropogenic cumulative impact on benthic habitats follows the amount of habitat area affected by the physical disturbance of the seabed. The indicator would primarily require spatially-detailed data from dredging, the disposal of dredged matter, bottom trawling fishery and various installation and construction works. Other human activities can be also added to this 'physical disturbance indicator'. This indicator addresses MSFD GES criterion 6.1, which calls for an assessment of anthropogenic impacts on benthic habitats and criterion 1.6 'habitat condition'. Underlying habitat maps were produced by the EUSeaMap project and the indicator has been tested by the pressure data from the HELCOM HOLAS project, presented in the HELCOM Initial Holistic Assessment (HELCOM 2010 b). GES measures an acceptable proportion of lost or significantly damaged habitats and is suggested to be based on the classification of the EU Habitats Directive. The assessment units would be the sub-basins.

Fishing targeted catches

Fishing affects offshore and coastal fish communities, seabed habitats and indirectly pelagic plankton communities. The catch data from ICES areas, rectangles or from spatially more detailed VMS-logbook data sets should be used to develop a coherent picture of the extent and intensity of fishing. This indicator is also contained in GES Descriptor 3 (commercially exploited fish stocks) and will most likely be developed by ICES. The indicator could be used in combination with the seabed habitat maps to produce an indicator of significantly affected benthic habitats.

Incidentally and non-incidentally killed white-tailed eagles

Information on the causes of mortality of the white-tailed eagles is available in many Baltic Sea countries. The indicator would follow the role of technical installations (towers, wind mills, power lines) and persecution in the population development of the species. GES should most likely be on the 'no increasing trend' basis. Assessment units would be the Baltic Sea countries.

Inputs of nitrogen and phosphorus

The HELCOM BSAP contains a provisional agreement on the annual maximum allowable inputs of nitrogen and phosphorus to the Baltic Sea, and an allocation of the inputs to sub-basins and countries (HELCOM 2007 a, HELCOM 2011). The indicator would be the total amounts of nitrogen and phosphorus draining to the sea areas (division of sub-basins by country borders and WFD catch-

Table 6.9. **Candidate pressure indicators for biodiversity status outlined by the expert group.**

MSFD GES descriptors and criteria affected by the pressure	Candidate pressure indicators
Descriptor 1, criterion 1.2 Descriptor 4, criterion 4.3	By-catch of mammals and seabirds
Descriptor 1, criterion 1.1	Impacts of underwater noise on marine mammals
Descriptor 1, criterion 1.2 Descriptor 4, criterion 4.3	Number of seabirds being oiled annually
Descriptor 1, criterion 1.2 Descriptor 4, criterion 4.3	Incidentally and non-incidentally killed white-tailed eagles
Descriptor 1, criteria 1.4 + 1.5 Descriptor 6, criteria 6.1 + 6.2	Cumulative impact on benthic habitats
Descriptor 1, criteria 1.2, 1.6 + 1.7 Descriptor 4, criterion 4.2	Fishing of targeted catches
Descriptor 1, criteria 1.4-1.7 Descriptor 6, criterion 6.2	Inputs of nitrogen and phosphorus

ment areas). The indicator is the prerequisite for the follow-up of the eutrophication status and is also a significant pressure indicator for biodiversity. Although the nutrient concentrations in seawater can show the pressure for the biodiversity, the input indicator is required to follow management measures to reduce the inputs of nutrients. The inputs of nutrients (both waterborne and airborne) are followed annually by the HELCOM Contracting States. The indicator was not specifically addressed by the CORESET project as its development of the indicator is ongoing in the HELCOM LOAD group.

6.3 Supplementary indicators to support the core indicators

The selection process for identifying core indicators identified several parameters which follow changes in the Baltic ecosystem but which were discarded from the final set for several reasons. Some indicators did not clearly reflect anthropogenic pressures - some were redundant to other indicators and for others it was not possible to develop a quantitative threshold to measure GES. Nevertheless, these parameters were considered important to support the assessments made by the core indicators.

The supplementary indicators also give valuable information on natural fluctuations in the environment. Some of the candidate indicators (see **Section 6.2**) can also be operationalised as supplementary indicators until they are further developed into core indicators. Many of the candidates have data in place and they provide useful information for marine status assessments.

In this section and in **Table 6.10**, both the biological and environmental supplementary indicators are presented. The supplementary indicators will have a similar reporting format as the HELCOM Indicator Fact Sheets that are presented on the HELCOM web site.

Table 6.10. Supplementary indicators for biodiversity. Web links to HELCOM Indicator Facts Sheets have been provided, if available.

Supplementary biodiversity indicators	Objective of the indicator
Population Development of Sandwich Tern	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/SandwichTern/
Population Development of Great Cormorant	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/Cormorant/
Population Development of White-tailed Sea Eagle	http://www.helcom.fi/BSAP_assessment/ifs/ifs2009/en_GB/WhitetailedSeaEagle/
Decline of the harbour porpoise (*Phocoena phocoena*) in the southwestern Baltic Sea	http://www.helcom.fi/BSAP_assessment/ifs/ifs2009/en_GB/HarbourPorpoise/
The abundance of comb jellies in the northern Baltic Sea	http://www.helcom.fi/BSAP_assessment/ifs/ifs2009/en_GB/CombJellies/
Ecosystem regime state in the Baltic Proper, Gulf of Riga, Gulf of Finland, and the Bothnian Sea	http://www.helcom.fi/BSAP_assessment/ifs/archive/ifs2007/en_GB/ecoregime/
Ratio of diatoms and dinoflagellates	Describes the change in taxonomic group composition, presumably caused by eutrophication. Not applicable for the entire sea area.
Ratio of autotrophic and heterotrophic organisms	Describes a change in functional group composition and energy flow in the food web. Not properly tested.
Intensity and areal coverage of cyanobacterial blooms	Describes effects of phosphorus inputs and internal loading (http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/Cyanobacterial_blooms/, http://www.helcom.fi/BSAP_assessment/ifs/archive/ifs2008/en_GB/CyanobacteriaBloomIndex/)
Abundance and distribution of non-indigenous invasive species	Presents the distribution, abundance and temporal trends of selected invasive non-indigenous species in the assessment units.
Biopollution index	Estimates the impacts of non-indigenous species on native species, habitats and the ecosystem functioning. *See text below.*

Table 6.10 continues…

Supplementary environment indicators	Objective of the indicator
Surface water salinity	Describes environmental conditions caused by climatic variability.
Near bottom oxygen conditions	Describes condition of the near-bottom habitats caused by climatic variability and nutrient inputs.
Sea water acidification	Describes a temporal change in sea water pH.
The ice season 2009-2010	Describes the extent of sea ice and also reflects a potential threat for ice-breeding seals: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/iceseason/
Total and regional Runoff to the Baltic Sea	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/Runoff/
Water Exchange between the Baltic Sea and the North Sea, and conditions in the Deep Basins	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/WaterExchange/
Hydrography and Oxygen in the Deep Basins	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/HydrographyOxygenDeepBasins/
Development of the sea surface Temperature in the Baltic Sea in 2009	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/SeaSurfaceTemperature/
Wave climate in the Baltic Sea in 2009	http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/waveclimate2009/
Bacterioplankton growth	http://www.helcom.fi/BSAP_assessment/ifs/ifs2011/en_GB/bacterioplankton/

Supplementary pressure indicators	Objective of the indicator
Nitrogen emissions to the air in the Baltic Sea area	Describes anthropogenic pressures for all biota in the form of eutrophication: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/NitrogenEmissionsAir/
Emissions from the Baltic Sea shipping in 2009	Describes anthropogenic pressures for all biota in the form of contamination and eutrophication: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/ShipEmissions/
Atmospheric nitrogen depositions to the Baltic Sea during 1995-2008	Describes anthropogenic pressures for all biota in the form of eutrophication: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/n_deposition/
Spatial distribution of the winter nutrient pool	Describes anthropogenic pressures for all biota in the form of eutrophication.http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/WinterNutrientPool/
Waterborne inputs of heavy metals to the Baltic Sea	Describes anthropogenic pressures for all biota in the form of contamination: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/waterborne_hm/
Atmospheric deposition of heavy metals on the Baltic Sea	Describes anthropogenic pressures for all biota in the form of contamination: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/hm_deposition/
Atmospheric deposition of PCDD/Fs on the Baltic Sea	Describes anthropogenic pressures for all biota in the form of contamination:http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/pcddf_deposition/
Shipping	Describes the extent of underwater noise, disturbance for seabirds, vector for non-indigenous species, offshore wastewater and, in shallow areas, seabed disturbance.
Illegal discharges of oil in the Baltic Sea during 2009	Describes anthropogenic pressures for all biota, particularly seabirds, in the form of contamination: http://www.helcom.fi/BSAP_assessment/ifs/ifs2010/en_GB/illegaldischarges/

6.3.1 Supplementary biodiversity indicators

The supplementary indicators for biodiversity include HELCOM Indicator Fact Sheets for the abundance of bird populations and the harbour porpoise, and some planktonic indicators. The CORESET expert group for biodiversity found it particularly difficult to develop core indicators for planktonic organisms. In many cases, promising indicators had relevance only in some parts of the Baltic Sea. An example is the ratio of diatoms and dinoflagellates, which has been used in many parts of the world to describe changes in the phytoplankton community. A diatom-dominated community is assumed to reflect an ecosystem in good environmental status and vice versa. In the Baltic

Sea, however, as this seems to hold true in some sub-basins only, the indicator was thus categorised as a supplementary indicator.

Another supplementary-labelled indicator is the ratio of autotrophic to heterotrophic planktonic organisms. Being wider in functional groups than the previous indicator, this indicator may be applicable in a larger area, but it currently lacks proper validation. Hence, it is considered a supplementary indicator until the pressure relationships, the applicability to all sub-basins and the GES boundary can be tested with data.

