STATE OF THE BALTIC SEA
- HOLISTIC ASSESSMENT -
First version 2017

THE INTEGRATED ASSESSMENT OF BIODIVERSITY

TO BE UPDATED IN 2018

-Supplementary Report to the First Version of the 'State of the Baltic Sea' Report 2017

HELCOM – BALTIC MARINE ENVIRONMENT PROTECTION COMMISSION

The integrated assessment of biodiversity - supplementary report to the first version of the HELCOM 'State of the Baltic Sea' report 2017

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Introductory note

This report contains the method description and summary results for the integrated assessment of biodiversity as presented in the first version of the HELCOM 'State of the Baltic Sea' report, which is available at http://stateofthebalticsea.helcom.fi/about-helcom-and-the-assessment/downloads-and-data/.

The results will be further updated in time for the consolidation and finalization of the 'State of the Baltic Sea' report in June 2018, so that the assessment results will be representative of the assessment period 2011-2016.

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Summary

Due to its unique salinity gradient and high variability in habitat types, the Baltic Sea contains a greater biodiversity and variety of plant and animal life than might be expected. However, growing pressures in recent decades have taken their toll on the species. Achieving a good status of the biodiversity in the long term is a HELCOM priority, strengthened by the revised Helsinki Convention in 1992. The latest results show that many species are still under threat. It is anticipated that biodiversity will show signs of improvement in the coming years, as the effects of recently implemented measures is being seen, but also that continued efforts to support biodiversity are of key importance.

This report gives the method description and more detailed assessment outputs of the integrated assessment of biodiversity which was carried out as part of second HELCOM holistic assessment of ecosystem health in the Baltic Sea. The key results, as given in the Chapter 4 of this report, are also presented in the 'State of the Baltic Sea' report (HELCOM 2017a).

The results for the years 2011-2015 show that many species are still under threat. Although some signs of improvement may be expected in the coming years, as a result of previously implemented environmental protection measures, a continued development of measures is needed to improve the biodiversity status of all studied ecosystem components; marine mammals, sea birds, fish as well and benthic and pelagic habitats.

The biodiversity status has not been possible to compare directly with the results of the previous holistic assessment (HELCOM 2010) since the basis for the assessment is different.

Indicators included

Ten biodiversity core indicators were used as the cornerstone of the assessment. The core indicators cover all key ecosystem components of the Baltic Sea at least partially, but continued indicator development is needed in order to achieve a more complete biodiversity assessment in the future. The biodiversity core indicators were supplemented with selected HELCOM eutrophication core indicators where no directly corresponding biodiversity indicators are yet available. Assessment results for commercial fish species were obtained from the International council for exploration of the sea (ICES). In coastal areas, national indicators were also used.

Integrated assessment results in brief

The integrated assessment was carried out separately for each biodiversity ecosystem component. The results for each of these show that:

- For benthic habitats, five out of twelve assessed open sea areas, representing only soft-bottom habitats, show adequate status. Around 50% of the coastal areas show good integrated status for benthic habitats. None of 6 open sea areas assessed for oxygen debt show good status.
- For pelagic habitats, around 25% of the coastal areas achieve good integrated status for pelagic habitats. One out of sixteen assessed open sea areas show adequate status for pelagic habitats. None of 10 open sea areas assessed for cyanobacterial blooms show good status.
- Around 50 % of the assessed coastal areas show good status for fish-based on core indicators. Three out of eight commercial fish stocks achieve good status. 14 stocks currently lack evaluation. The migrating species salmon and sea trout were not included in the integrated assessment but show inadequate status in most areas where they are assessed.
- For marine mammals, the population sizes of grey seal are increasing, but their nutritional and reproductive status is not good. Of the three management units of harbour seal, only the Kattegat population shows good status. Ringed seal shows inadequate status. The Gulf of Finland population is represented by around 100 animals. Harbour porpoise was not included in the integrated assessment but populations in the Baltic Sea are assessed as threatened in the HELCOM red list Red list.
- The abundance of waterbirds is in poor status during both breeding and wintering seasons. Only pelagic feeders as a group show good status in both seasons. Twelve out of twenty-six waterbird species breeding in the Baltic Sea have declined during the past decades. Sixteen out of twenty-seven waterbirds species wintering in the Baltic Sea have declined during the past decades.

Chapter 1. Background

The Baltic Sea is home to about 2 700 macroscopic species and innumerable smaller microscopic species (HELCOM 2012, 2013a). Around 1 700 macroscopic species are found in the most marine sub-basin of the Baltic Sea, the Kattegat, while only around 300 species occur in the most freshwater-influenced area, the Bothnian Bay, reflecting the effect of low salinity on the distribution of many species of marine origin (Figure 1).

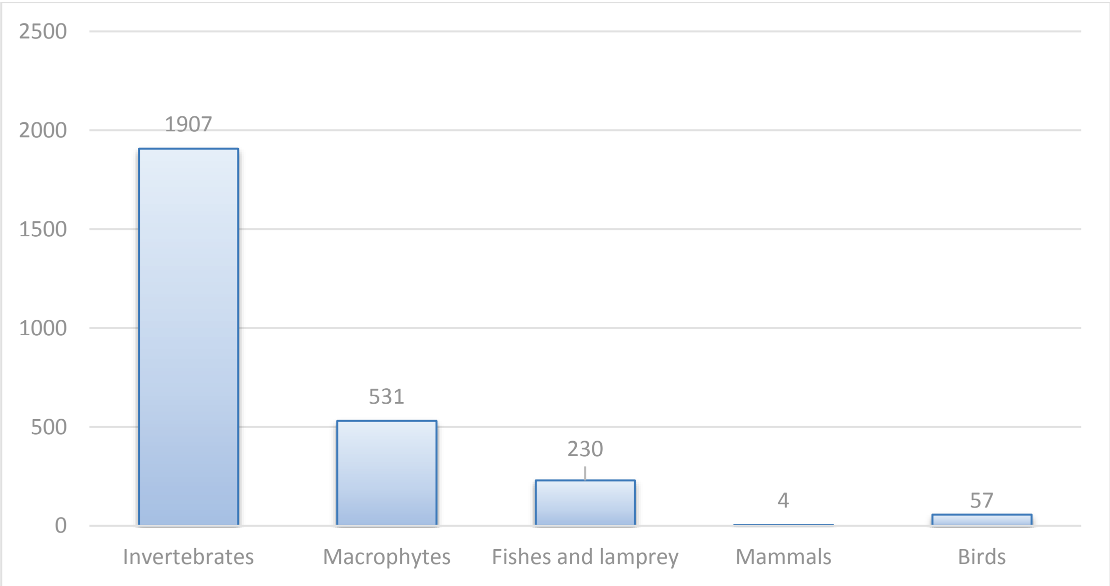

Figure 1. Number of macroscopic taxa in the Baltic Sea within different species groups. Based on HELCOM (2012).

The integrated assessment of biodiversity was carried out using the HELCOM Biodiversity Assessment Tool (BEAT 3.0). This report presents the indicators used in the assessment and outlines the method for how the integrated assessment was carried out. The results as also presented in Chapter 5 of the summary report 'State of the Baltic Sea' (HELCOM 2017a) are presented and in addition more detailed assessment outputs are provided in order to be able to trace the numeric results for different assessment units.

The assessment is a milestone in a continued method development, with the long term aim of HELCOM countries being to continuously include more aspects of biodiversity in a Baltic-wide assessment.

Chapter 2. Indicators used in the assessment

This biodiversity assessment builds on work over many years in HELCOM to develop core indicators to evaluate the status of important species and species groups, including their abundance, distribution, productivity, or physiological and demographic characteristics (HELCOM 2013b). The core indicators assess all key taxonomic groups occurring in the Baltic Sea, based on available data (Figure 2, Table 1).

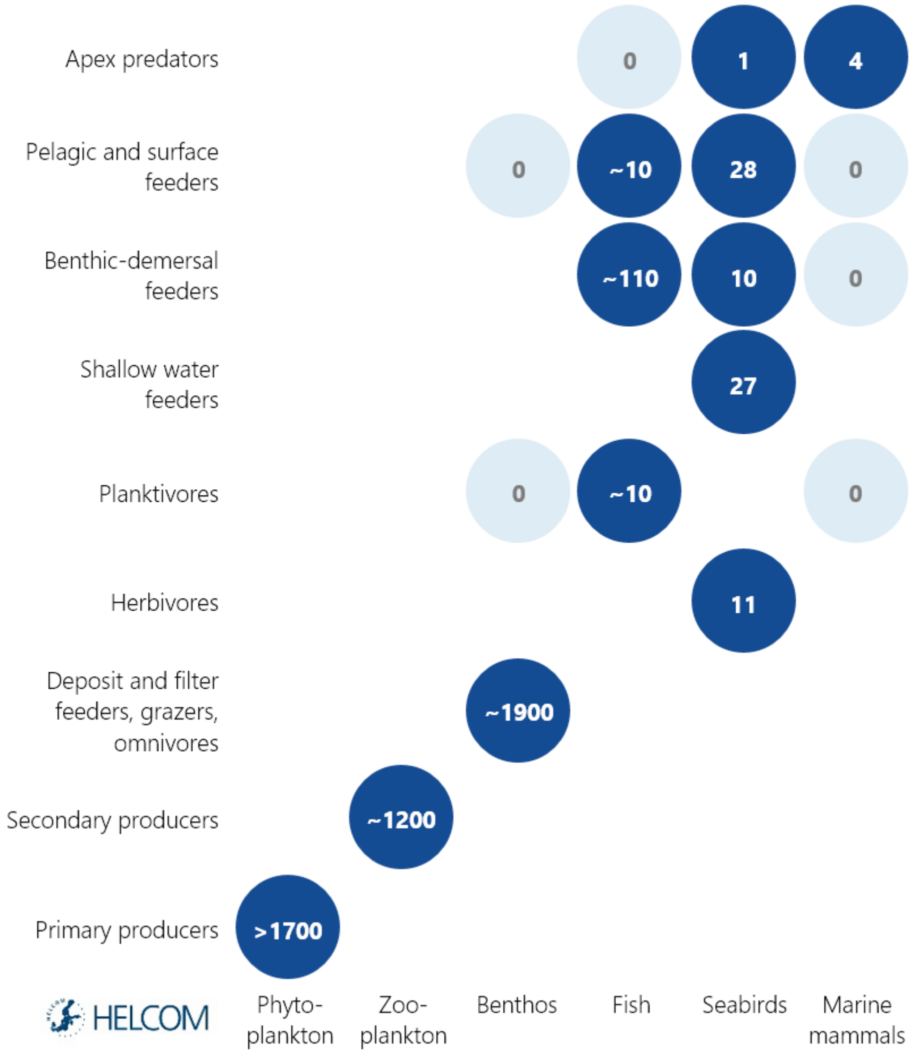

Figure 2 Estimated numbers of species in the Baltic Sea. The numbers are shown in relation to functional groups on the vertical axis and taxonomic groups on the horizontal axis. Light blue fields represent species groups typical to marine waters which are not represented in the Baltic Sea. Data sources: for numbers of phytoplankton and zooplankton: Ojaveer *et al.* (2010); benthic fauna: HELCOM (2013); fish (HELCOM 2012, fish classified as regularly or temporarily occurring in the Baltic Sea are included and biologically classified according to Fishbase (2017); birds: ICES (2016b). HELCOM core indicators are operational to address ecosystem components in all dark blue fields, to different level of extent depending on developmental status of the regionally agreed indicators

The integrated biodiversity assessment was carried out for the level of five ecosystem components; benthic habitats, pelagic habitats, fish, mammals, and water birds. The biodiversity core indicators were supplemented with additional indicators, with the aim of achieving a regionally representative assessment that is as comprehensive as possible.

Selected core indicators of eutrophication were added in cases where no directly corresponding biodiversity indicators are yet available (Table 2). In coastal areas, national indicators have also been used. Information on commercial fish were obtained from the International Council for exploration of the sea (ICES 2016a; Table 2, Annex 1).

HELCOM HOD 51-2016 clarified regarding all HELCOM core indicators, that at this point in time, HOLAS II indicators and threshold values should not automatically be considered by the Contracting Parties that are EU Member States, as equivalent to criteria threshold values in the sense of Commission Decision (EU) 2017/848 laying down criteria and methodological standards on good environmental status, but can be used for the purposes of their MSFD obligations by those Contracting Parties being EU Member States that wish to do so.

