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Background

The biodiversity assessment for HOLAS II uses the integrated assessment tool BEAT 3.0, which has been developed under the HELCOM BalticBOOST project and guided by the previous workshops HELCOM HOLAS II Biodiv 1-2015, HELCOM BalticBOOST Biodiv WS 1-2106, and HELCOM BalticBOOST Biodiv WS 2-2106. Based on guidance form these workshops and from the HOLAS II core team, test assessment have been performed by BalticBOOST, resulting in the assessment approach outlined in this document.

The development has been supervised by State & Conservation, and the approach suggested to be used in HOLAS II was presented for endorsement to the Heads of Delegation in December 2016 (HOD 51-2016). HOD 51-2016 endorsed the use of BEAT 3.0 for assessing biodiversity in HOLAS II, noting a remaining open issue regarding the integration of assessment results for mammals beyond species. HOD 51 mandated the national experts to come to an agreement on this at HELCOM SPICE Biodiv 1-2017 (this workshop), and mandated the HOLAS II project to continue working on the basis of the outcome of this workshop and to present the draft assessment results to the State and Conservation Working Group (next meeting to be held in May 2017).

HOLAS II 6E-2017 discussed remaining open issues and asked the SPICE project to prepare proposals to be discussed at a follow-up online meeting 9 February 2017. The follow-up online meeting agreed that the integrated assessments to be presented at this workshop should (1) use OOAO throughout the integration for mammals, and further agreed to (2) use an criteria based integration approach for fish, and (3) to assess birds at the level of species groups. The way how to treat primary and secondary criteria were also discussed with the conclusion that if secondary criteria which are considered important are not covered, a penalty in the overall confidence should be applied, in similar way as for primary criteria.

This document describes the approach for assessment of biodiversity in HOLAS II using the assessment tool BEAT 3.0, based on the outcome of HOD 51-2016 and including subsequent guidance from the HOLAS II core team. Initial assessment results based on the presented approach are given in document 3.

Actions

Participants are invited to

- familiarize with the content prior to the workshop and use it as background information when evaluating the results from the biodiversity assessment

Development of an integrated assessment of biodiversity

In the first integrated thematic assessment of the Baltic Sea biodiversity (HELCOM 2009) developments towards an indicator based biodiversity assessment were made with the BEAT tool. At that time, the main obstacle was the lack of commonly agreed Baltic-wide indicators to be used for such an integrated assessment. Instead, the first version of BEAT used a set of national case studies to present the concept of an integrated biodiversity assessment and serve as a starting point for discussions and development of indicators and future assessments. The first version of BEAT relied on indicators for which the acceptable deviation from reference conditions was defined to assess the status. BEAT was later developed further to better comply with the EU MSFD requirements (Andersen et al. 2014).

Development of a coherent system of indicators to measure progress towards ecological objectives in the Baltic Sea was initiated by the CORESET project (HELCOM 2013). The basic criteria for HELCOM core indicators are that monitoring data and assessments are comparable across the Baltic Sea and that they are scientifically sound. The indicator assessment thresholds are set according to common principles increasing the comparability across regions and indicators. As a result of the CORESET project, 20 core indicators for biodiversity were proposed (HELCOM 2013).

As biodiversity is a complex concept covering a variety of characteristics from broad-scale landscape and habitat features to intraspecific patterns, different assessment approaches have been used for the different core indicators. Due to restrictions in the underlying data, the setting of thresholds has been challenging and not possible for some indicators. In these cases, the desired direction of change (trend) has been the agreed on as the best available approach as an interim solution until data availability has been improved.

To make an integrated assessment of biodiversity status based on a diverse set of indicators is not straightforward. Thus, the BalticBOOST project had the task to develop an integrated biodiversity assessment tool that could tackle the challenges set by the HELCOM core indicators and be used in the 'State of the Baltic Sea' report. BalticBOOST reviewed existing methods and concluded that the basic features of the BEAT tool and the tool NEAT (which was developed in the EU FP7 project DEVOTES; Berg et al. 2016) were the most suitable, but that not all core indicators are possible to include in these tools. The hierarchical nested structure and integration rules of these tools were used as a starting point in the development of the assessment tool for use in HOLAS II. The resulting integrated biodiversity assessment tool, BEAT 3.0, can handle indicators using different approaches: monotonic, unimodal, conditional and trend indicators, covering all indicator types used in the core indicators. By normalizing the indicators and calculating the distance to the threshold value, integration of indicators is made possible.