Cyanobacterial blooms have been measured in the Baltic Sea for several years with two kinds of indicators: the intensity of the blooms and the areal coverage of the blooms. Both indicators respond to phosphorus and are thus linked to an anthropogenic pressure; however, it is difficult to define how often or how widely a bloom can occur while still being considered to be in GES, particularly in the Baltic Sea where cyanobacterial blooms are an intrinsic property of the ecosystem.

The abundance and distribution of non-indigenous invasive species (NIS) is an indicator that describes the abundance and further spreading of selected NIS which are known as invasive. Information on the spatial extent and abundance of NIS is relevant for marine status assessments. The expert group decided to define 'a dirty dozen' of NIS in the Baltic Sea and make distribution maps, accompanied by abundance and temporal trend information where available.

There are very few ways of objectively assessing the impacts of non-indigenous species on native species and biotopes. One of the most transparent methods has been described in Olenin et al. (2007) termed the 'biopollution index'. The index considers five factors for every non-indigenous species: abundance; distribution; impact on species; impact on habitats; and impacts on ecosystem functioning. Each factor has a number of qualitative classes which have been defined clearly with the index value being derived through a combination of the factor classes. As the index value is given only for single species, the overall biopollution of a site is derived through the one-out-all-out approach, where the highest impacting species determines the status. GES is 'no new impacts by non-indigenous species in an assessment period'. The assessment units of the indicator are the sub-basins divided by national borders and the offshore-coastal water boundary.

An assessment of impacts is an indicator used in combination with the core indicator following the number of arriving NIS; in cases of no new arrivals, the impact indicator is not used. New baseline studies with the already established NIS should be made regularly to follow the changes in the impacts of NIS in the ecosystem - though not as part of assessing if GES has been met.

6.3.2 Supplementary indicators for environmental variability

The HELCOM Indicator Fact Sheets contain several indicators that do not reflect anthropogenic pressures but describe causes of natural variability in different environmental features. There are, however, indicators describing chemical and physical features in the Baltic Sea. **Table 6.10** presents the available supplementary indicators for environmental variability.

6.3.3 Supplementary pressure indicators for biodiversity

The HELCOM Indicator Fact Sheets contain several indicators that measure various anthropogenic pressures, such as maritime activities and emissions or inputs of hazardous substances to the sea. Regarding the inputs of hazardous substances, these could also be listed under Chapter 7, as the aim of the expert group for hazardous substances is to include pressure indicators to the set of core indicators in the future.

Table 6.10 presents the available supplementary indicators for anthropogenic pressures. This selection of pressure indicators contains several indicators that should be considered as core indicators, such as inputs of hazardous substances. Currently, however, the Baltic-wide data that are available is so limited that such a development will not likely take place during the project period.

7 Hazardous substances core indicators

7.1 Proposed core indicators for hazardous substances

The CORESET expert group for hazardous substances identified 13 core indicators for concentrations of hazardous substances and their biological effects (**Table 7.1**). Each of the core indicators consist of 1-16 parameters (congeners of closely-related substances) that were selected on the basis of their adverse effects to the environment, cost-efficient analyses and available GES boundaries (see **Section 5.4.2**). The proposed core indicators are interim expert products, which require more scientific work on methodological details, for example.

Eight of the core indicators measure the BSAP ecological objective referring to the concentrations of hazardous substances; one measures the concentrations of the radioactive substance Cs-137; and four measure the biological effects of hazardous substances. The nine core indicators measuring concentrations cover the most common, widely distributed and harmful substances in the Baltic Sea. Although monitoring them is largely in place or under planning, large gaps have been found. The pharmaceutical substances diclophenac and 17-alpha-ethinylestradiol do not have established monitoring in the region. Moreover, monitoring the coverage of offshore waters needs to be improved for several substances.

GES boundaries, defining good environmental status (GES) and the status below GES (sub-GES), have been identified for all of the proposed core indicators. As most of the core indicators are current or proposed EU Priority Substances, their GES boundaries are Environmental Quality Standards (EQS, or specific QS for other matrices). The revision of the Priority Substances is still on-going and all of the EQS-based GES boundaries are therefore provisional. Some GES boundaries are, however, proposed to be the OSPAR Environmental Assessment Criteria (EAC).

The selection criteria for each of the core indicators, including policy relevance, environmental impacts (PBT properties), current management and the availability of monitoring are presented in the

Table 7.1. Proposed core indicators for hazardous substances in the Baltic Sea. The indicators assess the HELCOM BSAP ecological objectives *Concentrations of hazardous substances at natural levels, Radioactivity at pre-Chernobyl level* and *Healthy wildlife* as well as the EU MSFD GES Descriptor 8 *Concentrations of contaminants are at levels not causing pollution effects*. Approaches for the proposed GES boundaries are presented with the numeric boundaries given in Part B of this report (HELCOM 2012 a). Key: EAC = Environment Assessment Criterion; BAC = Background Assessment Criterion; EQS = Environmental Quality Standard; QS = specific Quality Standard.

Proposed core indicators	Parameters	Proposed GES boundaries
1 Polybrominated biphenyl ethers	Congeners triBDE 28, tetraBDE 47, pentaBDE 99 and 100, hexaBDE 153 and 154	For biota and sediment, but pending on EU adoption.
2 Hexabromocyclododacene	Hexabromocyclododacene (HBCD)	Identified EU QS for biota and sediment but pending on EU adoption.
3 Perfluorooctane sulphonate	Perfluorooctane sulphonate (PFOS)	Identified EU QS for biota but pending on EU adoption.
4 Polychlorinated biphenyls and dioxins and furans	CB congeners 28, 52, 101, 118, 138, 153 and 180. WHO-TEQ of dioxins and furans and dioxin-like PCBs	Dioxins: Identified EU QS for biota but pending on EU adoption. PCBs: tentatively EAC for CB 118 and 153 in biota and sediment until EU QS is adopted.
5 Polyaromatic hydrocarbons and their metabolites	The US EPA 16 PAHs in bivalves and sediment and selected metabolites in fish	Established OSPAR EACs and established and draft EQSs in mussels and sediment. Proposed EAC for metabolites in fish.
6 Metals	Cadmium (Cd), mercury (Hg) and lead (Pb)	Established EU EQS for biota (Hg). Pending EU QS for Cd and Pb in biota and sediment. Effect Range Low for Hg in sediment.
7 Radioactive substances	Caesium-137	Established by HELCOM MORS for fish and water.
8 Tributyltin compounds / imposex index	Tributyltin and/or imposex index	OSPAR EAC (established for concentrations in mussels and sediment), OSPAR EAC for imposex in mussels and EU QS $_{\text{human health}}$ in fish.
9 Pharmaceuticals	Diclofenac and 17-alpha-ethinylestradiol	Identified EU QS for biota and water but pending on EU adoption.
10 General stress indicator	Lysosomal membrane stability	EACs and BACs established for fish and *Mytilus* spp. For amphipods under development.
11 General stress indicator for fish	Fish disease index	Established BACs and EACs for flounder and cod.
12 Genotoxicity indicator	Micronucleus induction	BACs established for fish and bivalves. EACs under development.
13 Reproductive disorders	Malformed embryos of eelpout and amphipods	BACs and EACs established for amphipods. Established BACs for fish, but EACs under development.

descriptions of the core indicators in **Part B** of this report (HELCOM 2012 a).

The 'no deterioration' principle of the Water Framework Directive gives, in addition, the obligation not to allow increased concentrations of the above mentioned substances in biota. This is valid especially for persistent organic pollutants (POP) under the Stockholm Convention (Substances 1-4). This should be ensured with long-term monitoring, even if the tentative GES boundaries may change over time (EQS Directive 2008/105).

The four core indicators for biological effects cover responses at the enzymatic, cellular and organism levels. Monitoring is only carried out in few Baltic Sea countries, even though the required knowledge for monitoring is in place in all the countries. When these core indicators are compared with the biodiversity core indicators (e.g. population changes of seabirds and fish or the health status of marine mammals), the overall picture of the state of the ecosystem becomes even clearer.

The general stress indicator - Lysosomal membrane stability

The general stress indicator lysosomal membrane stability (LMS) is a parameter for the integrity of cell membranes and has been tested in various species of mussel and fish from different climate zones. Reduced LMS indicates a response to complex mixtures of chemicals present in water and sediments, point sources of pollution and single pollution events and accidents; it is also a means to discover new 'hot spots' of pollution. LMS is an integrative parameter that also responds to other stressors such as severe nutritional deprivation, severe hyperthermia, prolonged hypoxia, and liver infections associated with high densities of macrophage aggregates. In this respect, LMS may serve as an indicator of individual health status

Fish disease index

Fish disease index is a general stress indicator for fish. The occurrence of significant changes in the prevalence of externally visible fish diseases can be considered a non-specific and more general indicator of chronic rather than acute environmental stress.

Genotoxicity indicator

Genotoxicity is specifically measured by the induction of micronuclei in the cell (MN), which serves as an index of cytogenetic damage during cell divisions, i.e. a lack or damage of the centromere or chromosomal aberrations. The MN test can be applied in a range of species (e.g. bivalves and fish). The indicator of genotoxic effects reflects damage to the genetic material of organisms, which could affect their health and potentially their offspring. The application of cytogenetic assays on ecologically relevant species offers the opportunity to perform early health assessments in relation to exposure to contaminants.

Table 7.2. Core indicators for seafood safety in the Baltic Sea. The safety limits are taken from EC Regulation 1881/2006 (Anon. 2006).