Table 1. HELCOM core indicators used in the integrated biodiversity assessment. The corresponding core indicator reports are identified as HELCOM 2017b to HELCOM 2017m in the reference list and can also be found via the hyperlinks provided in column 2.

Ecosystem component (Assessment scale)	**Indicator**	**Comment**
Benthic habitats (4, open sea)	State of the soft-bottom macrofauna community	Has not been adopted in HELCOM yet and is currently tested. Applied above the permanent halocline.
	Oxygen debt	Eutrophication core indicator, Applied below the permanent halocline.
Pelagic habitats (3, open sea)	Zooplankton mean size and total stock	The indicator is assessed at spatial assessment unit level 2, but was included only in the open sea in the integrated assessment at this time. Included as test indicator.
	Chlorophyll-a	The indicator is assessed also for coastal areas, but national indicators were used for coastal areas at this time.
	Cyanobacterial bloom index	Has not been adopted in HELCOM yet and is currently tested
Fish (3, coastal areas)	Abundance of key coastal fish species	
	Abundance of coastal fish key functional groups	The two components of this indicator were included in separate
Mammals (2)	Population trends and abundance of seals	Assessed separately for grey seal, harbour seal and ringed seal
	Distribution of Baltic seals	Assessed separately for grey seal, harbour seal and ringed seal
	Nutritional status of marine mammals	Available only for grey seal
	Reproductive status of marine mammals	Available only for grey seal
Waterbirds (1)	Abundance of waterbirds in the breeding season	
	Abundance of waterbirds in the wintering season	

Table 2. Additional indicators used in the integrated biodiversity assessment.

Ecosystem component (Assessment scale)	Indicator	Comment
Benthic habitats (4, coastal areas)	Macrophytes	Includes indicators: Macrovegetation Quality element, Benthic macroflora depth distribution, Fucus vesiculosus depth distribution, Proportion of perennial species, Phytobenthos Ecological Quality Index, Furcellaria lumbricalis depth distribution
	Secchi depth	
	Macrofauna indices	Includes indicators: Macrofauna Quality element, Benthic Quality Index (BQI) and Brackish-water Benthic Index (BBI) (depending on country, as available in the eutrophication assessment workspace
	Oxygen	
Pelagic habitats (4, coastal areas)	Chlorophyll-a	
	Phytoplankton biomass	
Fish (open sea)	Spawning stock biomass (for cod, dab, sole, herring, sprat)	Assessed within the scale of ICES subdivisions, see Annex 1
	Fishing mortality (for cod, dab, sole, herring, sprat)	Assessed within the scale of ICES subdivisions, see Annex 1

While the biodiversity assessment has been considerably strengthened since the initial holistic assessment (HELCOM 2010) there is still room for improvement through the inclusion of additional features. For example, the current assessment does not encompass the condition of habitats and biotopes, and only one HELCOM core indicator, on zooplankton, is representing the plankton community. Developments are ongoing in HELCOM in this regard and new core indicators may be ready by 2018.

2.1 INDICATORS USED IN THE INTEGRATED ASSESSMENT OF BENTHIC HABITATS

The open sea was assessed based on the core indicator 'State of the soft- bottom macrofauna community'[5] which assesses changes in the species composition and also considers how sensitive different species are to disturbance (Box 2.1). In addition, the eutrophication core indicator 'Oxygen debt'[6] was used, in order to give information on living conditions for macrofauna in deeper areas.

Coastal areas were assessed using national indicators on macrofauna, macrophytes, and oxygen conditions, as well as water transparency to indicate the potential depth distribution of vegetation (Table 2). The use of national indicators makes results not directly comparable between coastal areas, and the results may also be influenced by variability in other factors, such as geomorphology and hydrology. Furthermore, as they are developed within the Water Framework Directive, the national indicators mostly focus on the assessment of eutrophication effects. Hence, the presented assessment of benthic habitats is not complete with respect to addressing the influence of other pressures that may influence benthic habitats.

Based on the currently available data and indicators, it is for example not possible to assess the status of benthic habitats against the pressure of physical loss and disturbance (See Chapter 4.7 in the State of the Baltic Sea summary report). In the future, with an improved knowledge about the occurrence and structure of benthic habitats, the impact of habitat loss and disturbance could be assessed quantitatively against a threshold value. HELCOM is currently developing a core indicator on 'Condition of benthic habitats' reflecting the area, extent and quality of specific benthic habitats that is expected to become operational in 2018. Indicators for benthic communities on hard bottoms have also been identified as a priority for future developments.

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[5] The threshold values for some of the assessment units for the core indicator 'State of the soft-bottom macrofauna community' are being tested in this assessment but are not yet adopted for all sub-basins

[6] The core indicator 'Oxygen debt' is not applicable in the southern Baltic Sea from the Kattegat to the Arkona Basin, in the Gulf of Riga or in the Quark.

Box 2.1 The core indicator based assessment of benthic habitats

The state of the soft-bottom macrofauna community in the open sea assessment units is evaluated using a method based on a common indicator, the Benthic Quality Index (BQI), The indicator takes into account the relative proportion of sensitive and tolerant species, as well as species richness and abundance (see figure below).

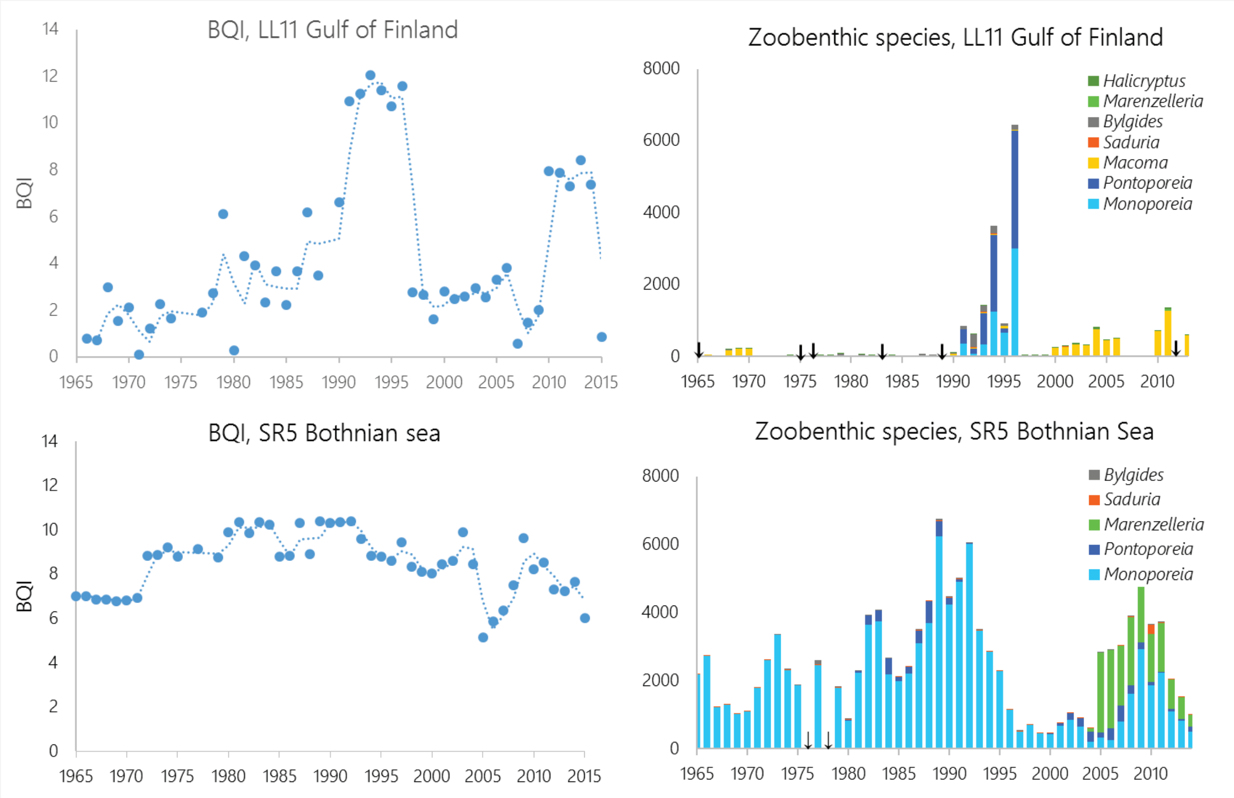

Figure Box 2.1. The core indicator 'State of the soft-bottom macrofauna community' is measured at assessment unit level by the Benthic Quality index (BQI), which addresses the abundance and species composition of benthic animals. The figures show examples of trends in the index measured at station level: Gulf of Finland (LL11) and Gulf of Bothnia (SR5). In the Gulf of Finland, there is a peak in the index in the early 1990s, reflecting improved oxygen conditions at the seabed. A similar pattern is seen in other stations from the Gulf of Finland during the same years (data not shown). In the Gulf of Bothnia the temporal pattern reflects inter-annual variability in the abundance of the amphipod Monoporeia affinis. In addition, the introduction of the non-indigenous species Marenzelleria sp. is visible in 2004. Dashed lines show the five-year moving averages and the arrows point to years with no data.

The oxygen debt is defined as the "missing" oxygen relative to a full saturated water column. It is an indirect effect of eutrophication, i.e. increase of organic matter descending to the bottom. It also has an indirect link to anthropogenic pressures, through increased anthropogenic nutrient loads and subsequent increase of organic matter descending to the bottom.

More details on the core indicator concepts and how threshold values have been defined can be found in the core indicator reports (see links in Table 1).

2.2 INDICATORS USED IN THE INTEGRATED ASSESSMENT OF PELAGIC HABITATS

Open sea areas were assessed using the core indicator 'Zooplankton mean size and total stock'[7], and the two eutrophication indicators 'Cyanobacterial bloom index'[8] and 'Chlorophyll-a' in order to represent changes in primary producers (Box 2.2). The indicator 'Chlorophyll-a', gives a general measure of the level of primary productivity, via variation in the biomass of phytoplankton, and responds strongly to eutrophication.

Coastal areas were assessed using national indicators on chlorophyll-a and phytoplankton bio-volume as defined for assessments in relation to the Water Framework Directive, focusing on eutrophication, which is a major pressure impacting the status of pelagic habitats (Table 2). However, particularly in coastal waters, the results of the biodiversity assessment may differ from the results of the eutrophication assessment in coastal areas (See chapter 5.1 in the State of the Baltic Sea report), which uses a different set of indicators.

[7] Included as a test indicator.

[8] Included as a test indicator.

Box 2.2 The core indicator based assessment of pelagic habitats

Zooplankton mean size and total stock evaluates the zooplankton community structure. In order to have good status, large sized zooplankters need to occur abundantly in the plankton community (See figure below). Due to strong environmental gradients, size distribution and total stock of the zooplankton corresponding to good status vary between the Baltic Sea sub-basins.

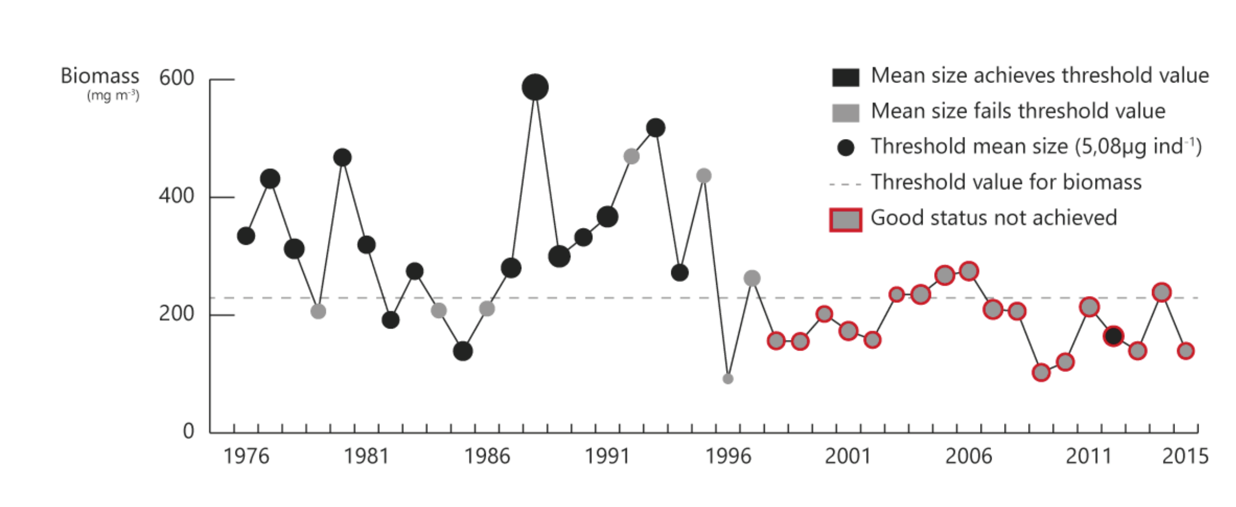

Figure Box 2.2 The assessment of the core indicator 'Zooplankton mean size and biomass' requires that a minimum level of both the total biomass and the mean size of the zooplankton community is reached. The figure shows the long term trend in the core indicator in the Northern Baltic Proper, as an example. The size of the circles corresponds to mean size of the zooplankton community, which ranged from 2 to 13 µg ind^{-1}. Black circles denote years when the mean size achieves the threshold value, and grey circles denote years with mean size below the threshold value. Circles marked with a red outline indicate years significantly below the threshold value for the core indicator, considering both mean size and biomass.