Methods

Integrated assessment structure

The biodiversity assessment consists of status assessments of five ecosystem components; benthic habitats, pelagic habitats, fish, marine mammals and sea birds. An integrated status assessment of each ecosystem component is done using the BEAT 3.0 tool (hereafter: BEAT), based on indicators. In BEAT, the ecosystem components *pelagic habitats* and *benthic habitats* are divided into broad habitat types and further to habitats, whereas the ecosystem components *birds*, *marine mammals* and *fish* are divided into species groups and (in some cases) further to species.

The indicator-based assessment is based on HELCOM core indicators and supplemented with additional indicators as outlined in Table 1. The purpose of the additional indicators is to improve the coverage of the assessment with respect to key elements where no core indicators are available. Each indicator is assigned to its relevant species group (for habitats: to broad habitat types) or species, and indicators within each species group (or species) are integrated based on the integration rules incorporated in the BEAT tool (Figure 1).

BEAT follows a balanced structure, weighing all groups equally at the same level in the structure. Weights are only allocated to elements which are represented by indicators, so that elements that are not represented by any indicator will not be included in the integrated assessment (for assessment of confidence in the integrated assessment, see below). No spatial aggregations of the results are done. The results are presented at ecologically relevant scales, which differ among the ecosystem components (as presented further below).