Seafood core indicators	Safety limit, representing the GES boundary
Polychlorinated biphenyls and dioxins and furans	Dioxins and furans: 4 ng kg^{-1} WHO-TEQ ww muscle Polychlorinated biphenyls (dioxin-like) and dioxins and furans: 8 ng kg^{-1} WHO-TEQ ww fish muscle; eel: 12 ng kg^{-1} WHO-TEQ ww. Non-dioxin-like PCBs: 75 µg kg^{-1} ww muscle; eel 300 µg kg^{-1} ww; fish liver 200 µg kg^{-1} ww.
Polyaromatic hydrocarbons	Benzo[a]pyrene in fish muscle - 2 µg kg^{-1} ww; crustaceans - 5 µg kg^{-1} ww; bivalves - 10 µg kg^{-1} ww.
Mercury	Fish muscle and crustaceans: 500 µg kg^{-1} ww; eel, pike and sturgeon: 1,000 µg kg^{-1} ww; mussel: 2,500 µg kg^{-1} dw.
Cadmium	Fish muscle and crustaceans: 50 µg kg-1 ww; eel: 100 µg kg^{-1} ww; bivalves: 1,000 µg kg^{-1} ww.
Lead	Fish muscle: 300 µg kg^{-1} ww; crustaceans: 500 µg kg^{-1} ww; bivalves: 1,500 µg kg^{-1} ww.

Reproductive disorders

Reproductive disorders are measured by counting malformed larvae in brood-bearing amphipods or eelpout (*Zoarces viviparus*) - a fish species giving birth to fully-developed young. The indicator is sensitive to general and point-source pollution from a wide array of contaminants, and thus serves as an indicator for reduced reproductive potential in a contaminated ecosystem, particularly in benthic habitats.

The BSAP ecological objective for the seafood safe to eat and the respective GES Descriptor 9 could be measured using the same biota sampled for the purpose of core indicators for the concentrations of hazardous substances in the environment (see **Section 5.4.3**). GES boundaries for Descriptor 9 are specific targets for human health. As the CORESET expert group had only limited expertise in food safety, the seafood core indicators are only presented provisionally. **Table 7.2** presents those core indicators which have safety limits for human consumption under EU legislation.

Seafood safety can also be assessed by other safety limits, which are not based on legislation but on research by the European Food Safety Agency, for example. The next step with the seafood core indicators is to identify other safety limits, which can be applied to the selected core indicators (**Table 7.1**).

7.2 Candidate indicators for hazardous substances

The expert group for hazardous substances core indicators withheld a decision to categorise these four indicators as core or supplementary indicators: alkylphenols, vitellogenin induction, Acetylcholin-esterase (AChE) inhibition and EROD/CYP1A induction (**Table 7.3**). The group considered the alkylphenols (nonylphenol and octylphenol) a substance group which may potentially have serious impacts in the Baltic environment. The recent HELCOM thematic assessment found high levels of it in sediment (HELCOM 2010 a). Nonylphenol and octylphenol have been listed in the BSAP and the Priority Substance Directive (Anon. 2008 b).

The three indicators for biological effects of hazardous substances – vitellogenin induction, AChE inhibition and EROD/CYP1A induction – are potentially good indicators for anthropogenic stress. Vitellogenin induction measures the exposure to estrogenic contaminants; AChE inhibition measures the neurotoxic effects; and EROD/CYP1A induction is sensitive to PAHs, planar PCBs and dioxins. More information is given in the indicator descriptions in **Part B** of this report (HELCOM 2012 a).

Table 7.3. Candidate indicators for hazardous substances in the Baltic Sea.

Candidate indicators	Possible GES boundary and other information
Alkylphenols (nonylphenol and octylphenol)	EQS for water and QS for biota and sediment.
Vitellogenin induction	Not established.
Acetylcholin-esterase inhibition	BACs and EACs under development for ***Mytilus*** spp., ***Macoma balthica***, herring, flounder, eelpout and perch.
EROD/CYP1A (Ethoxyresorufin-O-deethylase) induction	Established BAC for male flounder and eel. Herring BAC and EACs under development.

The next steps in the process of validating the candidate indicators as core indicators are to (1) assess their importance in describing the state of the environment in the Baltic Sea, also in their relation to contaminants, (2) develop or validate GES boundaries for them and (3) produce background documentation.

In addition to the candidate indicators in **Table 7.3**, the expert group also discussed the need for an indicator to follow the inputs of hazardous substances to the Baltic Sea. The inputs of lead, mercury and cadmium and, to a lesser extent, nickel, copper and zinc are being monitored by HELCOM Contracting States (e.g. HELCOM 2011). These indicators would show the inputs behind the concentrations found in water, sediment and biota. Thus, they also show the management success in the reduction of releases of heavy metals. However, as there are no targets agreed on these inputs, the trend-based GES targets should be used until the modelling of maximum allowable inputs has been carried out. The inclusion of POPs in this indicator is not yet seen as possible due to very large gaps in the monitoring. Several supplementary indicators that measure the inputs of hazardous substances from different sectors are presented in **Section 6.3**.

7.3 Supplementary indicators for hazardous substances

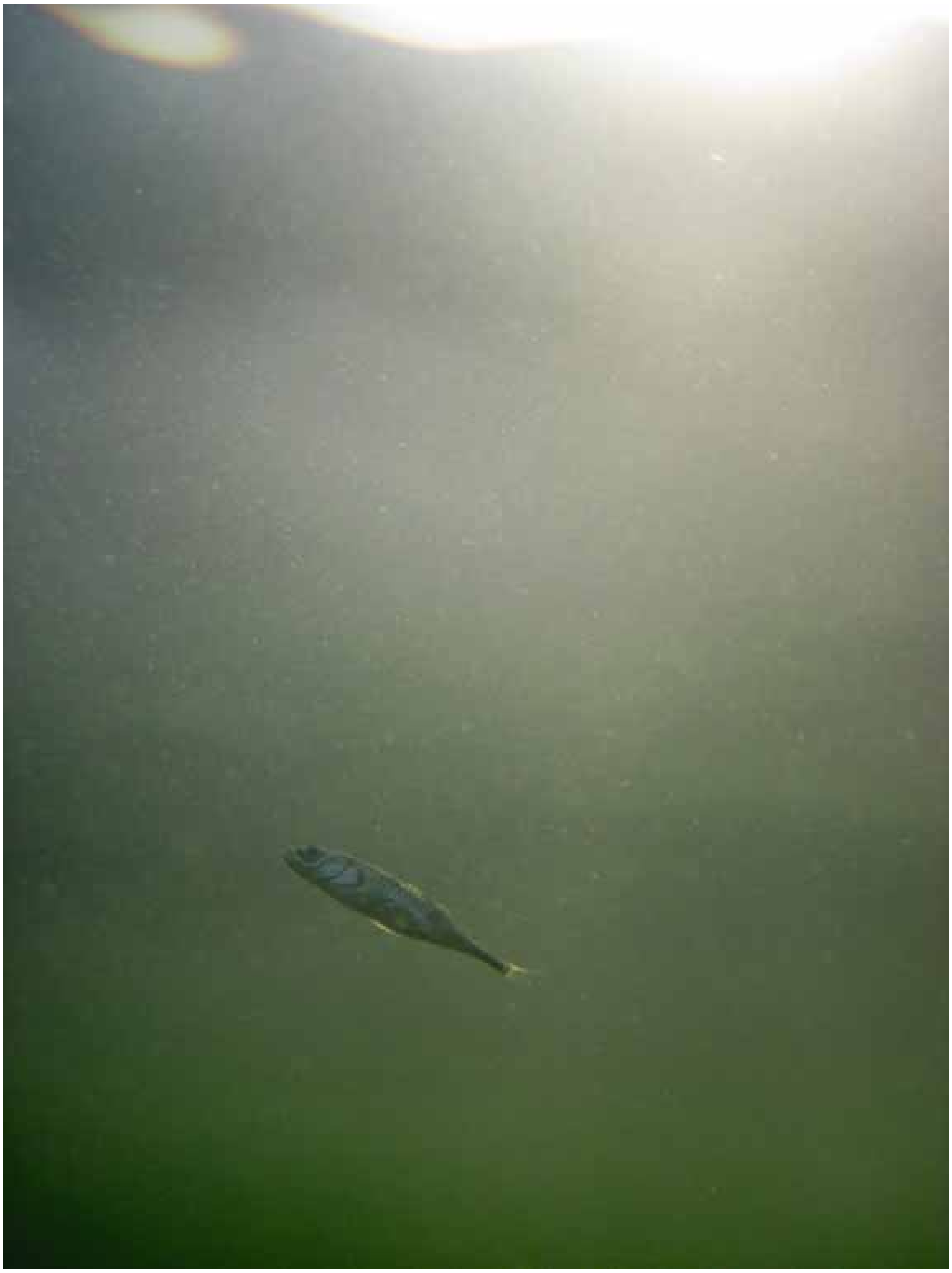
The supplementary indicators for the assessment of hazardous substances are organochlorine pesticides (represented by DDTs, HCHs and HCB), copper and zinc (**Table 7.4**). In the recent HELCOM thematic assessment (HELCOM 2010 a), DDE (degradation product of DDT) was found at high levels in many sites, whereas HCHs and HCB did not exceed the EU quality standards. As the organochlorine pesticides are banned or strictly managed in the Baltic Sea catchment area and their concentrations are decreasing, the expert group decided to categorise them as supplementary indicators, keeping in mind that their concentrations should be followed regularly in the Baltic Sea.

Copper and zinc were recognised as subregionally significant indicators of the state of the environment. Their levels have been increasing in some areas of the Baltic Sea, reflecting changes in their use. These indicators do not have any proposed GES boundaries but temporal trends in biota, sediment and water, and thus should be followed regularly.

Table 7.4. Supplementary indicators for hazardous substances in the Baltic Sea.

Supplementary indicators	Parameters	Possible GES boundaries
Organochlorine pesticides	DDTs, Hexachlorocyclohexanes (HCHs, incl. lindane), hexachlorobenzene (HCB)	EAC for DDT_{total} in sediment. EAC for DDE in mussel and sediment. EQS for lindane in water and specific QS in sediment and biota. EQS for HCB in biota and QS for water and sediment.
Copper	Copper (Cu)	N.A. Trend-based approach suggested.
Zinc	Zinc (Zn)	N.A. Trend-based approach suggested.