Chlorophyll-a: Chlorophyll-a concentration is used as a proxy of phytoplankton biomass, which increases along with increased eutrophication as a result of increased nutrient concentrations.

Cyanobacterial bloom index: The pre-core indicator evaluates cyanobacterial surface accumulations and cyanobacteria biomass during the summer period. The indicator describes the symptoms of eutrophication.

More details on the core indicator concepts and how threshold values have been defined can be found inthe core indicator reports (see links in Table 1).

2.3 INDICATORS USED IN THE INTEGRATED ASSESSMENT OF FISH

Coastal and open sea areas are characterised by different species groups, and there are also clear differences in species composition among sub-basins due to the gradient in salinity. About 230 fish species are recorded in the Baltic Sea (HELCOM 2012). Marine species are the most common in the southwestern Baltic Sea, and in the open sea. Coastal areas are key habitats for freshwater species, such as perch and cyprinids, as well as spawning and feeding areas for many marine species, such as cod, flounder, and herring. Most of the migrating species are born and spawn in rivers but spend most of their growth phase in the Baltic Sea, such as salmon and sea trout, but also sea lamprey and some populations of whitefish. The eel of the Baltic Sea is a highly migrant species and is the same population as all other European eels (for a summary on eel, see Box 5.3.1 in the summary report: HELCOM 2017a).

The integrated assessment of coastal areas includes core indicators representing characteristic Baltic Sea coastal fish species (Box 2.3).

Box 2.3 The core indicator based assessment of fish

Abundance of key coastal fish species: The core indicator is based upon changes over time in perch (*Perca fluviatilis*) or flounder (*Platichtys flesus*), with the species chosen depending on the natural distribution of these species. Perch is used in the eastern and northern coastal areas, and flounder in the southeast. Good status is achieved when the abundance is above a site-specific threshold value.

Abundance of coastal fish key functional groups: The core indicator evaluates the abundance of selected functional groups of coastal fish in the Baltic Sea: piscivores and a lower trophic level component (cyprinids/mesopredators). Low values in the core indicator component on 'piscivores' indicates disturbed food webs. The 'lower trophic level' component is most often measured as the abundance of fish from the taxonomic family cyprinids, for which high values are associated with eutrophication. Good status is achieved when the abundance of piscivores is above a site-specific threshold value, and the abundance of cyprinids or mesopredators is within an acceptable range for the specific site.

More details on the core indicator concepts and how threshold values have been defined can be found in the core indicator reports (see Table 1).

The core indicators also include the indicators 'Abundance of salmon spawners and smolt' and 'Abundance of sea trout spawners and parr' (HELCOM 2015a, HELCOM 2015b), which were not included in the integrated assessment at this time.

The open sea assessment was based on results for internationally assessed commercial fish stocks, using information on spawning stock biomass and fishing mortality based on ICES (2016a; Annex 1).

The migrating species salmon and sea trout are assessed by core indicators (HELCOM 2015a,b), but were not included in the integrated assessment at this time, due to inconsistencies in the input data (for a summary, see figure 5.3.2 in the summary report (HELCOM 2017a).

HELCOM work is ongoing to develop indicators to represent the demographic characteristics of fish communities (for example size distribution) as an important complement to the assessment in the future[9].

[9] The integrated assessment includes all fish species in the Baltic Sea area from which data was available and covered by operational indicators. Future regional assessments should be based on regional species lists agreed within HELCOM based on ecological relevance, coverage of ecological functions, pressure sensitivity and abundance in the assessment unit. As a result the species assessed under biodiversity might differ from those assessed under the assessment of commercial fishing as a pressure.

2.4 INDICATORS USED IN THE INTEGRATED ASSESSMENT OF MARINE MAMMALS

The status of the seal species was assessed by core indicators reflecting population trends and abundance, as well as their distribution (Box 2.4). Grey seals were also assessed using core indicators reflecting changes in nutritional status and reproductive status (Box 2.4). The seal populations in the Baltic Sea are managed and assessed according to management units that have been jointly agreed in HELCOM. There is currently no operational core indicator for harbour porpoise (For a summary on harbour porpoise, see the State of the Baltic Sea report chapter 5.4).

Threats on marine mammals from incidental by-catch and hunting on seals are covered in the summary report (HELCOM 2017a, Box 5.4.2, and Chapter 4.6, respectively).

Box 2.4 The core indicator based assessment of marine mammals

Population trends and abundance of seals: In order to have good status the population size needs to be above the limit reference level (10 000 individuals), and the species specific growth rate needs to be achieved. Seals are counted as the numbers of hauled-out individuals during moult.

Distribution of seals: Considering the occurrence at haul-out sites and the range of seals at sea, good status is achieved when the distribution of the species is close to pristine condition. If pristine conditions cannot be achieved due to irreversible long-term environmental changes, then good status is achieved when all currently available haul-out sites are occupied.

Nutritional status of seals: The core indicator is applied on grey seal, and evaluates the blubber thickness of a specimen of the population in relation to a defined minimum threshold value.

Reproductive status: Measures the proportion of pregnant adult grey seal females over the age of 6 years during July to February in relation to a minimum threshold value

Further, HELCOM is developing indicators on harbour porpoise abundance and distribution and number of drowned animals caught in fishing gear but at present there are no defined threshold levels against which the status can be assessed (see 'State of the Baltic Sea' report Box 5.4.2). HELCOM is also aiming to develop health indicators for mammals, based on lung lesions (caused by parasites and bacteria) in harbour porpoise and harbour.

More details on the core indicator concepts and how threshold values have been defined can be found in the core indicator reports (see Table 1).

2.5 INDICATORS USED IN THE ASSESSMENT OF WATERBIRDS

The Baltic Sea bird community is highly variable with seasons. Many species, such as the long-tailed duck, use the area as wintering ground, whereas others, such as the Arctic tern, migrate to the area for breeding. Others, such as the herring gull, occur in the Baltic Sea both during the wintering and the breeding period.

The Baltic bird species also encompass many different feeding types. Many birds are predators of fish, mussels and shellfish, but the Baltic Sea waterbirds also include scavengers, and grazers feeding on coastal vegetation, for example. Whereas some species are occurring all over the Baltic Sea region, such as breeding common terns and wintering long-tailed ducks, others are restricted to smaller parts of the Baltic or only selected sites, for example breeding pied avocets and wintering Steller's eiders.

To capture this variety, the two core indicators assess the status of forty-two bird species divided between the breeding and the wintering season. The species were chosen in order to represent the overall bird species composition as well as different species groups. The core indicators, 'Abundance of waterbirds in the breeding season' and 'Abundance of waterbirds in the wintering season', assess status by comparing an abundance index during the assessment period to a modern baseline (years 1991–2000).

Threats on waterbirds from incidental by-catch are covered in the State of the Baltic Sea report Box 5.5.2, and hunting on birds in the State of the Baltic Sea report chapter 4.6.

Box 1.1.4. The core indicator based assessment of waterbirds

'Abundance of waterbirds in the breeding season' and 'Abundance of waterbirds in the wintering season' assess status by comparing an abundance index during the assessment period to a modern baseline (years 1991–2000).

The breeding and wintering waterbirds are considered to reflect good status when at least 75% of the considered species deviate less than 30% downwards (20% for species laying only one egg per year) from the baseline condition during the reference period.

The HELCOM assessment is carried out on a regional scale, covering the whole Baltic Sea, in order to assess the overall population status. At a smaller geographical scale, changes in the relative abundance over time may differ markedly due to local factors such as habitat loss or enhancement, competition or disturbance, but also due to local protection.

More details on the core indicator concepts and how threshold values have been defined can be found in the core indicator reports (see Table 1).

Chapter 3. Method for the integrated biodiversity assessment

The HELCOM Biodiversity Assessment Tool (BEAT) is a multi-metric indicator-based tool. The first version of BEAT was developed for the HELCOM holistic assessment of 2010 (HELCOM 2010a), where an integrated thematic assessment of biodiversity was one component (HELCOM 2010b). The biodiversity assessment in the second HELCOM holistic assessment uses the integrated assessment tool BEAT 3.0, which has been developed under the HELCOM BalticBOOST project[10].

At the time of the first integrated thematic assessment of the Baltic Sea biodiversity (HELCOM 2009) one restriction to the assessment was the lack of commonly agreed Baltic-wide indicators. Instead, the biodiversity assessment was based on a set of national case studies, with the aim to present the concept of an integrated biodiversity assessment and to initiate the further development of regional indicators and integrated assessments. The first version of BEAT relied on indicators for which the acceptable deviation from reference conditions was defined to assess the status. The tool was later developed further to better comply with the requirements of the EU Marine Strategy Framework directive (Andersen *et al*. 2014).

The development of a coherent system of indicators to measure progress towards ecological objectives in the Baltic Sea was initiated by the CORESET project (HELCOM 2013b). 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. Currently, ten regionally agreed core indicators related to biodiversity are available for assessment and additionally three have been agreed to be used as test.

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 identification of indicator threshold values 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.

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 second HELCOM holistic assessment. After a review of currently existing methods, the basic features of the BEAT tool and the related tool NEAT (Nested environmental

[10] The HELCOM coordinated EU co-financed project: Baltic Sea project to boost regional coherence of marine strategies through improved data flow, assessments, and knowledge base for development of measures

status assessment Tool), which was developed in the EU FP7 project DEVOTES (Berg *et al*. 2016) were used as the basis for the further development.

The hierarchical nested structure and integration rules of these tools are also an important feature of the biodiversity assessment tool used in the second HELCOM holistic assessment, BEAT 3.0.

3.1 ASSESSMENT APPROACH OF THE BEAT TOOL

The BEAT 3.0 tool assesses the integrated status of biodiversity based on indicators following a nested structure. The assessment is conducted separately for the five key ecosystem components of the Baltic Sea: benthic habitats, pelagic habitats, fish, marine mammals and waterbirds.

To accommodate for the different types of indicators among the HELCOM core indicators, the tool can handle indicators using different approaches: monotonic, unimodal, conditional and trend indicators. By normalizing the indicators (see Chapter 2.3) and calculating the distance to the threshold value, integration of indicators is made possible.

The assessment applied in the second holistic assessment is based on HELCOM core indicators (Table 1) and supplemented with additional indicators (Table 2). 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. In the tool, each indicator can be assigned to its relevant species group or species (or to broad habitat types), and the indicators are integrated in a nested system based on the applied structure (Figure 3).

BEAT 3.0 follows a balanced structure, weighing all groups at the same level in the structure equally. Weights are only allocated to elements which are represented by indicators. This means that elements that are not represented by any indicator will not be included in the integrated assessment. No spatial aggregations of the results are done. The results are presented at ecologically relevant scales, which differ among the ecosystem components (see Chapter 3.4). The integration rule applied by default in BEAT is weighted averaging. However, for marine mammals, the one-out-all-out principle is applied.