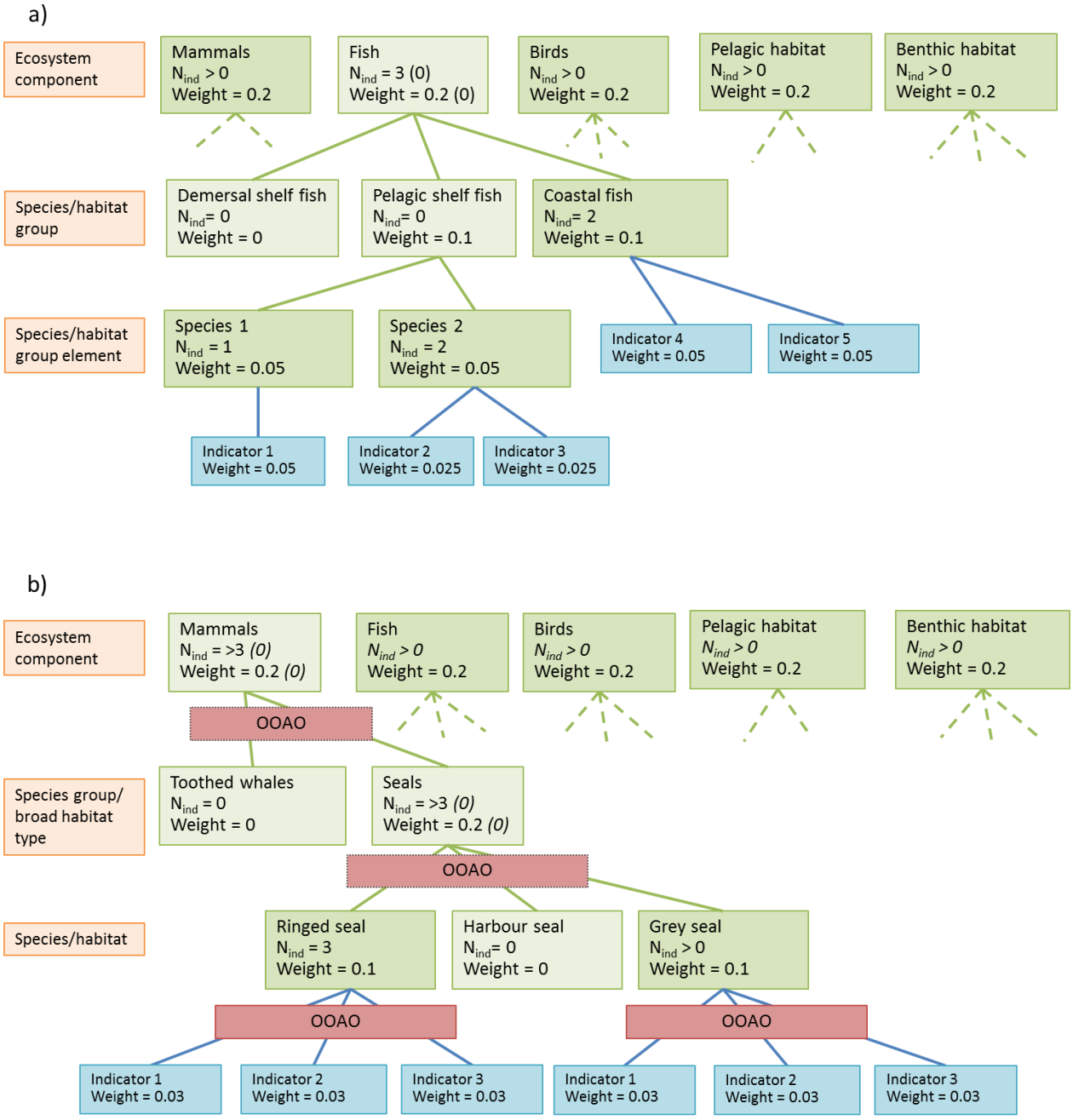

Figure 1. Assessment structure for ecosystem components with examples of how weights are distributed in order to give a balanced overall design: a) Example on how weights are distributed to the indicators when indicators are assigned to different hierarchical levels. For coastal fish, indicators are assigned to the species group level, whereas for pelagic shelf fish indicators are assigned to species level. b) Example for mammals. For this ecosystem component, the OOAO approach is used in the integration.

Incorporation of the indicators in the BEAT tool

The indicators included are developed based on different approaches and different kinds of data (units and scales). BEAT first normalizes the indicators to a common scale and unit in order to calculate the Biological Quality Ratio (BQR) for each indicator, and enable different indicators to be integrated. The normalization utilizes information on the minimum and maximum value of each indicator, which is provided by the indicator experts. Defining minimum and maximum values of an indicator is straightforward when sufficient data covering the whole spectrum is available. This is however not often the case, due to the environmental degradation and limited data for some indicators, and guidance has been provided on how to define minimum and maximum values also in those cases.

If information from the deteriorated conditions is available, this can be used to set the minimum value, and the maximum value can be defined as shown in Figure 2. The indicator threshold is scaled to 0.6 on the scale from 0 to 1. The BEAT tool has built-in approaches to normalize different types of indicators. Indicators with monotonic response curves are the default. For unimodal indicators, which have both an upper and a lower threshold, the normalization is done in relation to the threshold value closest to the assessment value. Trend-based indicators are assessed based on the slope of the trend or by an expert-judgment based approach that transforms assessment results into 4 classes (Figure 3). For conditional indicators, all assessed parameters are used in BEAT, but only the parameter with the lowest BQR is used in the integration process. For indicators where the results is presented only as sub-GES or GES, input values are given as 0.25 for sub-GES (mid-point of 0-0.5) or as 0.75 for GES (mid-point of 0.5-1).

In the assessment of pelagic and benthic habitats, eutrophication core indicators indicating habitat condition are also included (see Table 5). For these indicators the eutrophication ratio (ER) values have been used, meaning that the threshold is at 1. For their inclusion in BEAT, the maximum value for these indicators (indicating highest status) was set to 0 whereas the minimum value (indicating lowest status) was set to 3. In cases where the observed ER was >3, the assessment value was set as the minimum value. However, for the indicator ‘Oxygen debt’, minimum values were set to 1.5 (as higher values are not realistic for this indicator).