8 Eutrophication core indicators and targets



The HELCOM demonstration set of eutrophication core indicators was presented in the HELCOM Moscow Ministerial Meeting in 2010. There are six operational eutrophication core indicators, which are also integrated by the assessment tool HEAT (HELCOM 2009 a). The preliminary core set indicators for eutrophication and the integrated assessment are shown on the HELCOM website: http://www.helcom.fi/BSAP_assessment/en_GB/main/. The preliminary core indicators for eutrophication have been developed by intersessional work under HELCOM MONAS and are based on the work of HELCOM EUTRO and EUTRO-PRO.

The HELCOM eutrophication core indicators have aimed at quantitative assessments (GES boundaries presented on the HELCOM website); qualitative descriptions of GES are also given in **Annex 2** of this report.

8.1 Eutrophication core indicators

The eutrophication of the Baltic Sea can be currently assessed by six core indicators:
– water transparency (Secchi depth);
– dissolved inorganic nitrogen (DIN);
– dissolved inorganic phosphorus (DIP);
– chlorophyll a;
– multimetric benthic invertebrate community indices; and
– macrophyte depth distribution.

All the core indicators except for the macrophyte indicator are operational and the results are available on the HELCOM website [10]. The macrophyte indicator is partly operational but the compilation of data and GES boundaries has not yet been finalised (see **Section 6.1.1**).

The six core indicators measure the causative factors of eutrophication (nutrient levels); the direct effects of the nutrient enrichment (chlorophyll a, water transparency); and the indirect effects of nutrient enrichment (benthic communities and macrophyte depth distribution) (**Table 8.1**).

The six core indicators cover four of the five BSAP ecological objectives; only the objective for oxygen concentration is not covered by the core indicators. The core indicators cover all three GES criteria of the MSFD GES Descriptor 5 (**Table 8.1**).

8.2 Eutrophication indicators under development

The eutrophication experts have also identified and developed other indicators that can be used to assess the direct or indirect effects of nutrient enrichment (**Table 8.1**). The candidate indicators for direct effects include three indicators that measure the ratios of species sensitive and insensitive to eutrophication, and an indicator to follow

Table 8.1. The core indicators to assess eutrophication organised under GES criteria and GES indicators (Anon. 2010). Indicators under development are also shown.

GES criteria	GES indicators	Core indicators	Indicators under development
5.1 Nutrient levels.	5.1.1 Nutrients concentration in the water column.	DIN concentration. DIP concentration.	
	5.1.2 Nutrient ratios (silica, nitrogen and phosphorus), where appropriate.		
5.2 Direct effect of nutrient enrichment.	5.2.1 Chlorophyll concentration in the water column.	Chlorophyll a.	
	5.2.2 Water transparency related to increase in suspended algae, where relevant.	Water transparency.	
	5.2.3 Abundance of opportunistic macroalgae.		Biomass ratio of opportunistic and perennial macroalgae Cladophora length.
	5.2.4 Species shift in floristic composition such as diatom to flagellate ratio; benthic to pelagic shifts; as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities (5.2.4).		Ratio of diatoms and dinoflagellates. Ratio of autotrophic and heterotrophic organisms. Frequency and coverage of cyanobacterial blooms.
5.3 Indirect effects of nutrient enrichment.	5.3.1 Abundance of perennial seaweeds and seagrasses (e.g. fucoids, eelgrass and Neptune grass) adversely impacted by the decrease in water transparency.	Lower depth distribution limit of sensitive macrophyte species Multimetric benthic invertebrate community indices.	
	5.3.2 Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned.		Oxygen deficiency.

10 http://www.helcom.fi/BSAP_assessment/eutro/HEAT/en_GB/status/

the frequency and coverage of cyanobacterial blooms. All of these, except the indicator for the ratio of perennial and opportunistic macroalgae (see **Section 6.2.1**), are currently listed as supplementary indicators (see **Section 6.3.1**). The oxygen deficiency indicator is a candidate indicator for indirect effects and its operationalisation will be implemented in the near future. In offshore areas, it could follow the methodology of the HELCOM TARGREV project (HELCOM 2012 c), while in coastal areas, a recent methodological study by Conley et al. (2011) could be used. In addition, the HELCOM CORESET expert group on biodiversity indicators identified candidate indicators which can be used to assess the effects of eutrophication (see **Section 6.2.1**).

The HELCOM TARGREV project (HELCOM 2012 c) has studied the GES boundaries for the eutrophication core indicators and has also provided expert advice on their validity. The results of the project will be evaluated by the HELCOM eutrophication experts, possibly leading to the re-evaluation of the GES boundaries.

8.3 Assessment scales for eutrophication core indicators

The expert group for eutrophication core indicators decided that eutrophication core indicators should be assessed in coastal waters by WFD water types, and in offshore waters by 19 sub-basins. Offshore assessments of the indicators will be made at the sub-basin level (the division used in the recent eutrophication assessment, HELCOM 2009 a). HELCOM HOD 35/2011 endorsed these provisional assessment units for the core eutrophication indicators. As the national water quality assessments under the EU WFD are carried out at the water-body scale - a unit smaller than water type - this scale must also be heeded in the HELCOM assessment of eutrophication.

9 Monitoring needs for the proposed core indicators

9.1 Existing COMBINE monitoring for the proposed core indicators

The HELCOM COMBINE is a joint programme of all the Contracting States linking nationally monitored parameters in a commonly agreed way. It includes parameters targeted to measure the state and impacts of hazardous substances and eutrophication. There is no monitoring specifically aimed at biodiversity assessments; however, some parameters measuring effects of eutrophication can also be used for the biodiversity core indicators (**Table 9.1**). The biological parameters include:

- phytoplankton species composition, chlorophyll a and biomass;

– zooplankton species composition, abundance and biomass;
– macrozoobenthic invertebrate species composition, abundance and biomass; and
– phytobenthic species composition and depth distribution.

The COMBINE parameters for hazardous substances are:
– mercury, lead, cadmium, copper and zinc; and
– DDTs, PCBs, HCB and HCHs (**Table 9.2**).

The COMBINE parameters for eutrophication are:
– nitrogen, phosphorus and silicate;
– water transparency (Secchi depth); and
– oxygen concentration and hydrogen sulphide.

In addition, the COMBINE includes the monitoring of salinity, temperature and current speed and direction.

9.2 Other monitoring for the proposed core indicators

The HELCOM Contracting States also monitor parameters which have not been included in the COMBINE programme. The HELCOM FISH-PRO project has continued the monitoring of coastal fish communities since the 1990s, while HELCOM EG SEAL coordinates the monitoring of marine mammals in the Baltic Sea. Although waterbirds are not currently monitored by a joint programme, HELCOM has agreed on joint guidelines to monitor them. The HELCOM EG for cormorants focuses on compiling Baltic-wide data and other information on them.

These parameters may have varying sampling methods and analyses, and thus their suitability for common assessments need to be evaluated. Such an evaluation will take place during the next revision of the HELCOM COMBINE. An overview of the existing monitoring of biological parameters that forms the base of the core indicators is given below. Information on specific parameters measured in the Baltic Sea area has also been collected. Some initial consideration as regards future monitoring has been added to the table.

Table 9.1. A Summary of biodiversity-related monitoring programmes in the Baltic Sea area.

Proposed core indicators:	Monitoring programmes	Proposed changes to monitoring
Mammals		
Blubber thickness	FIN, GER, POL, SWE	The sampling and analysis methods have been partly harmonized as a result of expert-level co-operation. They should be formalized as HELCOM manuals.
Pregnancy rates	FIN, GER, POL, SWE	As above
Population growth rate	EST, FIN, GER, SWE, POL, DEN	As above
Birds		
White-tailed eagle productivity	All countries	Harmonization of methods needed
Abundance of wintering populations of seabirds	FIN, GER, LIT, POL, SWE, RUS?	Harmonization of methods needed
Costal fish		
Fish abundance index Fish size index Fish species demographic index Fish species diversity index Fish community trophic index	All countries. Harmonized monitoring and assessment, collected using fishery independent coastal fish sampling with passive gears, are conducted by Estonia, Finland, Latvia, Lithuania, and Sweden.	Harmonization of methods needed. Formalized HELCOM manuals. If proven to serve the needs of assessing biodiversity, additional data such as commercial catch statistics collected within the EU's data collecting framework might be used.
Seabed		
Multimetric macozoobenthos indicators	All countries, except RUS	Harmonization of methods needed
Lower depth distribution limit of macrophyte species	All countries, except RUS	Harmonization of methods needed
Pelagial		
Non-indegenous species:		
Trends in arrival of new species	All countries	Targeted screenings in ports

Table 9.1 continues…		
Candidate indicators:	**Monitoring programmes**	**Proposed changes to monitoring**
Mammals:		
Distribution of harbour porpoise	DEN, GER, LIT, HELCOM/ ASCOBANS database, SAMBAH project	Regular assessments on densities
By-catch of seals and harbour porpoise	No monitoring	New monitoring scheme needs to be considered
Fatty-acid composition of seals as measure of food intake composition (D4, new proposal of BD3)	No monitoring	New monitoring scheme needs to be considered
Birds:		
Abundance of breeding populations of seabirds	FIN, GER, SWE, DEN?	Harmonization of methods
Fish:		
Salmon smolt production capacity	All countries	
Sea trout parr density	All countries	
Fish indicators using fishery-based data	All countries	
Seabed:		
Ratio of perennial and annual macrophytes	EST, DEN, GER, POL	Consider to include as parameters in existing monitoring of macrophytes
Cladophora length	-	Consider to include as parameters in existing monitoring of macrophytes
Blue mussel cover	-	New monitoring scheme needs to be considered
Population structure of long-lived species	All countries, if biomass/abundance ratio can be used.	Harmonization of methods
Pelagial:		
Biomass of copepods	All countries	Zooplankton to be considered as core variable in HELCOM COMBINE
Biomass of microphageous mesozooplankton	All countries	As above
Zooplankton diversity index	All countries	Zooplankton to be considered as core variable in HELCOM COMBINE
Phytoplankton diversity or eveness	All countries	As above
Mean zooplankton size (D4, new proposal of BD3)	All countries	As above
Zooplankton:phytoplankton (D4 new proposal of BD3)	All countries	As above
Seasonal succession of functional phytoplankton groups	Ferry-line datasets: most sub-basins	As above
Supporting indicators:	**Monitoring programmes**	**Proposed changes to monitoring**
Biopollution index	All countries	Targeted screenings in ports.
Diatom:dinoflagellate ratio	All countries	Zooplankton to be considered as core variable in HELCOM COMBINE
Ratio autotrophs: heterotrophs	All countries	As above
Cyanobacterial blooms	Remote sensing	Harmonization of remote sensing results
Abundance of particularly invasive species	All countries	

Table 9.2. Monitoring of the proposed core indicators for hazardous substances by the HELCOM Contracting States in biota, sediment and water. Contracting States in parentheses means that only project-based data exist.