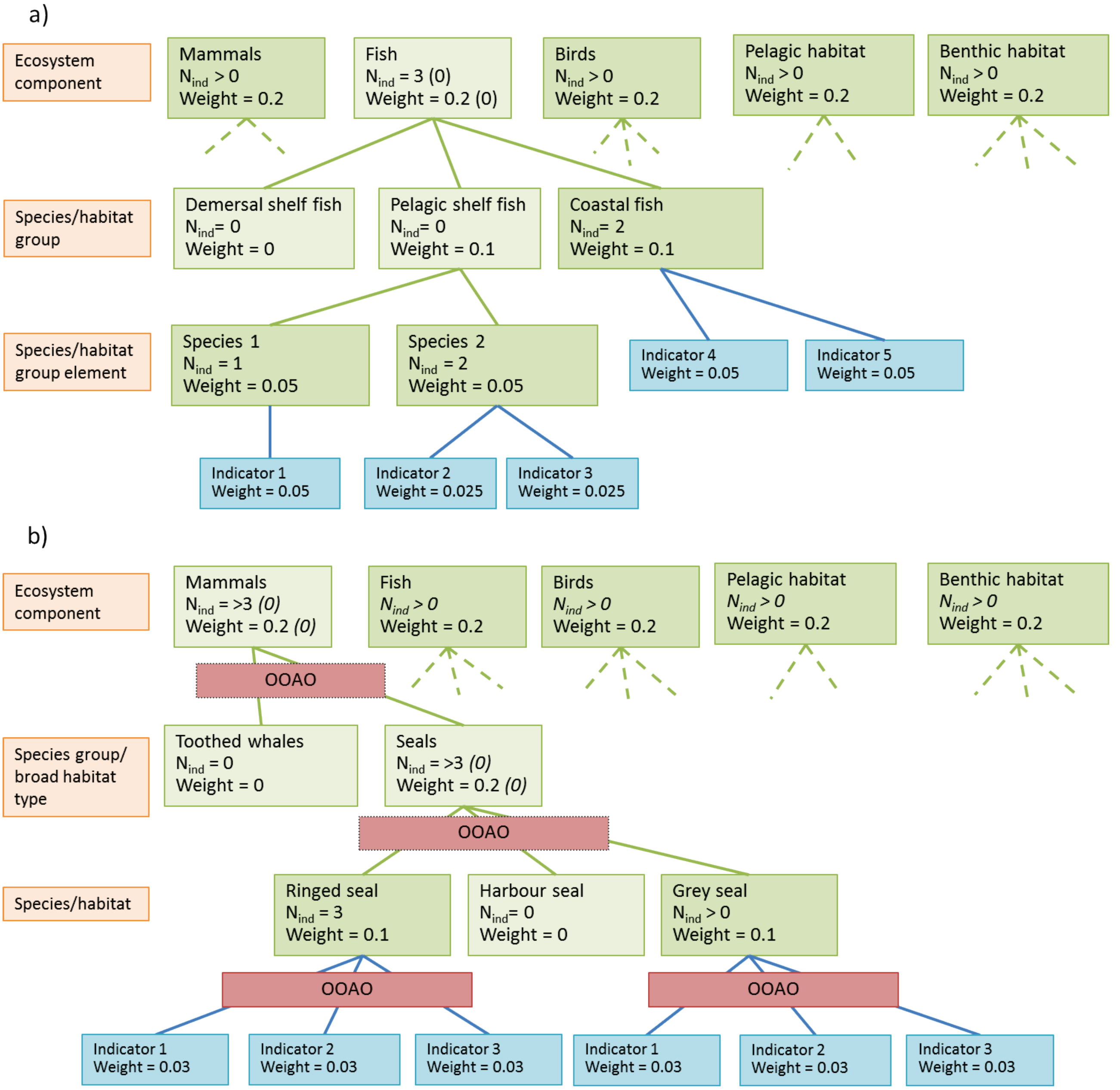

Figure 3. Assessment structure for ecosystem components in BEAT 3.0, with theoretical examples of how weights are distributed in order to give a balanced overall design when different numbers of indicators are used: a) Example on how weights are distributed to the indicators when indicators are assigned to different hierarchical levels. For coastal fish, indicators are assigned to the species group level, whereas the indicators for pelagic shelf fish are assigned to species level. b) Example for mammals. For this ecosystem component, the OOAO approach is used at all steps in the integration.

3.2 CONFIDENCE ASSESSMENT METHODOLOGY

The BEAT tool produces a confidence assessment in parallel to the status assessment. The confidence rating is based on the quality of the underlying monitoring data and the reliability of the indicator.

The confidence is initially determined at the indicator level. The experts on each indicator are asked to estimate the confidence based on four aspects into the classes 'high', 'intermediate' or 'low' (Table 3), for each indicator and assessment unit.

To align the replies among indicators, the judgement was made by answering a set of predefined questions (Annex 2), and the experts were asked to as far as possible motive their judgement by making use of quantitative information in line with the provided guidelines.

Table 3. Aspects considered in the assessment of confidence in the integrated assessment of biodiversity using BEAT 3.0. The indicator experts were asked to classify the indicator confidence separately for each aspect into 'high', 'intermediate' or 'low' based on the definitions presented in the table, basing the judgement on numerical information as far as possible. The assessment is made separately for each indicator and assessment unit. Hence, different confidence estimates can be given to the same indicator in different assessment unit.

Confidence aspect	**High**	**Intermediate**	**Low**
Confidence of classification (Estimated accuracy of the indicator result, for example the precision of the estimate in relation to the threshold value. The tool also allows for entering standard error values)	The indicator assessment result is considered correct with at least 90% probability	The indicator assessment result is considered correct with between 70 and 90% probability	The indicator assessment result is considered correct with less than 70% probability
Temporal coverage (How well does the data cover inter-annual variability during the assessment period)	Monitoring data is available for all years of the assessment period. For indicators that do not show variability between years, the temporal monitoring requirements are met.	Monitoring data is available for more than three years of the assessment period.	Monitoring data is available for one or two years of the assessment period.
Spatial representation (How well does the indicator data cover spatial variation within the assessment unit)	Data represents the whole assessment unit in a reliable way (at least 80% of the relevant habitat types occurring in the area are covered, or in cases with a clear spatial gradient or patchiness, the monitoring covers at least 80% of this variation).	The data represents between 60 and 80% of the relevant habitat type, or between 60 and 80% of the spatial variation or patchiness in the assessment unit.	The data represents less than 60% of the relevant habitat type, or less than 60% of the spatial variation or patchiness in the assessment unit.

Methodological confidence (Quality of the monitoring methodology)	The monitoring has been conducted according to HELCOM guidelines for parameters where these are available, and the data is quality-assured according to HELCOM or other internationally accepted guidelines.	The monitoring data has been collected only partly according to HELCOM guidelines or originates from mixed sources. The monitoring is partly quality-assured according to HELCOM or other international standards or by national/local standards.	The monitoring has not been conducted according to HELCOM guidelines, has not been quality-assured, or the methodological confidence is considered bad for some other reason.

The confidence estimates were provided in categorical form (low, intermediate and high confidence) and were translated into numbers (0, 0.5 and 1) in the assessment tool in order to be able to carry out the integrated analysis.

Subsequently, the integrated confidence is calculated following the same assessment structure and integration rules as used in the biodiversity assessment for the concerned ecosystem component. The BEAT output gives the combined results for all confidence aspects taken together, but also provides the results in separate for each aspect, for purposes of transparency.

Finally, the overall assessment confidence is considered. To evaluate the overall confidence of the integrated assessment, the aspect of how well the indicators cover the key species groups of the assessed ecosystem component is also evaluated. A penalty is applied to the integrated confidence if a critical species group is not assessed in the assessment unit, for example due to lack of agreed indicator or data.

This concept of assessing confidence is in line with that used in the integrated assessment of eutrophication using the HEAT tool and in the assessment of contamination status using the CHASE tool.

In the integrated biodiversity status assessment of the second holistic assessment, when indicators for key species groups or habitat types are lacking in the assessment, the overall confidence is reduced by 25% at the final step. For marine mammals, confidence is also reduced if a species listed in Annex II of the Habitats directive is not included (Table 4).

Table 4. Cases were overall confidence penalties were applied in the integrated biodiversity assessment.

Ecosystem component	Penalty applied
Benthic habitats	Confidence was lowered by one step compared to the BEAT output in open sea sub-basins only assessed by a eutrophication core indicator.
Pelagic habitats	Confidence was lowered by one step compared to the BEAT output in open sea sub-basins only assessed by a eutrophication core indicator.
Fish	Confidence was lowered by one step in open sea assessment units lacking indicators on demersal fish
Marine mammals	Confidence was lowered by one step in the assessment units where indicators on population condition were lacking for ringed seal or harbour seal.
Waterbirds	none applied

When presenting the results, the overall confidence results are again expressed as categories (Table 5).

Table 5. Confidence classes applied in the integrated biodiversity assessment. The colors in column two are those used in the associated confidence maps (See Chapter 4).

Confidence Score	Confidence Status
≥ 0.75	Class I (High)
between 0.5 and 0.75	Class II (Moderate)
<0.50	Class III (Low)

3.3 BEAT INPUT DATA

The indicators that are included in the biodiversity assessment are developed based on different approaches and different kinds of data, regarding the applied units and scales, for example. To enable inclusions of different types of data in the same assessment, the BEAT 3.0 tool first normalizes the indicators to a common scale and unit, and thereafter calculates the Biological Quality Ratio (BQR) for each indicator.

The normalization utilizes information on the minimum and maximum values of each indicator, which are 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 was been provided on how to define minimum and maximum values also in those cases (Annex 3).

The normalization transfers all indicator assessment values to a scale from 0 to 1, where the threshold value is 0.6. There are approaches built in the BEAT tool 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 lying closer. 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 (Annex 4). In conditional indicators all assessed parameters are used in BEAT, but only the parameter with the lowest biological quality ratio (BQR) is used in the integration process. The BEAT 3.0 tool can accommodate for indicators with both a positive and a negative response, meaning that both indicators that increase with improving status and indicators that decreased with improving status can be included (Table 6).

Table 6. Example input data table to the BEAT tool. The example shows the first rows of the input data for the assessment of benthic habitats. SAUD = ID number for the spatial assessment unit, Indicator ID= ID number for the indicator represented by that row, IndType = Indicator type (code for monotonic or unimodal), Bad = Min value, ModGood = Threshold value, High = Max value, Obs= Indicator assessment value, ConfA = confidence in the assessment based on accuracy, ConfT = confidence in the assessment based on temporal aspect, ConfS = confidence in the assessment based on spatial aspect, ConfM = confidence in the assessment based on monitoring aspect.

SAUID	**IndicatorID**	**Assessment area**	**Indicator**	**Unit**	**IndType**	**Bad**	**ModGood**	**High**	**Obs**	**ConfA**	**ConfT**	**ConfS**	**ConfM**
23	127	Bay of Mecklenburg - open sea	Zoo b	ER	1	0	0.5	1	0.41	h	h	h	h
27	127	Eastern Gotland Basin - open sea	Zoo b	ER	1	0	0.5	1	0.66	h	h	l	i
28	127	Western Gotland Basin - open sea	Zoo b	ER	1	0	4	10.9	4.47	i	h	l	h
29	127	Gulf of Riga - open sea	Zoo b	ER	1	0	0.5	1	0.55	i	h	h	i
etc	…	…	…	…	…	…	…	…	…	…	…	…	…

3.4 ASSESSMENT STRUCTURE BY ECOSYSTEM COMPONENT

Benthic habitats

Benthic habitats in the open sea were assessed using the core indicators 'State of the soft-bottom macrofauna community' and 'Oxygen debt' (see Chapter 2.1).

The 'State of the soft-bottom macrofauna community[11]' indicator was not included for the Kattegat, Great Belt, Sound, Gdansk Basin, Kiel Bay, Bornholm Basin and Arkona Basin, due to lack of threshold values. The indicator and some of its associated threshold values are still being tested in some countries and may be further developed in HELCOM as a result of the outcome of the testing, or the results may show that the indicator is not suitable for use in a specific sub-basin. The indicator has been agreed to be tested in this assessment.

The 'Oxygen debt' indicator is not applicable in the southern assessment units from the Kattegat to the Arkona Basin, in the Gulf of Riga, or in the Quark. It was not included in the Bothnian Sea or the Bothnian Bay as these basins do not suffer from hypoxia.

Coastal areas were assessed by national indicators representing water transparency ('Secchi depth') and oxygen conditions ('Oxygen'), as well as the status of macrophytes and macrozoobenthos' (See table 2).

The indicators representing benthic habitats were assessed at assessment level 4, which is the most detailed HELCOM spatial scale for results in coastal areas. The assessment structure is shown in table 7.

Table 7. Assessment structure for benthic habitats, showing indicators included and the weights applied for each integration level. For details on the included indicators, see text and Table 2.