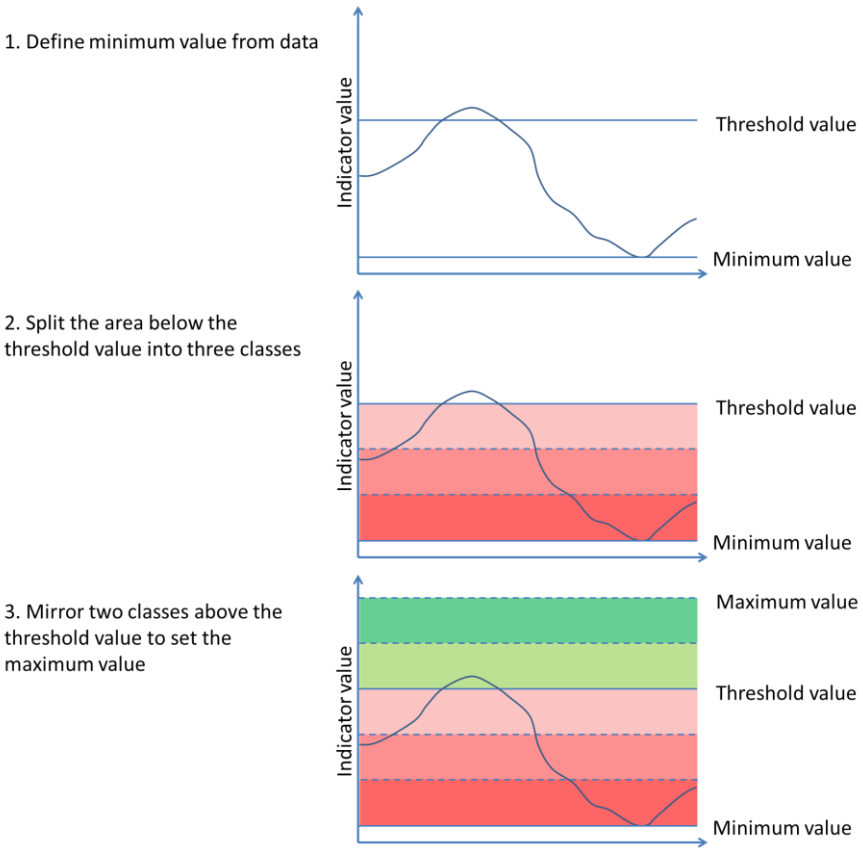

Figure 2. Example for an indicator with threshold value and data available for deteriorated conditions, assuming linearity.

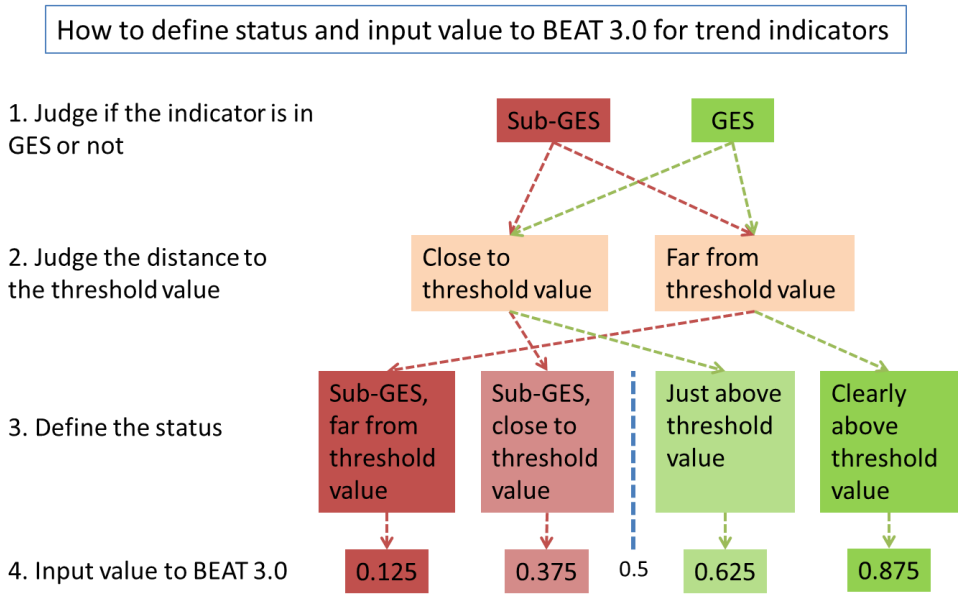

Figure 3. The general approach for how to include indicators with a trend-based assessment in BEAT 3.0.

Integration rules

The integration rule applied by default in BEAT is weighted averaging. One exception is marine mammals, where the one-out-all-out principle is applied at all levels of integration (Figure 1b). Indicators are given weights based on the ecosystem element level they are assigned to, so that a balanced structure in the assessment hierarchy is achieved (Figure 1a).

Confidence assessment

In parallel to the biodiversity assessment, BEAT calculates the confidence of the biodiversity assessment based on the evaluated confidence of the indicators. Indicator confidence is evaluated by the indicator experts considering four aspects; confidence of classification, temporal coverage, spatial representation and methodological confidence, into the classes: high, intermediate and low (see tables 1-4).

The overall assessment of confidence is calculated based on the indicator confidences transformed into numerical form (high=1, intermediate=0.5, low=0), averaged for the indicator and then following the same integration rules as used in the biodiversity assessment for that ecosystem component (OAOO for marine mammals, averaging for the other cases).