Core indicator / substance	Biota		Sediment	Water
	Countries	Species	Countries	Countries
Polybrominated diphenylethers	DEN, FIN, GER, SWE (EST, LAT, LIT, POL)	eelpout, flounder, herring, cod, dab, perch, guillemot	FIN, (LIT), SWE	LIT, (EST, LAT)
Hexabromocyclo-dodecane	DEN, FIN, SWE (EST, LAT, LIT, POL)	herring, cod, guillemot, perch, flounder	FIN, SWE, (LIT)	(EST, LAT, LIT, POL)
Polychlorinated biphenyls and dioxins	DEN, EST, FIN, GER, LIT, POL, SWE (LAT)	various species	FIN, GER, LIT, POL, RUS, SWE	GER, LIT
Perfluorooctane sulphonate	(DEN, EST,GER, LAT, LIT, POL, SWE)	various species	(DEN, FIN, GER, SWE)	(DEN, FIN, GER, LIT SWE)
Polyaromatic hydrocarbons	DEN, GER, SWE (FIN, LIT, POL)	mussels, fish (metabolites)	FIN, LIT, SWE, (RUS)	LIT, (RUS)
Metals	All countries	various species	All?	N.A:
Tributyl tin and imposex	DEN, FIN, GER, SWE (EST,LAT, LIT, POL)	herring, flounder, perch, mussel, snails	DEN, FIN, LIT, SWE (LAT, POL)	DEN, GER, LIT
Pharmaceuticals	only screening		only screening	only screening
Cesium-137	All countries	herring, flounder, plaice	N.A.	All?
Lysosomal membrane stability	DEN, (FIN, GER, SWE)	eelpout, flounder, herring, perch, amphipods, blue mussels	N.R.	N.R.
Genotoxicity –MN	(LIT, POL, RUS, SWE)	cod, dab, eelpout, flounder, herring, perch, blue mussel, Macoma balthica	N.R.	N.R.
Fish diseases	GER, POL, RUS (LIT)	cod, flounder	N.R.	N.R.
Reproductive disorders	DEN, SWE (GER, RUS)	eelpout, amphipods	N.R.	N.R.

9.3 Identified gaps in the Baltic monitoring

The CORESET project identified gaps in the current availability of data for the proposed core indicators. For the biodiversity core indicators, the following remarks can be made:

- Marine mammal core indicators are monitored in the countries where the major parts of the populations occur. Monitoring the harbour porpoise in the Baltic Proper is based on a project only.
- Seabird monitoring may be adequate in coastal areas, whereas it needs to be strengthened in offshore areas; a minimum five-year monitoring cycle is required to observe changes over time.
- Fish core indicators are currently described only for a specific coastal fish sampling scheme used in the HELCOM FISH-PRO project (HELCOM 2012 b). Monitoring coastal fish by this method covers some parts of the Baltic coastal zone, with the exception of Russian, German and Danish waters. There are also other sources of data available, even though they have not been tested by the project to date. There are large datasets from research surveys available for the offshore areas, ICES estimates on stocks, national estimates on stocks and fishery data. The project considered that there will be data available for fish indicators once they have been finalised.
- Benthic macrophytes and macroinvertebrates are monitored in the Baltic Sea, but current monitoring for the EU Water Framework Directive is focused on coastal waters.
- Zooplankton monitoring is relatively adequate for the proposed indicators, which is mainly targeted to offshore areas.
- Phytoplankton indicators, which are currently in the testing phase, seem to be dependent on frequent monitoring, such as on ship-of-opportunity sampling.
- Non-indigenous species are followed through various monitoring programmes, screenings and projects – mainly focused on harbour areas and along intensive shipping routes at regular intervals.

For hazardous substances, a general remark was made during the project that the sampling methods need to be harmonised, and that and cost-efficiency should be considered when sampling for food safety and environmental authorities. The following more specific remarks were made:

- PBDE, HBCD and PFOS monitoring does not adequately cover the Baltic Sea marine area.
- PCBs and dioxins/furans are monitored covering the entire Baltic Sea area.
- PAHs are monitored in about half of the HELCOM Contracting States, but the monitoring lacks a joint view of the parameters and matrices.
- Metals – cadmium, mercury and lead – are being monitored covering the entire Baltic Sea area.
- Cesium-137 is being monitored adequately in the Baltic Sea.
- TBT monitoring is not done coherently, but biased to harbours.
- The pharmaceutical substances diclofenac and EE2 are not monitored anywhere; screenings are carried out in some countries, which shows the need for more frequent monitoring.
- Core indicators for the biological effects of hazardous substances are only monitored in few areas even though they would provide information of point-source pollution in the vicinity of cities, and also reflect the general degradation of the marine environment.

9.4 Existing monitoring and the selection of core indicators

The availability of monitoring from all the Contracting States is one of the common principles for the HELCOM core indicators (**Table 2.1**). As discussed in **Chapter 5**, it was possible to disregard this principle in the selection process if a proposal for new monitoring (or a modification of the existing) was proposed. The rationale behind this exception followed the discussion in HELCOM that the revision of the HELCOM joint monitoring requires a study of the core indicators before the revision process can begin. At this stage of the project, most proposals for new or adapted monitoring are incomplete and the finalised proposals may even require a separate process. Nevertheless, several core indicators or candidate indicators were identified which lack proper monitoring data but were nevertheless seen as essential indicators for marine environmental assessments.

During its second phase, the CORESET project will continue to develop the identified indicators and draft the proposals for the new or adapted monitoring.

10 Conclusions

The HELCOM CORESET project has made considerable progress in developing a set of indicators to address hazardous substances and biodiversity. In particular, the project has developed a pressure-based approach for the selection of indicators which is in line with MSFD guidelines, and which also renders the indicators suitable for the follow-up of the management measures.

This means that while the indicators are mainly related to the state of biodiversity, they respond to human pressures and are thereby linked to the impacts of human activities. In future, a better coverage of pressures and impacts should be envisaged through indicators, in particular where GES is more appropriately tackled through pressure and impact targets than state targets. This would ensure a sufficient link between state and pressure, and enable an assessment of the effectiveness of the measures. CORESET should be revisited to ensure that all aspects of MSFD Descriptors 1-11 are sufficiently covered in order to deliver future ecosystem-based assessments and the evaluation of the progress made towards GES, and to ensure synergies of the indicators across the descriptors.

The following results can be highlighted as regards the working process of the biodiversity group:

- In accordance with the GES criteria document (Anon. 2010), the project has identified a set of predominant habitats, functional groups, and key species in the Baltic Sea. The lists are intended to facilitate the identification of suitable indicators as well as to cross-check that the monitoring efforts cover key components of the Baltic Sea's ecosystem. The lists are living documents that will be further developed.
- In accordance with the GES criteria document (Anon. 2010) and several guiding documents for the MSFD process (e.g. the EU TG1 report on biodiversity, ICES WGECO 2010 report), the project has assessed the impacts of anthropogenic pressures on Baltic Sea functional groups and habitats as a starting point for indicator selection. This has been based on expert judgements using relatively simple criteria. To increase the reliability in the assessment of impacts, the evidence base should be improved as well as the procedures for expert judgement, including a representative participation of experts.
- In order to facilitate the development of indicators, information on current monitoring of biological parameters has been compiled which can be used during the revision process of the Baltic Sea monitoring programmes.

The proposed set of core indicators was not aimed to include indicators for every functional group or habitat; rather it has been developed into a set of focused indicators avoiding redundancy and omitting indicators with weak evidence of response to human activities. However, the set of core indicators lacks some key functional groups, species and habitats that should be represented in an environmental assessment of the Baltic Sea, such as zooplankton, phytoplankton, harbour porpoise and benthic fauna on hard substrata. These gaps were considered significant and thus candidate indicators have been proposed and presented in this report for each of them.

The set of core indicators is considered to cover the HELCOM BSAP ecological objectives well, whereas some GES criteria of the EC decision document (Anon. 2010) are not covered. The spatial distribution of habitats (criterion 1.4) and physical damage to seafloor (criterion 6.1) are not addressed by any core indicator; further, the abundance or distribution of key trophic groups and species (criterion 4.3) are only partly covered by the core indicators. The proposed indicators under Descriptor 4 are duplicated under Descriptor 1 while the project did not propose a specific indicator for food webs.

The HELCOM principles for the core indicators and guidance during the CORESET process aimed to develop the core indicators as stand-alone indicators which can be used to assess the state of the marine environment. They were also developed to be used in integrated assessments, where they each assess the state of a part of the ecosystem. The HELCOM assessment tools that were used in the thematic assessments of eutrophication, hazardous substances and biodiversity (HELCOM 2009 a, b, 2010 a), and the HELCOM Initial Holistic Assessment (HELCOM 2010 b) are tools that are able to integrate the core indicators. The tools will be adjusted to apply to the assessment requirements of the MSFD.