Indicator used in BEAT	Core/WFD	Weight	Integrated level
Open sea areas			
State of the soft-bottom macrofauna community	Core	0.5	Open sea benthic
Oxygen debt	Core	0.5	
Coastal areas			
Macrofauna indices	national	0.25	Coastal benthic
Oxygen concentration	national	0.25	
Macrophytes	national	0.25	
Secchi depth	national	0.25	

[11] Included as test indicator

Pelagic habitats

Pelagic habitats were assessed by the biodiversity core indicator, the 'Zooplankton mean size and total stock'[12], and by the eutrophication core indicators 'Chlorophyll-a' and 'Cyanobacterial bloom index'[13] (see Chapter 2.2).

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. The indicator is assessed using Scale 2 HELCOM assessment units, which cover both coastal and open sea areas, but it was applied only in the open sea at this assessment.

The 'Chlorophyll-a' indicator was assessed in all areas, except for the Sound at this time. The 'Cyanobacterial bloom index' is a pre-core indicator agreed to be included as a test indicator in this assessment. Its threshold values are yet to be commonly agreed in HELCOM. It is not applicable to the Kattegat, Great Belt, Sound, Kiel Bay, Åland Sea, Quark or Bothnian Bay. Coastal areas were assessed by national indicators '**Chlorophyll-a' and 'Phytoplankton biovolume'.**

Pelagic habitats were assessed at assessment level 4, which is the most detailed HELCOM spatial scale for results in coastal areas. The assessment structure is shown in table 8.

Table 8. Assessment structure for pelagic habitats, showing indicators included and the weights applied for each integration level. For details on the included indicators, see text and Tables 1, 2.

Indicator used in BEAT	**Core/national**	**Weight**	**Integrated level 1**
Open sea areas			
Zooplankton mean size and total stock	Core	0.33	Open sea pelagic
Chlorophyll a	Core	0.33	
Cyanobacterial blooms	Core	0.33	
Coastal areas			
Chl a	national	0.5	Coastal pelagic
Phytoplankton biovolume	national	0.5	

Fish

Fish in the open sea were assessed based on information from ICES on the status of commercial fish and coastal areas based on HELCOM core indicators (See Chapter 2.3).

For the open sea, indicators representing the 'Spawning stock biomass' and level of 'Fishing mortality' were included for those stocks where assessment results were available by April 2017. The result for the indicator out of these two

[12][12] Included as test indicator
[13][13] Included as test indicator

which showed the worst status was used in the integrated assessment, separately for each assessed stock. The following species were included: sprat (assessment applicable to all parts of the Baltic Sea), herring (available for all areas except the Bothnian Bay, separated on different stocks), plaice (assessment applicable to the Sound and Belt Sea areas), cod and sole (available for the Western Baltic Sea corresponding to ICES sub-divisions 22-24). Input data for the integrated assessment was derived as explained in Annex 1.

The results for commercial fish are used as interim information for those stocks where information is available. The ICES advice to be used in the final version of the State of the Baltic Sea report is expected to cover additional stocks and data until 2016.

In coastal areas the core indicators 'Abundance of key coastal fish species' and 'Abundance of coastal fish key functional groups' were used. The latter indicators is composed of two components, the functional groups 'Abundance of piscivores' and 'Abundance of cyprinids or mesopredatory fish', which were included as separate indicators in BEAT. Data for the assessment of the 'Abundance of key coastal fish species' was available for 21 of the 47 coastal assessment units at scale 3. For the indicator 'Abundance of coastal fish key functional groups' data was available for 16 assessment units

Coastal fish were assessed at assessment level 3, and open sea fish were assessed using the spatial delineation of subdivisions used by ICES, in alignment how those results were provided (see map in Annex 1). The assessment structure is shown in table 9.

Table 9. Assessment structure for fish, showing indicators included and the weights applied for each integration level. For details, see text. For details on the included indicators, see text and Table 2.

Indicator used in BEAT	**Weight1**	**Integrated level 1**	**Weight2**	**Integrated level 2**
Open sea				
Herring	0.25	Pelagic fish	0.5	Open sea fish
Sprat	0.25			
Cod	0.167	Demersal fish	0.5	
Plaice	0.167			
Sole	0.167			
Coastal areas				
Abundance of key coastal fish species –perch	0.25	Abundance of key coastal fish species	0.5	Coastal fish
Abundance of key coastal fish species - flounder	0.25			
Abundance of coastal fish key functional groups-cyprinids/mesopredators	0.25	Abundance of coastal fish key functional groups	0.5	
Abundance of coastal fish key functional groups-piscivores	0.25			

Marine mammals

The status of seals were assessed using the indicators 'Population trends and abundance of seals', 'Distribution of Baltic seals' and for grey seals additionally the 'Nutritional status of seals' and 'Reproductive status of seals' (See Chapter 2.4).

Marine mammals were assessed at the first step by integrating the indicator results to the species level using the one-out-all-out principle. Hence, the integrated result at species level shows the status according to the indicator with the lowest biological quality ratio in that assessment unit. The indicators 'Population trends and abundance of seals' and 'Distribution of Baltic seals' were assessed using several parameters and follow the approach for conditional indicators. That is, all parameters were included in the tool but only the parameter with the lowest BQR value was used in the integration. All assessed parameters are included in the indicator count in the output (see table 17).

In the second step, the integrated assessment at the level of marine mammals (seals) was also done following the one-out-all-out principle. Hence, the integrated result in each assessment unit shows the status for the seal species showing the lowest biological quality ratio in that unit.

Marine mammals were assessed at assessment level 3. The assessment structure is shown in table 10.

Table 10. Assessment structure for seals, showing indicators included and the weights applied for each integration level. For details on the included indicators, see text and Table 2. OAOO="one-out-all-out"

Indicator used in BEAT	**Integrated level 1**	**Integrated level 2**
Grey seal		Seals (OAOO)
Population trends and abundance of seals	Grey seals (OAOO)	
Nutritional status of seals[14]		
Reproductive status of seals[15]		
Distribution of Baltic seals		
Ringed seal		
Population trends and abundance of seals	Ringed seal (OAOO)	
Distribution of Baltic seals		
Harbour seal		
Population trends and abundance of seals	Harbour seal (OAOO)	
Distribution of Baltic seals		

Waterbirds

Sea birds were assessed by the core indicators 'Abundance of waterbirds in the breeding season' and 'Abundance of waterbirds in the wintering season' (See Chapter 2.5).

Waterbirds were assessed at assessment level 1, which is the whole Baltic Sea. The assessment structure is shown in table 11.

Table 11. Assessment structure for waterbirds, showing indicators included and the weights applied for each integration level. For details, see text

Indicator used in BEAT	**Weight1**	**Integrated level 1**
Abundance of waterbirds in the breeding season	0.5	Waterbirds
Abundance of waterbirds in the wintering season'	0.5	

[14] Note that nutritional status of seals is consider as a demographic characteristic and is thus a secondary criterion (D1C3) according to the draft revision of the European Commission Decision on GES criteria.
[15] Note that reproductive status of seals is consider as a demographic characteristic and is thus a secondary criterion (D1C3) according to the draft revision of the European Commission Decision on GES criteria.

3.5 OUTPUTS FROM THE BEAT TOOL

The BEAT tool generates output tables for the integrated assessment and confidence assessment separately. In both tables, the results for each assessment unit and ecosystem component level are given as one row. The results output gives the integrated BQR score per ecosystem component level and also for relevant MSFD criteria. The integrated confidence output follows the same structure. BEAT also generates tables with the number of indicators included in each assessment unit and calculated BQR values and confidence for indicators used. When presenting the results in maps, the resulting integrated scores are classified into status categories as outlined in table 12.

Table 12. Result categories of the integrated biodiversity assessment.

	BQR score	**Integrated status category**
BQR score equal to or above 0.6	0.8-1.0	Good – Highest score
	0.6-0.8	Good – High score
BQR score less than 0.6	0.4-0.8	Not Good – Low score
	0.2-0.4	Not Good – Lower score
	0-0.2	Not Good – Lowest score

3.6 DATA SOURCES

The integrated biodiversity status is assessed based on the HELCOM core indicator evaluations, and more detailed descriptions of the data sources are found in each of the core indicator reports. For additional indicators, other than the core indicators, only data that has been approved at national level have been included. A summary of the data sources is given below. The data used in the current assessment gives results for the years 2011-2015. Data for the year 2016 is expected to be added by the time of release of the final version of the State of the Baltic Sea report[16].

It should be noted that reporting of biodiversity data to HELCOM COMBINE database has not been complete in the past years, and additional data collection and manual processing to harmonize data has been required for the assessment.

Phytoplankton and zooplankton data reporting have encountered taxonomical problems when the reported data has been extracted for use in indicators.

Biodiversity data not falling under the COMBINE programme have been collected within specific HELCOM Expert Groups/indicator leads for the purposes of the second holistic assessment, or by *ad-hoc* data calls. The coverage of data stemming from these data collection activities (outside of COMBINE) has not been complete, and there may exist restrictions to data use for this kind of data, preventing open access of the complete underlying indicator dataset.

Benthic habitats

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.

Pelagic habitats

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.

Fish

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.

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[16] See also document 3MA-2 to State and Conservation 6-2017

Marine mammals

Seal abundance data has also been collected into a common database in the BalticBOOST project. For the indicators '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.

Waterbirds

Waterbird count data have been reported nationally and stored to a HELCOM database also developed in BalticBOOST project.

Eutrophication core indicators

For the eutrophication core indicators used in this assessment, data are calculated in the Eutrophication assessment workspace.

Indicators for open sea areas are calculated based on data from the COMBINE database and supplemented with Russian data from the Gulf of Finland year project. The indicators are calculated directly from the assessment database in Eutrophication workspace.

Coastal indicator results have been 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).

Chapter 4. Results

4.1 INTEGRATED ASSESSMENT RESULT FOR BENTHIC HABITATS

Based on the assessed indicators, good status of benthic habitats was achieved in five of the twelve open sea assessment units that were assessed, reflecting only the status of soft-bottom habitats.

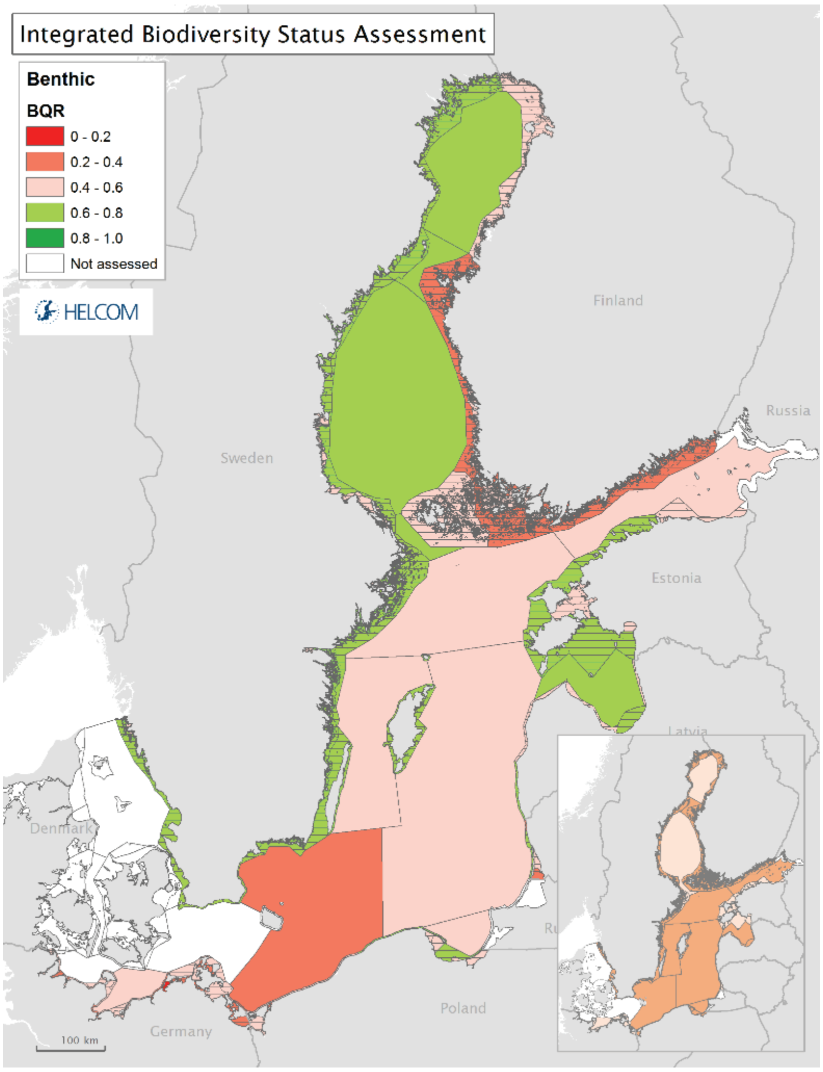
Not good status was observed in the Bay of Mecklenburg (which was assessed with the core indicator 'State of the soft-bottom macrofauna community[17]') and in all assessment units where the core indicator 'Oxygen debt' was included (Figure 4). Long term data show that the oxygen debt below the halocline has increased over the past century in the Baltic Proper, and also in the Bornholm Basin (see 'State of the Baltic Sea report, Chapters 5.1 and 4.1). The indicator 'State of the soft-bottom macrofauna community' achieved the threshold value in most assessed areas, indicating good status in these cases (Figure 4). This indicator is only applied above the halocline in those assessment units where a permanent halocline exists.