When indicators for MSFD criteria or species groups/broad habitat types are lacking in the assessment, the overall confidence is reduced by 25% for missing criteria or/and missing species/broad habitat types at the final step. For marine mammals, confidence is also reduced if a HD annex II listed species is not included.

The overall confidence is presented in categorical form (High >0.75 ≥ Intermediate ≥ 0.5 > Low).

Table 1. Guidelines for how to evaluate the temporal confidence of the indicator.

Score	**Evaluation: choose the score where the answer is 'YES' (to at least one question).**
HIGH	Does the monitoring data cover the entire HOLAS II assessment period? i.e. - if year-to-year variation occurs, are all years in the range 2011-2016 included? - if year-to-year variation does not occur, are the requirements for temporal frequency of monitoring met?
INTERMEDIATE	Does the monitoring data cover most of the HOLAS II assessment period? i.e. - if year-to-year variation occurs, are 3 or 4 years in the range 2011-2016 included?
LOW	Does the monitoring data cover the HOLAS II assessment period inadequately? i.e. - if year-to-year variation occurs, are only 1 or 2 years in the range 2011-2016 included? - if year-to-year variation does not occur, are the requirements for temporal frequency of monitoring not met? (Supplementary information: What is needed to improve)

Table 2. Guidelines for how to evaluate spatial confidence of the indicators.

Score	Evaluation: choose the score where the answer is 'YES' (to at least one question).
HIGH	Is the monitoring data considered to cover the full spatial variation of the indicator parameter in the assessment area? i.e. - does the data represent reliably at least 90% of the relevant habitat type(s) in the assessment area? - if a clear gradient or patchiness is shown in the parameter value, is the monitoring set to cover at least 90% of this variation?
INTERMEDIATE	Is the monitoring data considered to cover most of the spatial variation of the indicator parameter in the assessment area? i.e. - does the data represent reliably at least 70-89% of the relevant habitat type(s) in the assessment area? - if a clear gradient or patchiness is shown in the parameter value, is the monitoring set to cover 70-89% of this variation?
LOW	Is the monitoring data considered not to cover the spatial variation of the indicator parameter properly in the assessment area? i.e. - does the data represent reliably less than 70% of the relevant habitat type(s) in the assessment area? - if a clear gradient or high patchiness is shown in the parameter value, is the monitoring set to less than 70% of this variation?

Table 3. Guidelines how to evaluate confidence of classification for the indicators.

For indicators that allow calculation of standard error for assessment evaluation:

Please provide the standard error of the evaluation data. The assessment tool will be able to score accuracy by combining this information with the status scoring.

For indicators that do not allow calculation of standard error for assessment evaluation:

Score	Evaluation: choose the score where the answer is 'YES'
HIGH	Does a compliance check to the threshold value show a clear signal whether GES has been achieved or not? i.e. - GES has been / has not been achieved by at least 90% probability
INTERMEDIATE	Does a compliance check to the threshold value show that values are generally clearly GES/sub-GES, though some outliers and variation in the data are present? i.e. - GES has been / has not been achieved by 70 – 89% probability
LOW	Does a compliance check to the threshold value not show clearly whether the data points are GES/sub-GES, and/or the overall evaluation is very close to the boundary? i.e. - GES has been / has not been achieved by less than 70% probability

Table 4. Guidelines how to assess methodological confidence for the indicators.

Score	**Evaluation: choose the score where the answer is 'YES' (to at least one question).**
HIGH	For indicator parameters that have HELCOM guidelines for monitoring: has the monitoring been conducted according to these? Is the data quality assured according to HELCOM or other internationally accepted guidelines?
INTERMEDIATE	For indicator parameters that have HELCOM guidelines for monitoring: has the monitoring been conducted only partly according to these? Is the data from mixed sources, partly quality assured according to HELCOM or other international standards? Is the data quality assured, but according to local standards?
LOW	For indicator parameters that have HELCOM guidelines for monitoring: has the monitoring data not been collected according to these? Is the monitoring data not quality assured?

Indicators included

The published HELCOM core indicator reports are found at http://www.helcom.fi/baltic-sea-trends/indicators. Updated indicator reports were discussed at STATE & CONSERVATION 5-2016 and further updates will be available during spring 2017. Below, a short summary of indicators used in the assessment of the different ecosystem components is presented. All the included indicators are presented in Table 5.