The applicability of the core indicators depends on the availability of data. All the core indicators have at least some data to support them - data that was also used to propose GES boundaries; however, for several core indicators, the spatial and temporal design of the monitoring programmes need to be improved to ensure Baltic Sea-wide data coverage. For some indicators, no or little monitoring has taken place in the past and it will take some years to build up time series that allow the evaluation of changes in status over time. One of the secondary objectives of the CORESET project was to identify these gaps in the monitoring programmes and, hence, facilitate the revision of the HELCOM monitoring programmes. Recommendations for data requirements for each core indicator have been suggested in the respective descriptions in **Part B** of this report (HELCOM 2012 a). Often, the regional gaps in data availability have resulted in gaps in the setting of GES boundaries, or validating the existing GES boundaries in the area. However, the project also acknowledges financial restrictions in monitoring and gives proposals for the frequency of monitoring. For example, it is noted that the development of new core indicators does not necessarily lead to new monitoring; monitoring can be adjusted to include other parameters and can be performed over longer time intervals.

As the CORESET project was not able to finalise or even test all the indicators and GES boundaries by September 2011, it was proposed that the development work of the core indicators will continue to:

– operationalise the core indicators (i.e. make them applicable for assessment);
– develop and validate sub-regional GES boundaries;
– produce detailed guidance documents on how to compute and use the indicators and carry out the assessment;
– further develop candidate indicators (many of which would fill significant gaps); and
– ensure data flows to maintain the regional core indicator assessments.

The proposed core indicators in this report should thus be considered as provisional until further developed in the continued CORESET process.

The project concludes that the development work of the core indicators is typically 'learning-by-doing', where some indicators, for example, were identified rather easily from existing data sets, while for others the development required much more work than anticipated. Some potential indicators, for instance, were temporarily set aside as candidate indicators because of unexpected difficulties in defining GES boundaries. The project also acknowledged that the GES boundaries for the core indicators depend on prevailing climatic conditions and may require regular revision. In addition, as the scientific basis for setting several of the GES boundaries should be enhanced, all the proposed GES boundaries should be considered as tentative and open for future revision.

The proposed set of core indicators is based on the existing anthropogenic pressures and the current understanding of their impacts on the Baltic Sea ecosystem. The future activities and their impacts may result in the need to add new or revise the current core indicators. Such an adaptive management is the prerequisite for all environmental assessments.

The vision of a healthy Baltic Sea in the Baltic Sea Action Plan is being assessed regularly as it heads towards 2021; further, the six-year reporting rounds of the Marine Strategy Framework Directive each require an assessment of the state of the marine environment. The regular assessment needs to ensure a comparability of the assessment results over longer time periods, but they also open up possibilities to revisit the indicator selection and the level of GES boundaries. The HELCOM core indicators will be publicly presented on the HELCOM website. Regular updates of assessment results will also ensure a good possibility to follow the state of the environment and review the methodology and data behind the assessments.

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12 Glossary

Biological diversity (biodiversity): 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 (as used by the Convention on Biological diversity, 1992).

Biotope: A habitat and its associated community.

Candidate indicators: Indicators discussed in the CORESET project that are considered promising but do not fulfil the selection criteria for core indicators, e.g. in terms of monitoring, or those that require further validation of the GES boundaries.

Community: The collection of organisms found at a specific place and time (McCune et al, Analysis of ecological communities 2002).

Core indicators: Indicators considered in the HELCOM CORESET project that fulfil the criteria used for indicator selection; and the validation of indicators and proposed GES boundaries that are considered sufficient.

Criteria: As used in the Commission's decision on criteria and methodological stands on good environmental status of marine waters (Anon. 2010), criteria refers to an aspect of biodiversity that is used to assess its state and which can be assessed by one or more indicators.

Descriptor: MSFD Annex I provides a list of 11 qualitative descriptors which build the basis for the description and determination of GES. The descriptors will be substantiated and specified with the GES **criteria** of EC decision 2010/477/EU.

Ecosystem function: The characteristic exchanges within an ecosystem including energy and nutrient exchanges, decomposition and the production of biomass.

Ecosystem health: An ecological system is healthy if it is 'stable and sustainable', i.e. maintaining its organisation and autonomy over time, and its resilience to stress (Rapport D.J., Costanza, R., McMichael, A.J. 1998. Assessing ecosystem health).

Ecosystem processes: The mechanistic processes, such as decomposition and resource use, that regulate ecosysystem functions.

Ecosystem structure: The distribution and composition of species, communities and habitats, and the quantity and distribution of abiotic components.

Favourable conservation status (FCS): According to the Habitat Directive (92/43/EEC), conservation status of a natural habitat means the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions, as well as the long-term survival of its typical species. The conservation status of a natural habitat will be taken as 'favourable' when:

- its natural range and areas it covers within the range are stable or increasing; and
- the specific structure and functions that are necessary for its long-term maintenance exist, and are likely to continue to exist for the foreseeable future; and
- the conservation status of its typical species is favourable.

The conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations. The conservation status will be taken as 'favourable' when:

- the population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats; and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
- there is and will probably continue to be a sufficiently large habitat to maintain its populations on a long-term basis.

Functional Group;

Generally (Wikipedia): In ecology, functional groups are collections of organisms based on morphological, physiological, behavioural, biochemical, environmental responses or on trophic criteria.

In MSFD Descriptor 1: In the Task Group 1 report (Cochrane et al. 2010), species groups are called 'ecotypes' or 'ecological grouping' which apply for mobile species such as mammals, birds and fish. The division of ecotypes is given but not justified.

In MSFD Descriptor 4: A group of organisms that use the same type of prey (Rogers et al 2010).

Good Environmental status (GES): According to the MSFD, Member States should achieve or maintain GES in the marine environment by 2020. According to Article 3.5 of the MSFD, GES is defined as: "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" and so forth. Furthermore, GES for biodiversity should be defined according to criteria outlined in document (2010/477/EU).

Habitat: The physical and environmental conditions (e.g. the seabed substratum and associated hydrological and chemical condition) that support a particular biological community or communities (Cochrane et al. 2010).

Indicator, state: State indicators give a description of the quantity and quality of physical, biological or chemical phenomena in a certain area. The state of biodiversity can be assessed through, e.g. the abundance, condition, composition and distribution of species and habitats (EEA definition).

Indicator, pressure: Pressure indicators describe the release of anthropogenic substances, physical and biological agents, and the use of resources. They measure the factors that cause changes in the state of the environment through actions taken by humans, e.g. nutrient load, by-catch and introduction of non-indigenous species (EEA definition).

Key species: Key species refers, in principle, to any species that is important to ecosystem structure and function in whatever form (e.g. biomass, abundance, productivity or functional role) driving ecosystem processes or energy flows (Piraino et al. 2002).

Keystone species: A species whose effect on ecosystems is disproportionately large relative to its biomass in the community as a whole (Power et al. 1996). Thus, a keystone species is per definition not an abundant species. The term was originally coined for predators (Paine 1969) but has since become broadened and used for species at other trophic levels as well as ecosystem engineers (as recognised by, e.g. Power et al. 1996).

Reference condition / state: A state or condition with no or very little anthropogenic disturbance. Reference condition or reference state is used as an anchor in environmental assessments when defining a *baseline* (see **Target**), against which the current state is compared. Reference condition / state is used predominantly in the EU WFD and also in the HELCOM HEAT and BEAT assessment tools.

Target: According to Article 3.7 of the MSFD, an 'environmental target' means a (qualitative or) quantitative statement on the <u>desired condition of the different components</u> of, and <u>pressures</u> and <u>impacts</u> on, marine waters. According to Annex IV, #3, an environmental target should reflect the desired condition based on the definition of good environmental status. The target should be <u>measurable</u> and <u>associated indicators</u> should be developed to allow for the follow-up of the implementation of the measures through monitoring and assessment. As used in HELCOM assessments, a 'Target' is more specific and reflects the boundary between GES and sub-GES, sometimes called the *baseline*. In existing HELCOM assessments, the boundary has been based on a specific score (cf. ecological quality ratio, EQS, sensu WFD and also used in HEAT and BEAT) that has been derived through the use of an 'Acceptable deviation' from a 'Reference condition'.

Trophic group: This refers to a category of organisms within a trophic structure, defined according to their mode of feeding (Rogers et al 2010).

Annex 1. Pressures impacting functional groups and predominant habitats

The matrices were filled in by the HELCOM CORESET expert group for biodiversity indicators. Red denotes a significant negative impact; orange an intermediate negative impact; and yellow a low negative impact. Pressures are categorised according to the EU MSFD. Note that low impacts have mostly been left out of the summary tables. The working team for fish indicators made a separate pressure evaluation in the HELCOM thematic assessment of coastal fish communities (HELCOM 2012 b).

Table 1. **Marine mammals.**

	Microbial pathogens	Introductions of non-indigenous species and translocations	Selective extraction of species, incl. non-target catches	Introduction of non-synthetic compounds	Introduction of radioactive substances	Introduction of synthetic compounds	Changes in salinity regime	Changes in thermal regime	Inputs of fertilizers	Inputs of organic matter	Marine litter	Underwater noise and electromagnetic fields	Abrasion	Changes in siltation	Selective extraction of non-living resources	Sealing	Smothering
Toothed whales																	
Population distribution			red			orange	orange		orange	orange		red				orange	
Population size			red			orange	orange		orange	orange		red				orange	
Population condition			red	orange		orange	orange		orange	orange		red				orange	orange
Seals																	
Population distribution			red			orange						orange					orange
Population size			red			orange	orange					orange					
Population condition	red	orange	red	red		red	orange					red					orange

Table 2. Seabirds. Note that the definitions and names of functional groups have changed during the project.