Although a high share of the total Baltic Sea area was covered by the assessment, both core indicators had only partial coverage. The Bornholm Basin and the Gdansk Basin were only assessed with the core indicator 'Oxygen debt', since threshold values for the 'State of the softbottom macrofauna community' have not been agreed yet for these basins. Open sea areas in the Kattegat, the Sound, the Belt Seas and Arkona Basin were not assessed by any indicator due to lack of thresholds values for these assessment units.

Coastal areas had good integrated status in around half of the assessed area, measured by area covered (or in 58 out of 199 assessed units, Figure 5).

The confidence in the assessment varied between intermediate and high in both coastal and open sea areas, after a penalty was applied (see Table 5).

[17] Included as a test indicator.



	Soft bottom macrofauna community	Oxygen debt
Kattegat		
Great Belt		
The Sound		
Kiel Bay[18]		
Bay of Mecklenburg		
Arkona Basin		
Bornholm Basin		
Gdansk Basin		
Eastern Gotland Basin		
Western Gotland Basin		
Gulf of Riga		
Northern Baltic Proper		
Gulf of Finland		
Åland Sea		
Bothnian Sea		
The Quark		
Bothnian Bay		

Figure 4. Integrated biodiversity status assessment for benthic habitats using the BEAT tool[19]. Status is shown in five categories based on the integrated assessment scores obtained in the tool. Biological Quality Ratios (BQR) above 0.6 correspond to good status. The assessment in open sea areas was based on the core indicators 'State of the soft-bottom macrofauna community'[20] and 'Oxygen debt'. Coastal areas were assessed by national indicators, and may hence not be directly comparable with each other (striped areas in the map). The confidence assessment is shown in the smaller map, darker shaded areas indicating areas with lower confidence[21]. The table to the right shows which core indicators were included in each open sea assessment unit, and the corresponding core indicator results. Green denotes good status and red not good status. White cells denote areas not assessed by that indicator.

[18] Data foreseen by end of 2017.
[19] Results for coastal waters in Estonia may be subject to change.
[20] Included as a test indicator.
[21] Confidence has been lowered by one step compared to the BEAT output in open sea sub-basins only assessed by the eutrophication core indicator 'Oxygen debt'.

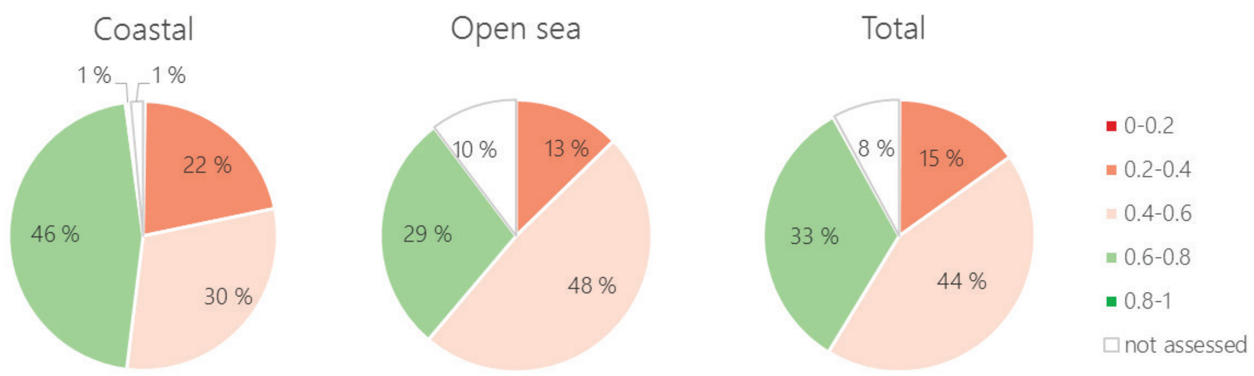


Figure 5 Summary of the integrated assessment result for benthic habitats, showing the proportion of the Baltic Sea area within five categories, based on km^2. The categories are based on the obtained biological quality ratios (BQR scores) as shown in the legend. Scores above 0.6 correspond to good status. The white sector represents not assessed areas, and includes areas not assessed due to the lack of indicators or data, and all Danish coastal areas. The category representing best status (highest value) was not obtained in any area.

An extract on the BEAT output for the assessment of open sea benthic habitats is shown in Table 14. The corresponding results for coastal areas are shown in Annex 4.

Table 13. Output from the integrated assessment of benthic habitats. The confidence was lowered in the assessment units assessed without any biodiversity core indicators (marked *).

Spatial assessment unit	**BQR**	**Confidence**	**Number of indicators**	**% of area assessed**
Bay of Mecklenburg - open sea	0.49	high	1	0.8
Bornholm Basin - open sea	0.31	intermediate*	1	9.3
Gdansk Basin - open sea	0.40	intermediate*	1	0.9
Eastern Gotland Basin - open sea	0.56	Intermediate	2	17.0
Western Gotland Basin - open sea	0.51	intermediate	2	5.3
Gulf of Riga - open sea	0.64	intermediate	1	2.1
Northern Baltic Proper - open sea	0.55	intermediate	2	7.6
Gulf of Finland - open sea	0.51	intermediate	2	4.0
Åland Sea - open sea	0.75	high	1	0.5
Bothnian Sea - open sea	0.71	high	1	11.9
The Quark - open sea	0.70	intermediate	1	0.7
Bothnian Bay - open sea	0.79	high	1	5.1

4.2 INTEGRATED ASSESSMENT RESULTS FOR PELAGIC HABITATS

Good status was not achieved in any open sea sub-basin, with the exception of Kattegat (Figure 6). The integrated results reflect a deteriorated status according to all assessed core indicators in most cases.

The indicator 'Cyanobacterial bloom index'[22] did not achieve the threshold value in any of the open sea sub-basins where it was assessed. Based on satellite data, the frequency and coverage of cyanobacterial blooms have oscillated since the 1970s (Kahru and Elmgren 2014). The total area of cyanobacterial accumulations has been above the earlier values since 1999.

The core indicator 'Chlorophyll-a' achieved the threshold value only in the Kattegat. It showed particularly deteriorated status in the Bornholm Basin, Northern Baltic Proper and Gulf of Finland. Chlorophyll-a concentrations have increased since the 1970s in most sub-basins east of the Bornholm Basin, but the increase has levelled off since the late 1990s. In the Kattegat and Danish Straits the chlorophyll-a concentrations have decreased since late 1980s.

The zooplankton community indicator achieved the threshold value in the Bothnian Bay and Bothnian Sea, but not in the Åland Sea, Northern Baltic Proper or Gulf of Finland[23]. In the Northern Baltic Proper, both the zooplankton mean size and the biomass have decreased from the 1970s to the present (see also the figure in box 2.2).

Coastal areas showed higher variability, with the results of integrated assessment indicating good status in 24 out of 114 assessed coastal areas, corresponding to 19% of the area of the Baltic Sea region (Figure 7).

The confidence in the assessment was between moderate and high in the open sea and low in coastal areas.

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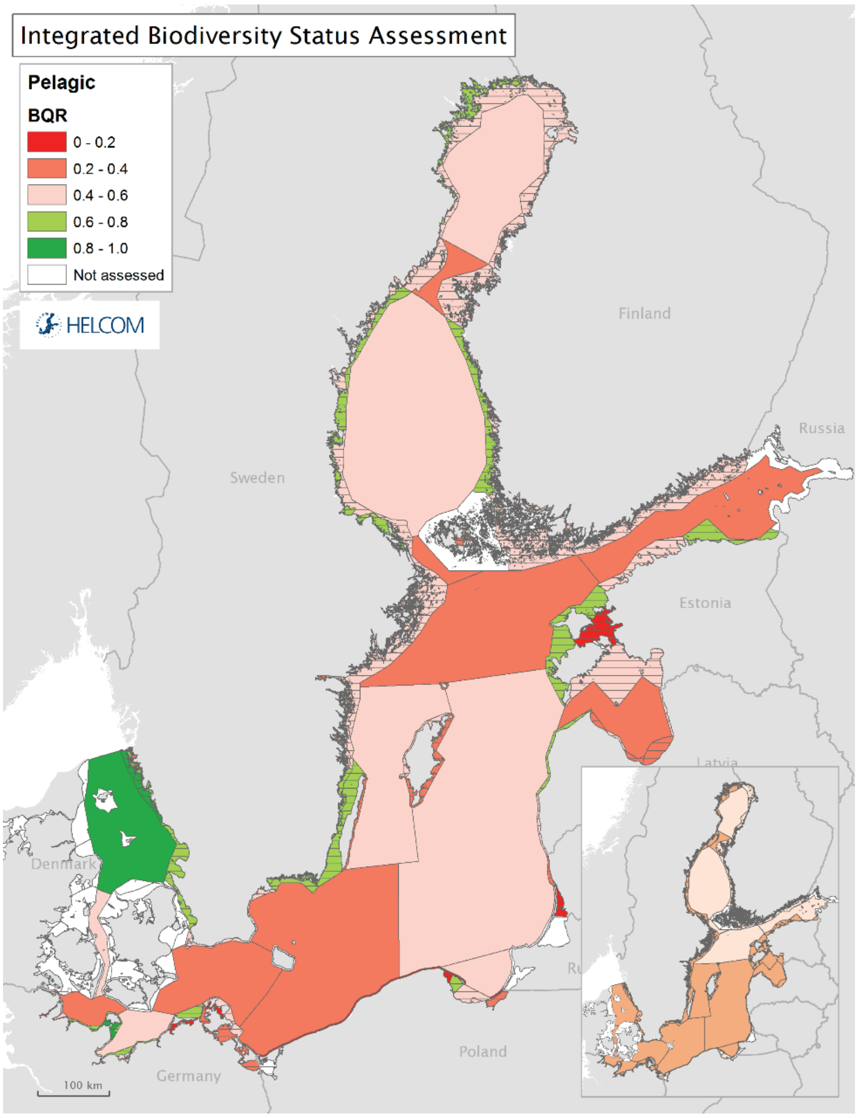
[22] Included as a test indicator.

[23] This result refers to assessment outcome at core indicator level, where the core indicator 'Zooplankton mean size and total stock' is assessed at spatial assessment unit level 2. In the integrated assessment, the zooplankton indicator was only included in the assessment of open sea at this time.



	Cyanobacterial bloom index	Chlorophyll-a	Zooplankton
Kattegat			
Great Belt			
The Sound			
Kiel Bay			
Bay of Mecklenburg			
Arkona Basin			
Bornholm Basin			
Gdansk Basin			
Eastern Gotland Basin			
Western Gotland Basin			
Gulf of Riga			
Northern Baltic Proper			
Gulf of Finland			
Åland Sea			
Bothnian Sea			
The Quark			
Bothnian Bay			

Figure 6. Integrated biodiversity status assessment for pelagic habitats[24]. Status is shown in five categories based on the integrated assessment scores obtained in the tool. Biological Quality ratios (BQR) above 0.6 correspond to good status. The assessment in open sea areas was based on the indicator Cyanobacterial bloom index'[25], and by the core indicators 'Chlorophyll-a', and 'Zooplankton mean size and total stock' in the open sea. Coastal areas were assessed by national indicators. The confidence assessment is shown in the smaller map, darker shaded areas indicating areas with lower confidence[26]. The table to the right shows which core indicators were included in each open sea assessment unit, and the corresponding core indicator results. Green denotes good status and red denotes not good status. White cells denote areas not assessed by that indicator.

[24] Results for coastal waters may be subject to change.

[25] Included as a test indicator.

[26] Confidence has been lowered by one step compared to the BEAT output in open sea sub-basins only assessed by eutrophication indicators: the indicator 'Cyanobacterial bloom index' (included as a test indicator), and/or the core indicator 'Chlorophyll-a'.