Benthic habitats

Benthic habitats are assessed using the core indicator 'State of the soft-bottom macrofauna community'. Macrozoobenthos forms an important link in the marine food web and has functional importance in linking the sediment and water column habitats. The indicator evaluates the composition of the macrofauna community based on the proportion of sensitive and tolerant (to anthropogenic pressures) species as well as accounts for species richness and total abundance of macrofauna.

The benthic habitat is also assessed by the core eutrophication indicators 'Oxygen debt' in the open sea and 'Secchi depth', 'Macrophytes', 'Macrozoobenthos' and 'Oxygen' in coastal areas. These respond to the eutrophication pressure and indicate the condition of the benthic habitat.

- The ndicators representing benthic habitats are assessed at the most detailed spatial scale meaning water type or water body scale in coastal areas.
- The 'State of the soft-bottom macrofauna community' indicator currently lacks threshold values in Bornholm Basin and Arkona Basin and is not assessed in these areas.
- When assigning indicators to broad habitat types, indicators linked to the phytobenthic zone were assigned as 'infralittoral', whereas indicators linked to soft bottom macrofauna were assigned as 'circalittoral'.

Pelagic habitats

Pelagic habitats currently have only one operational core biodiversity indicator. 'Zooplankton mean size and total stock' reflects the status of the zooplankton community from a food web perspective. Zooplankton mean size indicates both feeding conditions for fish that feed on zooplankton and grazing pressure on phytoplankton, whereas the total stock of zooplankton measures the capacity of this energy transfer.

The pelagic habitat is also assessed by the core eutrophication indicators 'Cyanobacterial blooms', 'Chl a' and 'Phytoplankton biomass' which indicate the condition of the pelagic habitats and respond to eutrophication pressure.

- Pelagic habitats are assessed at the most detailed spatial scale meaning water type or water body scale in coastal areas (assessment unit level 4).
- The 'Zooplankton mean size and total stock' indicator is currently only assessed for the Bothnian Bay, Bothnian Sea, Åland Sea, Gulf of Finland and Northern Baltic Proper.

Fish

The status of fish is assessed using both HELCOM core indicators and ICES indicators for commercial fish species. Fish play an important role in food webs and ecosystem functioning and are also of high socio-economic importance in the Baltic Sea. 'Abundance of key coastal fish species' reflects the long-term development in abundance of the key fish species in coastal areas, which is perch or flounder, depending on the sub-basin. 'Abundance of coastal fish key functional groups' expresses the status of coastal food webs and ecosystem functioning, assessing the functional groups 'piscivores' and 'cyprinids' ('mesopredatory fish' are used in areas outside of the natural distribution range of cyprinids).

In addition, the indicator 'Abundance of salmon spawners and smolt' measures the reproductive success of the anadromous predatory fish and responds to fishing pressure and barriers in the reproduction rivers, and will be included depending on data availability.

Commercial fish will be included in the integrated assessment using information from ICES, based on assessments in relation to thresholds for spawning stock biomass (SSB) or based on trend over time (depending on data availability for the concerned stock). The ICES advice in relation to commercial fish, D3 is foreseen by May 2017, and will cover data until 2016. For the first version on the 'State of the Baltic Sea' report, advice based on data until 2015 can be used as interim information for those stocks where this is available.

- Fish are assessed at sub-basin scale, differentiating between coastal and open sea areas.

Marine mammals

Marine mammals are assessed at species level. Currently, there are only operative core indicators for seals. As top predators, seals indicate the state of food webs, levels of hazardous substances and direct human disturbance. 'Population trends and abundance of seals' signals changes in the number of marine top predators in the Baltic Sea taking into account the present population size but also trends in population development. 'Distribution of Baltic seals' takes into account three aspects of distribution: haul-out sites, breeding sites and foraging areas.

'Nutritional status of seals' and 'Reproductive status of seals' are providing information of the condition of the seal populations. At the moment these indicators are only assessing grey seal.

- Marine mammals are assessed at sub-basin scale.

Sea birds

Sea birds are assessed by two core indicators, 'Abundance of waterbirds in the breeding season' and 'Abundance of waterbirds in the wintering season', which both assess the status based on fluctuations in key sea bird species abundances. Sea birds have functional significance in the marine ecosystem and respond to numerous pressures caused by human activities. The indicators give a general view of the status of marine birds and reflect the cumulative impact of pressures.

- Sea birds are assessed at Baltic Sea scale at the level of species group.

Table 5. HELCOM core biodiversity indicators, as well as ICES indicators on commercial fish species (marked with *), used in the integrated biodiversity assessment.