	Microbial pathogens	Introductions of non-indigenous species and translocations	Selective extraction of species, incl. non-target catches	Introduction of non-synthetic compounds	Introduction of radioactive substances	Introduction of synthetic compounds	Changes in salinity regime	Changes in thermal regime	Inputs of fertilizers	Inputs of organic matter	Marine litter	Noise	Abrasion	Changes in siltation	Selective extraction of non-living resources	Sealing	Smothering
Top predatory birds																	
Species distribution																	
Population size																	
Population condition																	
Subtidal benthic feeders																	
Species distribution																	
Population size																	
Population condition																	
Intertidal benthic feeders																	
Species distribution																	
Population size																	
Population condition																	
Inshore pelagic feeders																	
Species distribution																	
Population size																	
Population condition																	
Inshore surface feeders																	
Species distribution																	
Population size																	
Population condition																	
Offshore pelagic feeders																	
Species distribution																	
Population size																	
Population condition																	
Offshore surface feeders																	
Species distribution																	
Population size																	
Population condition																	

Table 3. **Pelagic (water column) habitats and associated communities.**

	Microbial pathogens	Introductions of non-indigenous species and translocations	Selective extraction of species, including incidental non-target catches	Introduction of non-synthetic compounds	Introduction of radioactive substances	Introduction of synthetic compounds	Changes in salinity regime	Changes in thermal regime	Inputs of fertilizers	Inputs of organic matter	Marine litter	Underwater noise and electromagnetic fields	Abrasion	Changes in siltation	Selective extraction of non-living resources	Sealing	Smothering
Zooplankton																	
Estuarine waters																	
Coastal waters																	
Offshore above halocline																	
Offshore below halocline																	
Phytoplankton																	
Estuarine waters																	
Coastal waters																	
Offshore above halocline																	
Pelagic abiotic habitat																	
Estuarine waters																	
Coastal waters																	
Offshore above halocline																	
Offshore below halocline																	

Table 4. Benthic habitats and associated communities.

	Microbial pathogens	Introductions of non-indigenous species and translocations	Selective extraction of species, incl. non-target catches	Introduction of non-synthetic compounds	Introduction of radioactive substances	Introduction of synthetic compounds	Changes in salinity regime	Changes in thermal regime	Inputs of fertilizers	Inputs of organic matter	Marine litter	Underwater noise and electromagnetic fields	Abrasion	Changes in siltation	Selective extraction of non-living resources	Sealing	Smothering
Hydrolittoral hard substrata																	
Extent																	
Condition of prennial macroalgae																	
Condition of ephemeral macroalgae																	
Condition of zoobenthos																	
Condition of the abiotic habitat																	
Hydrolittoral sediment																	
Extent																	
Condition of macrophytes																	
Condition of zoobenthos																	
Condition of abiotic habitat																	
Infralittoral hard substrata																	
Extent																	
Condition of prennial macroalgae																	
Condition of ephemeral macroalgae																	
Condition of crustacean fauna																	
Condition of mollusc fauna																	
Condition of abiotic habitat																	
Infralittoral sediment																	
Extent																	
Angiosperms and charophytes																	
Perennial macrophytes																	
Infauna																	
Abiotic habitat																	

Table 4 continues…

	Microbial pathogens	Introductions of non-indigenous species and translocations	Selective extraction of species, incl. non-target catches	Introduction of non-synthetic compounds	Introduction of radioactive substances	Introduction of synthetic compounds	Changes in salinity regime	Changes in thermal regime	Inputs of fertilizers	Inputs of organic matter	Marine litter	Underwater noise and electromagnetic fields	Abrasion	Changes in siltation	Selective extraction of non-living resources	Sealing	Smothering
Circalittoral hard substrata																	
Extent																	
Condition of zoobenthos																	
Condition of abiotic habitat																	
Circalittoral sediment																	
Extent																	
Condition of zoobenthos																	
Condition of abiotic habitat																	
Hard substrata under halocline																	
Extent																	
Condition of zoobenthos																	
Condition of abiotic habitat																	
Sediment under halocline																	
Extent																	
Condition of zoobenthos																	
Condition of abiotic habitat																	

Annex 2. Qualitative descriptions of GES

Qualitative descriptions of Good Environmental Status (GES) of the core indicators and the criteria of the MSFD descriptors.

The HELCOM CORESET expert groups were tasked by the Joint Advisory Board of the HELCOM CORESET and TARGREV Projects to develop qualitative in addition to quantitative descriptions for the GES boundaries of the core indicators. This table contains these descriptions and also GES descriptions for some candidate indicators which are close to being finalised (*marked by italics*). The descriptions were also developed for the criterion level in order to guide the work. These descriptions were primarily developed with the aim to facilitate the development of quantitative GES boundaries.

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
1.1 Species distribution	The spatial distribution of populations is in line with physiographic, geographic and climate conditions. Previously lost distribution areas have been restored.	**Wintering seabirds:** Comparison to a reference period in the early 1990s (IBA studies).	GES is met when the spatial distribution of wintering seabird populations does not decrease from the baseline level of the early 1990s. **State indicator.**
		Harbour porpoise: *Based on historic distribution.*	*GES is met when (Intermediate target:) there is an increase in the harbour porpoise distribution or (Ultimate target:) the distribution covers the Baltic Proper (density treshold> ind km^2)* ***State indicator.***
1.2 Population size	The population size of any naturally occurring species of the marine region does not deviate from the natural fluctuations of the population.	**Marine mammals:** Based on the theoretical analysis of biological constraints and empirical analyses of the growth rate of depleted populations.	**Seals and toothed values:** GES is met when the population growth rate of seals and harbour porpoise is close to the intrinsic growth rate of a population undisturbed by human pressures. **State indicator.**
		Wintering seabirds: Reference period.	GES is met when the abundance of wintering populations of selected **seabird** species does not deviate from the state of 2007-2011 or 1992-1993, depending on species, more than an acceptable deviation of X% (Definite GES boundary pending on the modelling studies on relations of the environmental targets for eutrophication). **State indicator.**
		Species abundance index for coastal fish: Based on site-specific reference data. If the reference data are missing, trends in available data and expert judgements are used to assess the status.	GES is met when the abundance of a coastal fish species is at an appropriate level to support community functions - including food provisions and trophic state - is based on a reference data set that has been defined as representing GES (or sub-GES); is defined as a value >X>; and is primarily site-specific. **State indicator.**
		By-catch of harbour porpoise, seals and water birds*: trend-based target.*	*The by-catch of harbour porpoise, seals, water birds and non-target fish species has been significantly reduced with the aim to reach by-catch rates close to zero.* ***Pressure indicator.***
1.3 Population condition	The population should be in a condition of good health, ensuring the reproduction and long-term viability of the population.	**Blubber thickness of mammals:** Based on the reference data of a healthy population of grey seals from by-caught and hunted before 2004.	GES is met when the blubber thickness does not deviate from the natural fluctuations of a population defined as representing GES. **State indicator**.
		Pregnancy rate of mammals: Based on the reference data of healthy populations of grey seals in 2008-2009.	GES is met when the pregnancy rate of female **grey** seals does not deviate from the natural fluctuations of population defined as representing GES. **State indicator**.
		WT-eagle: Based on reference data from the pre-1950s.	GES is met when the brood size of white-tailed eagle does not show symptoms of pollution effects or poor nutritional status. **State indicator.**
		Species demographic index of coastal fish: Based on site-specific reference data. If the reference data are missing, trends in the available data and expert judgements are used to assess the status.	GES is met when the population mean size of a coastal fish species is at an appropriate level to support community functions, including trophic state. It is given as the mean length >X > cm and is primarily site-specific. **State indicator.**

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
1.4 Habitat distribution	The distribution of habitats, including habitat-forming species, in the marine region is in line with physiographic, geographic and climate conditions. Previously lost distribution areas have been restored.		
1.5 Habitat extent	Habitat extent (areal extent and/or volume) is in line with the prevailing physiographic, geographic and climatic conditions; loss of extent is minimised but accommodates defined levels of sustainable use.	**Lower depth distribution limit of macrophytes:** Several approaches as used in the WFD: generally within natural fluctuations of what has been defined as a type specific reference conditions.	GES is met when the lower depth distribution of macrophytes shows only slight signs of disturbance. **State indicator.**
1.6 Habitat condition	The habitat – defined by abiotic and biotic parameters – is in a condition to be able to support its ecological functions and the diversity of its associated community.	**Macrozoobenthic indices:** Several approaches as used in the WFD.	GES is met when the level of diversity and the abundance of invertebrate taxa is only slightly outside the range associated with the type-specific conditions. **State indicator.**
		Community size index coastal fish: Based on site-specific reference data. If the reference data are missing, trends in available data and expert judgements are used to assess the status.	GES is met when the size structure of the fish community is at an appropriate level to support community function, including food provision and resilience. It is given as individuals >X cm and is primarily site-specific. **State indicator.**
		Community diversity index coastal fish: As above.	GES is met when the diversity of the associated fish community is at an appropriate level to support community function and resilience; is based on the reference data series that has been defined as representing GES; is given as a unitless index value >X>; and is primarily site-specific. **State indicator**.
		Community abundance index coastal fish: As above.	GES is met when the abundance of cyprinids and piscovores is at an appropriate level to support the community functions and resilience, based on the reference data series that has been defined as representing GES; is given as abundance >X>; and is primarily site-specific. **State indicator**.
		Biomass of copepods (absolute or relative): GES is based on a reference data set that represents a time period when zooplanktivorous fish growth/condition and fish stocks were relatively high.	GES is met when the copepod biomass is sufficient to support favourable feeding conditions for zooplanktivorous fish. A GES boundary is defined for each sub-basin of the Baltic Sea provided that monitoring data for the area are available. **State indicator**.
		Biomass of microphagous mesozooplankton (absolute or relative): GES is based on a reference data set that represents a time period when chlorophyll and water transparency complied with GES.	GES is met when the biomass of microphagous mesozooplankton does not exceed levels typical for the Baltic Sea unaffected by eutrophication. A GES boundary is defined for each sub-basin and WFD coastal water types. **State indicator.** *Also environmental targets under 5.1 and 5.2.*
1.7 Ecosystem structure	Food web elements and habitat extent and conditions guarantee the provision of ecosystem services.	**Community trophic index coastal fish:** Based on site-specific reference data. If the reference data are missing, trends in available data and expert judgements are used to assess the status.	GES is met when the trophic structure of the community is at an appropriate level to support the trophic state, and is based on the reference data series that has been defined as representing GES; is given mean trophic level >X>; and is primarily site-specific. **State indicator.**