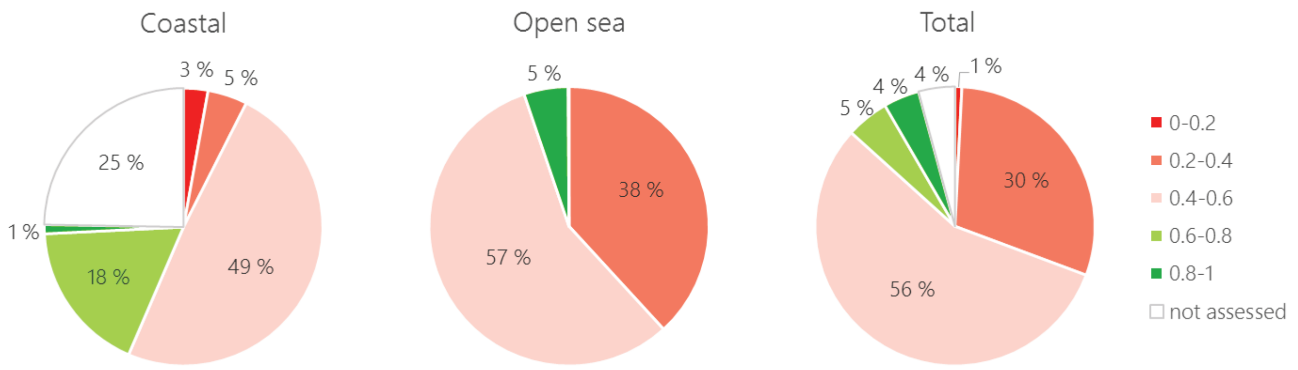


Figure 7. Summary of the integrated assessment result for pelagic habitats, showing the proportion of the Baltic Sea area within five categories, based on km^2. The categories are based on the obtained biological quality ratios (BQR scores) as explained in the legend. Scores above 0.6 correspond to good status. The white sector represents not assessed areas, and includes areas not assessed due to the lack of indicators or data, and all Danish coastal areas.

An extract on the BEAT output for the assessment of open sea pelagic habitats is shown in Table 14. The corresponding results for coastal areas are shown in Annex 5.

Table 14. Output from the integrated assessment of pelagic habitats. Confidence was generally assessed as high at indicator level but was lowered by one step in areas not assessed by any biodiversity core indicator (marked *).

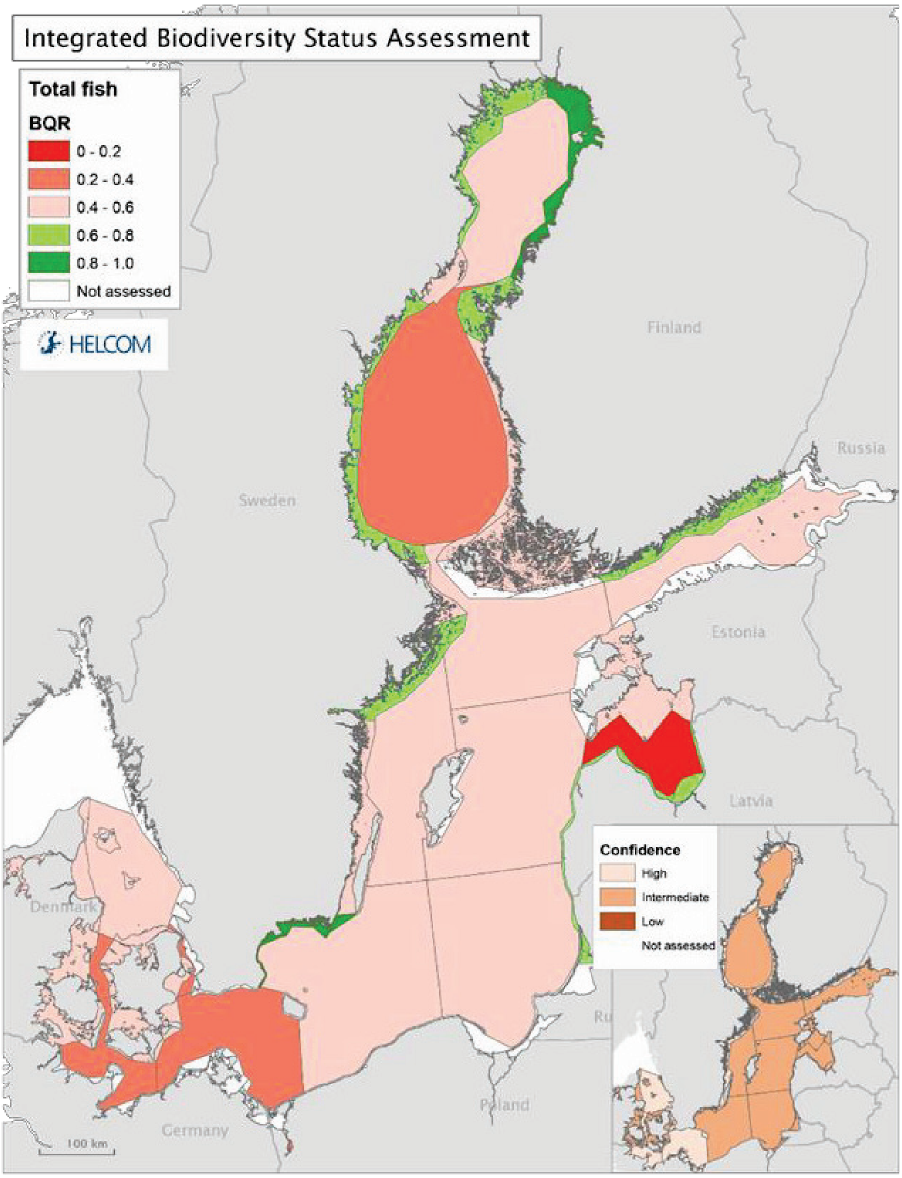
Spatial assessment unit	BQR	Confidence	Number of indicators	% of area assessed
Kattegat - open sea	1	Intermediate*	1	3.9
Great Belt - open sea	0.45	Intermediate*	1	0.5
Kiel Bay - open sea	0.37	Intermediate*	1	0.7
Bay of Mecklenburg - open sea	0.44	Intermediate*	2	0.9
Arkona Basin - open sea	0.34	Intermediate*	2	3.3
Bornholm Basin - open sea	0.39	Intermediate*	2	9.5
Gdansk Basin - open sea	0.4	Intermediate*	2	0.9
Eastern Gotland Basin - open sea	0.44	Intermediate*	2	17.4
Western Gotland Basin - open sea	0.44	Intermediate*	2	5.4
Gulf of Riga - open sea	0.37	Intermediate*	2	2.1
Northern Baltic Proper - open sea	0.34	High	4	7.8
Gulf of Finland - open sea	0.37	High	4	4.1
Åland Sea - open sea	0.28	High	3	0.5
Bothnian Sea - open sea	0.52	High	4	12.2
The Quark - open sea	0.34	Intermediate*	1	0.7
Bothnian Bay - open sea	0.54	High	3	5.2

4.3 INTEGRATED ASSESSMENT RESULTS FOR FISH

The integrated status of coastal fish was good in about half of the twenty-one assessed coastal areas (Figure 8). The assessment covered around 75% of the coastal area of the region, but the density of monitoring sites within each assessment unit was low.

The integrated status in the open sea was assessed as not good for both pelagic and demersal fish. Demersal fish were only included for the southern Baltic Sea. Separate results for each fish stock are given in Annex 1.

The assessment results for additional commercial fish stocks, including also demersal fish in the eastern parts of the Baltic Sea, are foreseen to be included in the updated assessment of June 2018.



ICES SD	BQR score	
	Demersal	Pelagic
21	0.43	0.45
22	0.33	0.30
23	0.33	0.30
24	0.15	0.30
25		0.53
26		0.53
27		0.53
28		0.53
28.1		0.30
29		0.53
30		0.43
31		0.15
32		0.53

Figure 8. Integrated biodiversity status assessment for fish. Status is shown in five categories based on the integrated assessment scores obtained in the BEAT tool. Biological Quality ratios (BQR) above 0.6 correspond to good status. The assessment is based on core indicators of coastal fish in coastal areas, and on internationally assessed commercial fish in the open sea. The open sea assessment includes fishing mortality and spawning stock biomass as an average over 2011–2015. These results are given by ICES subdivisions, and are not shown where they overlap with coastal areas. The assessment of commercial fish is

provisional. It does not comply with the multiannual plans and needs to be developed further for the next assessment period. The table to the right shows the corresponding integrated results separately for pelagic and demersal commercial fish by the same colors as in the map legend. Results for each stock are presented in Annex 1. The confidence assessment is shown

An extract on the BEAT output for the assessment of coastal fish is shown in Table 14 and for open sea areas in Table 15.

Table 15. Output from the integrated assessment of costal fish. In areas marked * the number of indicators is 4 because the indicator on key species was assessed both for perch and flounder.

Spatial assessment unit	BQR	Confidence	Number of indicators	% of coastal area assessed
Bothnian Bay Finnish Coastal waters	0.83	High	3	5.0
Bothnian Bay Swedish Coastal waters	0.70	High	3	4.8
The Quark Finnish Coastal waters	0.62	High	3	3.1
The Quark Swedish Coastal waters	0.45	High	3	1.7
Bothnian Sea Finnish Coastal waters	0.52	High	3	3.8
Bothnian Sea Swedish Coastal waters	0.70	High	3	5.6
Åland Sea Swedish Coastal waters	0.52	Intermediate	3	1.5
Archipelago Sea Coastal waters	0.52	High	3	9.5
Northern Baltic Proper Swedish Coastal waters	0.70	High	4*	4.4
Gulf of Finland Finnish Coastal waters	0.68	High	3	5.1
Gulf of Riga Estonian Coastal waters	0.45	Intermediate	3	7.5
Gulf of Riga Latvian Coastal waters	0.62	Intermediate	3	1.6
Western Gotland Basin Swedish Coastal waters	0.51	High	4′	5.1
Eastern Gotland Basin Latvian Coastal waters	0.75	Intermediate	3	0.5
Eastern Gotland Basin Lithuanian Coastal waters	0.70	Intermediate	4*	0.6
Bornholm Basin Swedish Coastal waters	0.83	Intermediate	3	1.4
Arkona Basin Danish Coastal waters	0.45	Intermediate	1	1.6
Mecklenburg Bight Danish Coastal waters	0.45	Intermediate	1	0.3
Belts Danish Coastal waters	0.45	Intermediate	1	7.9
The Sound Danish Coastal waters	0.45	Intermediate	1	0.3
Kattegat Danish Coastal waters, including Limfjorden	0.45	Intermediate	1	5.2

Table 16. Output from the integrated assessment of open sea fish. The spatial assessment units are the ICES subdivisions, see figure in Annex 1. The confidence in the assessment of open sea fish was generally assessed as high at indicator level, but the confidence in the overall assessment was lowered by one step for subdivisions lacking an assessment of demersal fish (marked *).

Spatial assessment unit	BQR	Confidence	Number of indicators	% of area assessed
21	0.44	High	3	
22	0.32	High	5	4.5
23	0.32	High	5	0.6
24	0.22	High	4	6.1
25	0.53	Intermediate*	2	11.1
26	0.53	Intermediate*	2	10.4
27	0.53	Intermediate*	2	7.7
28_2	0.53	Intermediate*	2	10.0
28_1	0.15	Intermediate*	2	4.1
29	0.53	Intermediate*	2	12.1
30	0.30	Intermediate*	2	16.4
31	0.53	Intermediate*	1	9.1
32	0.43	Intermediate*	2	8.0

4.4 INTEGRATED ASSESSMENT RESULTS FOR SEALS

Seals are not in good status according to the integrated assessment, with exception of the Kattegat where only the harbour seal population was assessed (Figure 9). Good status would require all populations for all species to reach good status for all indicators. All four core indicators were used in the assessment, but those reflecting reproduction status and nutritional status are currently only applied to grey seals. The confidence in the assessment was higher for grey seals than for the other seal species due to the lack of indicators reflecting population conditions for harbour seals and ringed seals.