Indicators for use in HOLAS II	Species	Species group / Broad habitat type	Assessment scale
Benthic habitats			
Status of the soft-bottom macrozoobenthos	-	Circalittoral	Open sea
Eutro - Oxygen debt	-	Circalittoral	Open sea
Eutro - Macrophytes[1]	-	Infralittoral	Coast
Eutro - Secchi	-	Infralittoral	Coast
Eutro - Macrofauna indices[2]	-	Circalittoral	Coast
Eutro - Oxygen	-	Circalittoral	Coast
Pelagic habitats			
Zooplankton mean size and total stock	-	Coastal, Shelf	Open sea
Eutro - Cyanobacterial blooms	-	Shelf	Open sea
Eutro - Chl a	-	Coastal, Shelf	Coast, open sea
Eutro - Phytoplankton biomass	-	Coastal	Coast
Fish			
Abundance of key coastal fish species	-	Coastal fish	Coast
Abundance of coastal fish key functional groups	-	Coastal fish	Coast
Abundance of salmon spawners and smolt	salmon	Pelagic shelf fish	Coast, open sea
D3C2 ICES - SSB herring*	herring	Pelagic shelf fish	Open sea
D3C2 ICES - SSB sprat*	sprat	Pelagic shelf fish	Open sea
D3C2 ICES - SSB salmon*	salmon	Pelagic shelf fish	Open sea
D3C2 ICES - SSB seatrout*	sea trout	Pelagic shelf fish	Open sea
D3C2 ICES - SSB Brill*	brill	Demersal shelf fish	Open sea
D3C2 ICES - SSB cod*	cod	Demersal shelf fish	Open sea
D3C2 ICES - SSB dab*	dab	Demersal shelf fish	Open sea
D3C2 ICES - SSB flounder*	flounder	Demersal shelf fish	Open sea
D3C2 ICES - SSB plaice*	plaice	Demersal shelf fish	Open sea
D3C2 ICES - SSB sole*	sole	Demersal shelf fish	Open sea
D3C2 ICES - SSB turbot*	turbot	Demersal shelf fish	Open sea
D3C2 ICES - SSB european eel*	european eel	Coastal fish	Coast
Mammals			
Population trends and abundance of seals	3 seal species	Seals	Sub-basins
Nutritional status of seals	grey seal	Seals	Sub-basins
Reproductive status of seals	grey seal	Seals	Sub-basins
Distribution of Baltic seals	3 seal species	Seals	Sub-basins
Birds			
Abundance of waterbirds in the breeding season	-	5 species groups	Baltic Sea
Abundance of waterbirds in the wintering season	-	5 species groups	Baltic Sea

[1]Includes Macrovegetation Quality element, Benthic macroflora depth distribution, Fucus vesiculosus depth distribution, Proportion of perennial species, Phytobenthos Ecological Quality Index, Furcellaria lumbricalis depth distribution in the workspace for eutrophication.

[2]Includes the indicators Macrofauna Quality element, Benthic Quality Index (BQI) and Brackish-water Benthic Index (BBI) (depending on country, as available in the eutrophication assessment workspace).

Data sources

The assessment period of HOLAS II is 2011-2016. However, at the current date, data has mainly been available for the years 2011-2015. Only data that has been approved at national level are included.

Data on **benthic macrofauna** was extracted from the COMBINE database and supplemented by data from Estonia, Latvia, Lithuania and Germany. No assessment is made for Kattegat, Great Belt, The Sound or Arkona Basin.

Zooplankton data have been reported nationally. The indicator is currently only assessed for the Bothnian Bay, Bothnian Sea, Åland Sea, Northern Baltic Proper and Gulf of Finland.

Data on **coastal fish** were extracted from the HELCOM Coastal fish database newly developed in the BalticBOOST project. The commercial fish indicators are based on data collection and assessments coordinated by ICES.

Seal abundance data has also been collected into a common database in the BalticBOOST project. For the **Nutritional status** of seals and **Reproductive status** of seals data has only been reported by Finland and Sweden and only grey seal has sufficient data for an assessment.

Sea bird data have been reported nationally.

Eutrophication core indicators are calculated in the Eutrophication assessment workspace, where indicators for open sea areas are calculated directly through the COMBINE database and coastal indicators reported by the contracting parties. It has to be noted that not all contracting parties have yet updated the coastal indicators, and in these cases the data used stem from the EUTRO-OPER assessment (2007-2012).