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
2.1 Abundance and characterisation of NIS	GES is met when there are no new anthropogenic introductions.	N.A.	GES is met when the number of new NIS is zero during the assessment period. **Pressure indicator.**
2.2 Environmental impact of invasive NIS	GES is met when further impacts from NIS are minimised, with the ultimate goal of no adverse alterations to the ecosystems.	N.A.	GES is met when further impacts from NIS are minimised, with the ultimate goal of no adverse alterations to the ecosystems during the assessment period. **Pressure indicator.**

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
4.1 Productivity of key species – trophic groups		**Marine mammals:** Based on the theoretical analysis of biological constraints and empirical analyses of the growth rate of depleted populations.	**Seals and toothed values:** GES is met when the population growth rate of seals and harbour porpoise is close to the intrinsic growth rate of a population undisturbed by human pressures. **State indicator.**
		WT-eagle: reference period.	**White-tailed eagle** productivity (the mean number of nestlings out of all occupied nests) is at levels not being affected by hazardous substances, poor prey availability and human disturbance. **State indicator.**
4.2 Proportion of selected species at top	The proportion of predatory species of adequate size is at a level enabling efficient top-down control of the food web.	**Proportions of fish trophic groups:** Based on site-specific reference data. If the reference data are missing, trends in available data and expert judgements are used to assess the status.	Proportion of large **pikeperch** (XXcm), **cod** (XXcm), **perch** (XXcm) is XX% of the entire population in the assessment area. **State indicator.** Proportion of **piscivorous** fish, **non-piscivorous** fish and **cyprinids** are at levels ensuring natural proportions of these trophic groups in the food web in the assessment area. **State indicator.** [The abundance of wintering bird populations can also be used under 4.2]
		Fish community trophic index: As above.	Fish community trophic index is >XX >. **State indicator.**
4.3 Abundance of key trophic groups/species	All trophic groups and key species of the marine food webs function in balance.	**Biomass of copepods**: As under D1.	Biomass of **copepods**: As under D1.
		Biomass of microphagous mesozooplankton: As under D1.	Biomass of microphagous **mesozooplankton:** As under D1.

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
5.1 Nutrients levels	Concentrations of nutrients in the euphotic layer are in line with prevailing physiographic, geographic and climate conditions and not resulting in unacceptable direct or indirect effects of nutrient enrichment	**Nutrient concentrations:** Reference periods and other methods used in WFD.	Winter concentrations of DIP, DIN in the 0-10 layer: Acceptable deviation from sub-region specific baseline conditions is < 50%. **State indicator**.
		Nutrient inputs: *BSAP maximum allowable inputs.*	Sub-basin specific nutrient loads should be below the maximum allowable annual nutrient inputs for countries as specified in the HELCOM BSAP. **Pressure indicator.**
5.2 Direct effect of enrichment	Clear water and natural levels of algal blooms and growth, not resulting in unacceptable reduced water quality and other indirect effects.	**Secchi depth:** Reference periods and other methods used in WFD.	In the summer-time Secchi depth, the acceptable deviation from sub-region specific baseline conditions is < 25%. **State indicator**.
		Chlorophyll a: Reference periods and other methods used in WFD.	In the summer-time concentrations of chlorophyll a in the 0-10 m layer, the acceptable deviation from sub-region specific baseline conditions is < 50%. **State indicator.**
		Ratio of opportunistic and perennial macroalgae: *Low impacted areas?*	*Ratio of opportunistic and perennial macroalgae deviate from the sub-region/type specific baseline < XX%.* ***State indicator.***
5.3 Indirect effect of enrichment	Natural proportions and distribution of plants and animals and no reduction of oxygen concentration.	**Macrozoobenthic indices:** Several approaches in WFD	As under D1, 1.6.

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
6.1 Physical damage, substrate characteristics	Seabeds, particularly biogenic structures, are in favourable conservation status, providing habitats and resources for associated sessile and mobile species.	**Physical impacts:** Ultimately, the biological effects of impacts; tentatively, a mean cumulative impact.	*Significant cumulative impacts of physical anthropogenic disturbances on the benthic habitats do not cover more than 15% of the habitat area in the marine region.* ***Pressure indicator.***
6.2 Condition of benthic community	The benthic community is in a condition to be able to support its ecological functions, species diversity and the abundance of species is in line with physiographic and climatic conditions.	**Macrozoobenthic indices:** Several approaches in WFD.	As under D1, 1.6.

GES criterion	Suggestion for GES description	Approach for setting the GES boundary	Description of the GES boundary
8.1 Concentration of contaminants	Concentrations of contaminants in the most relevant matrix (biological tissue, sediment, water) are at levels not giving rise to pollution effects in sensitive marine organisms, and the health of top predators is safeguarded.	All GES boundaries are based on ecotoxicological effect levels and concentrations of POP substances in biota do not increase over time.	Concentrations of Priority Substances are below Environmental Quality Standards or respective specific Quality Standard. **State indicator.** Concentrations of other selected hazardous substances are below other thresholds used by marine conventions (Environmental Assessment Criteria, Background Assessment Criteria or similar). **State indicator.** Concentrations of persistent organic pollutants in biota do not increase over time. **State indicator.**
8.2 Effects of contaminants	Contaminants do not cause unacceptable biological effects at any level of food web, ensuring a healthy wildlife.	All GES boundaries are based on the threshold levels of biological effects indicative at different biological levels in relevant important species of the BS ecosystem.	The biological effects are below the defined Environmental Assessment Criteria levels for Baltic Sea organisms to assess biological effects. **State indicator.**
9.1 Level, number and frequency of contaminants in seafood	Human health is not jeopardised by concentrations of contaminants in seafood.	All GES boundaries are based on average daily doses, and the effect levels on human health.	The safety levels of EC Regulation 1881/2006 and other food safety legislation have not been exceeded. **State indicator.**

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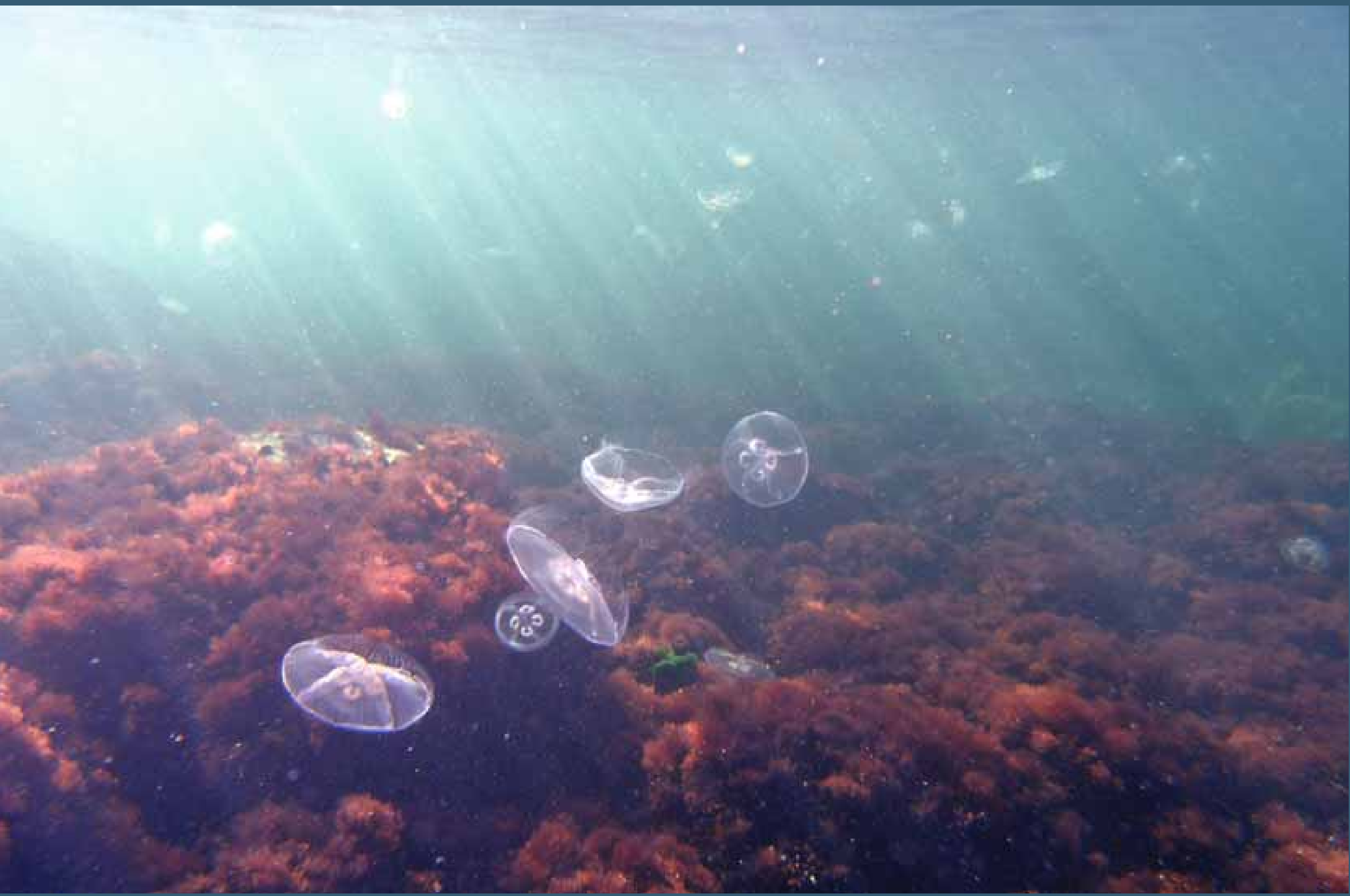

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