All three species of seal have also been evaluated under the EU Habitats Directive in 2013, where the assessment is bounded by national borders. The HELCOM assessment is carried out based on populations or sub-populations, which are equivalent to regionally agreed management units. Another difference is that evaluation is made against a modern or historic baseline under the Habitats Directive and against thresholds set to ensure future viability of the management unit in the HELCOM assessment (Härkönen *et al*. 2017). Due to these differences, the evaluation results may differ between the EU Habitats Directive and the HELCOM assessment.

The integrated assessment results at species level for the three seal species are presented below, as well as the integrated results separately for grey seal, harbour seal and ringed seal. More details to the results summarized below can also be found in the respective core indicator reports (see Table 1).

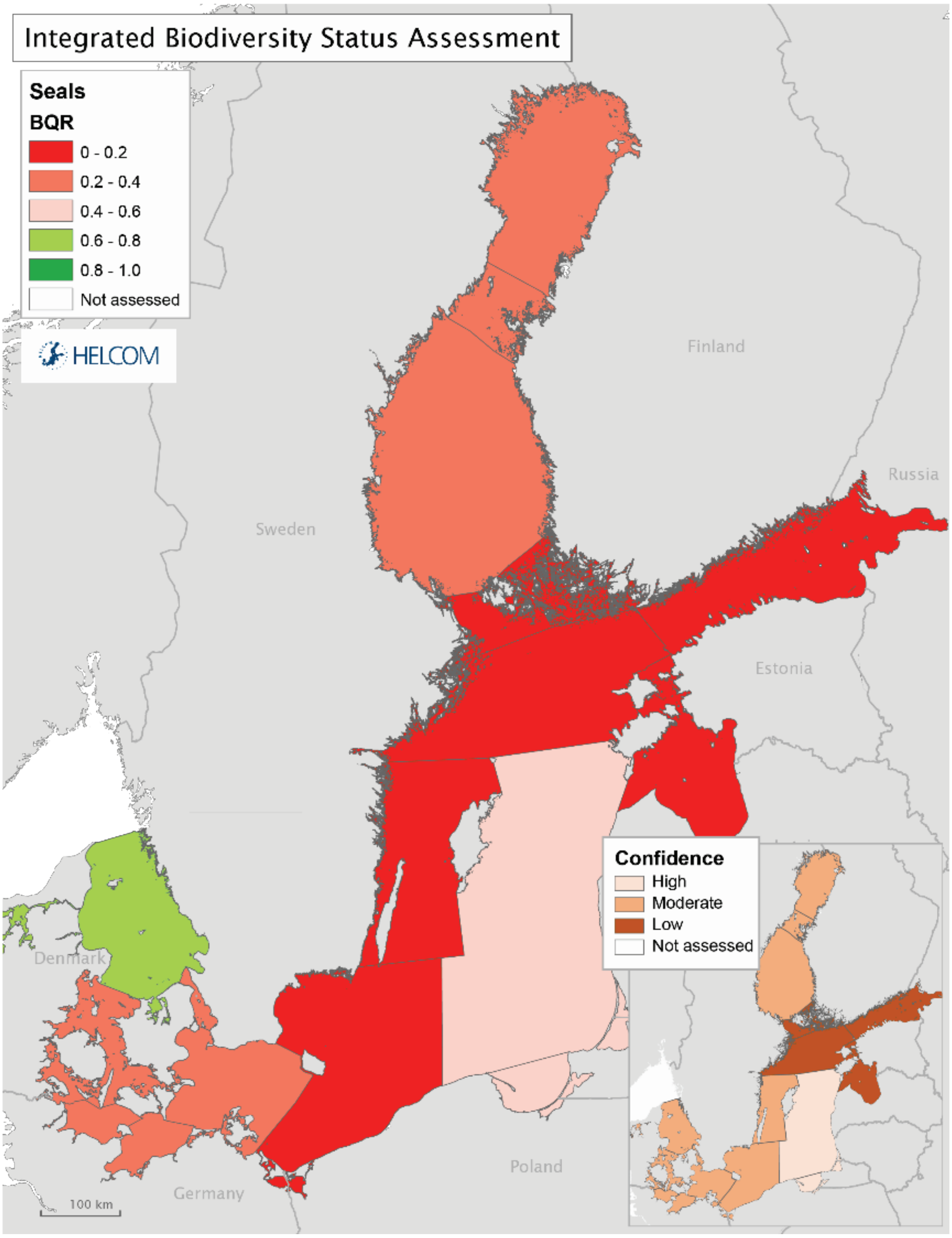


Figure 9. Integrated biodiversity status assessment for seals using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool. Biological Quality ratios (BQR) above 0.6 correspond to good status. Green denotes good status and red not good status. The assessment is based on the one-out-all-out approach. By this approach, the species reflecting the worst status determines the status in each assessment unit. The result for each assessment unit shows the status of the species furthest away from good status, see Figures 10-12). The confidence assessment is shown in the smaller map, with darker shaded areas indicating areas with lower confidence.

An extract on the BEAT output for the assessment of marine mammals is shown in Table 17.

Table 17. Output from the integrated assessment of marine mammals (seals). The number of indicators is higher than the number of core indicators since the indicators were assessed with many parameters, which were entered into the assessment tool individually. Where several parameters were assessed, the result for the parameter with the lowest score was used. A penalty was applied to the confidence in areas marked *, due to missing indicators on population condition for ringed seal and harbour seal.

Spatial assessment unit	BQR	Confidence	Number of indicators	% of area assessed
Kattegat	0.79	Intermediate*	5	5.7
Great Belt	0.30	Intermediate*	13	2.6
The Sound	0.30	Intermediate*	13	0.3
Kiel Bay	0.30	Intermediate*	13	0.8
Bay of Mecklenburg	0.30	Intermediate*	13	1.1
Arkona Basin	0.30	Intermediate*	13	4.2
Bornholm Basin	0.12	Intermediate*	13	10.1
Gdansk Basin	0.48	High	8	1.4
Eastern Gotland Basin	0.48	High	8	18.0
Western Gotland Basin	0.12	Intermediate*	13	6.6
Gulf of Riga	0.08	Low*	13	4.5
Northern Baltic Proper	0.08	Low*	13	9.5
Gulf of Finland	0.08	Low*	13	7.2
Åland Sea	0.08	Low*	13	3.9
Bothnian Sea	0.30	Intermediate*	13	14.4
The Quark	0.30	Intermediate*	13	2.0
Bothnian Bay	0.30	Intermediate*	13	7.7

Grey seal (Halichoerus grypus)

The number of grey seals counted in the whole Baltic Sea region in 2015 was 30 000 individuals, which is above the limit reference level of 10 000 individuals, and the population trend is assessed as being in good status. However the status of the grey seal in the overall assessment is not good (Figure 10). This is due to the inadequate reproductive and nutritional status, although the values in the assessment period are relatively close to the threshold values for the respective indicator. The reasons for the inadequate condition of the grey seal population have not yet been established.

All grey seals in the Baltic Sea belong to the same management unit and they forage across the entire Baltic Sea. However, their abundance varies between sub-basins; in 2015 about 22 000 grey seals were counted in the Gulf of Bothnia, Åland and Archipelago Seas (including Stockholm county), while counts along the Polish coast were only a few tens of animals. With regard to distribution, some known historic grey seal haul-outs in the southern Baltic Sea are not used, and some have vanished due to exploitation of sand, and according to the definition of the core indicator the distribution of grey seals is thus not achieving good status in the southwestern Baltic Sea.

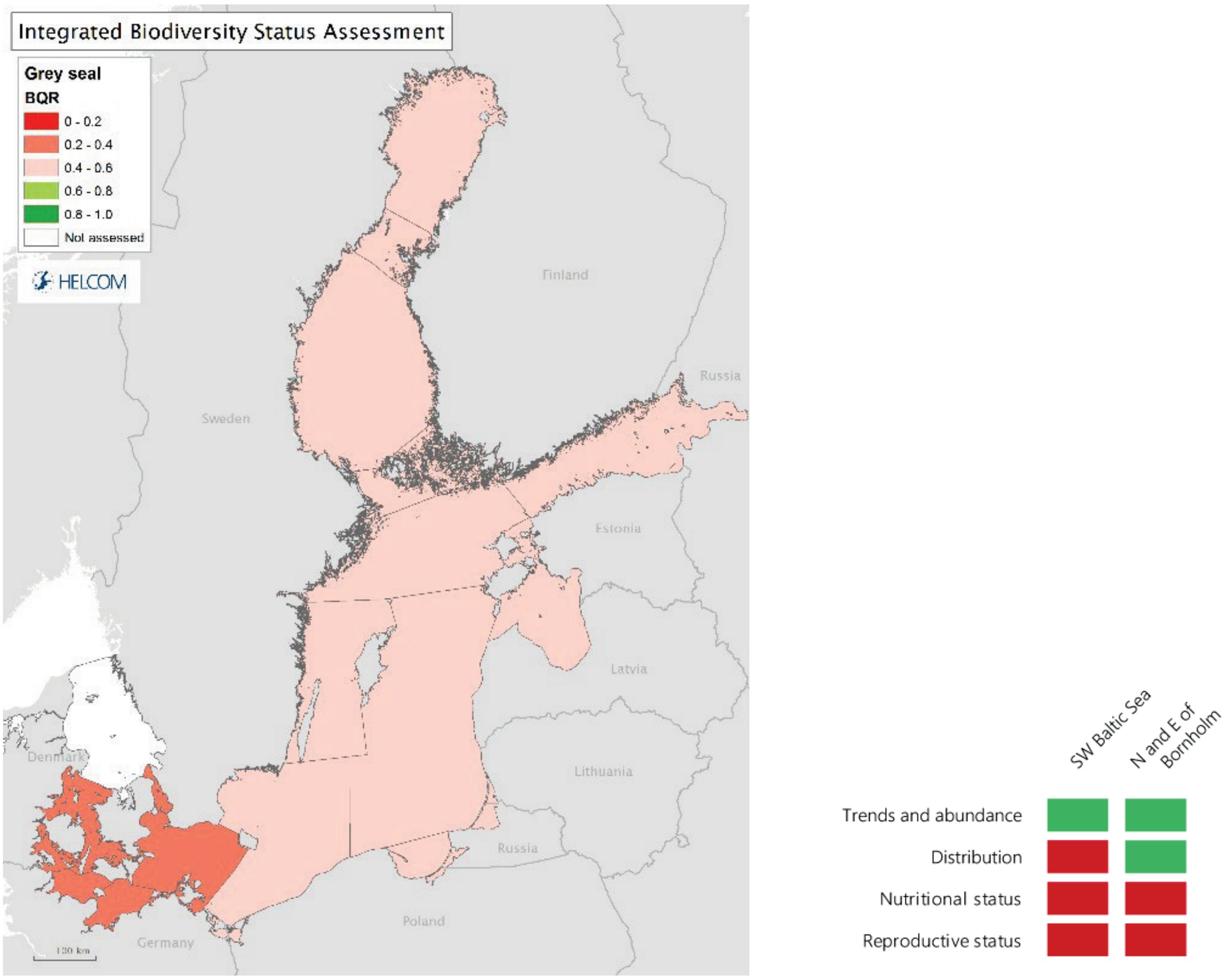


Figure 10. Integrated status of grey seal in the Baltic Sea using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool. The assessment is not applicable in the Kattegat (white area in the map). Biological Quality ratios (BQR) above 0.6 correspond to good status. The assessment is based on the one-out-all-out approach, meaning that the indicator reflecting the worst status determines the status of the species. All assessed grey seals belong the same management unit (Baltic Sea) however the assessment is carried out according to two units: the sub-basins east and north of Bornholm and the southwestern Baltic Sea (west of Bornholm). The table to the right shows core indicator results per management unit. Green denotes good status and red denotes not good status.

Harbour seal (*Phoca vitulina*)

Of the three management units of harbour seals in HELCOM area, only the Kattegat population shows good status (Figure 11).

The harbour seals in the southwestern Baltic and the Kattegat are connected and are assessed as one so called metapopulation with respect to abundance. However, they are assessed as separate sub-populations in terms of growth rate. The metapopulation was about 16 000 animals in 2015 and achieves the threshold value for abundance, but the sub-population in the southwestern Baltic does not achieve threshold value for growth rate. However growth rate is close to the threshold value. Hence, the core indicator on trends and abundance achieves good status in Kattegat but not in the southwestern Baltic Sea.

The Kalmarsund population is genetically divergent from the other populations of harbour seal. The population meets the threshold value for population growth rate, but the total abundance was still only about 1 100 seals in 2015. The Kalmarsund population is also categorised as vulnerable in the HELCOM Red List (HELCOM 2013a).

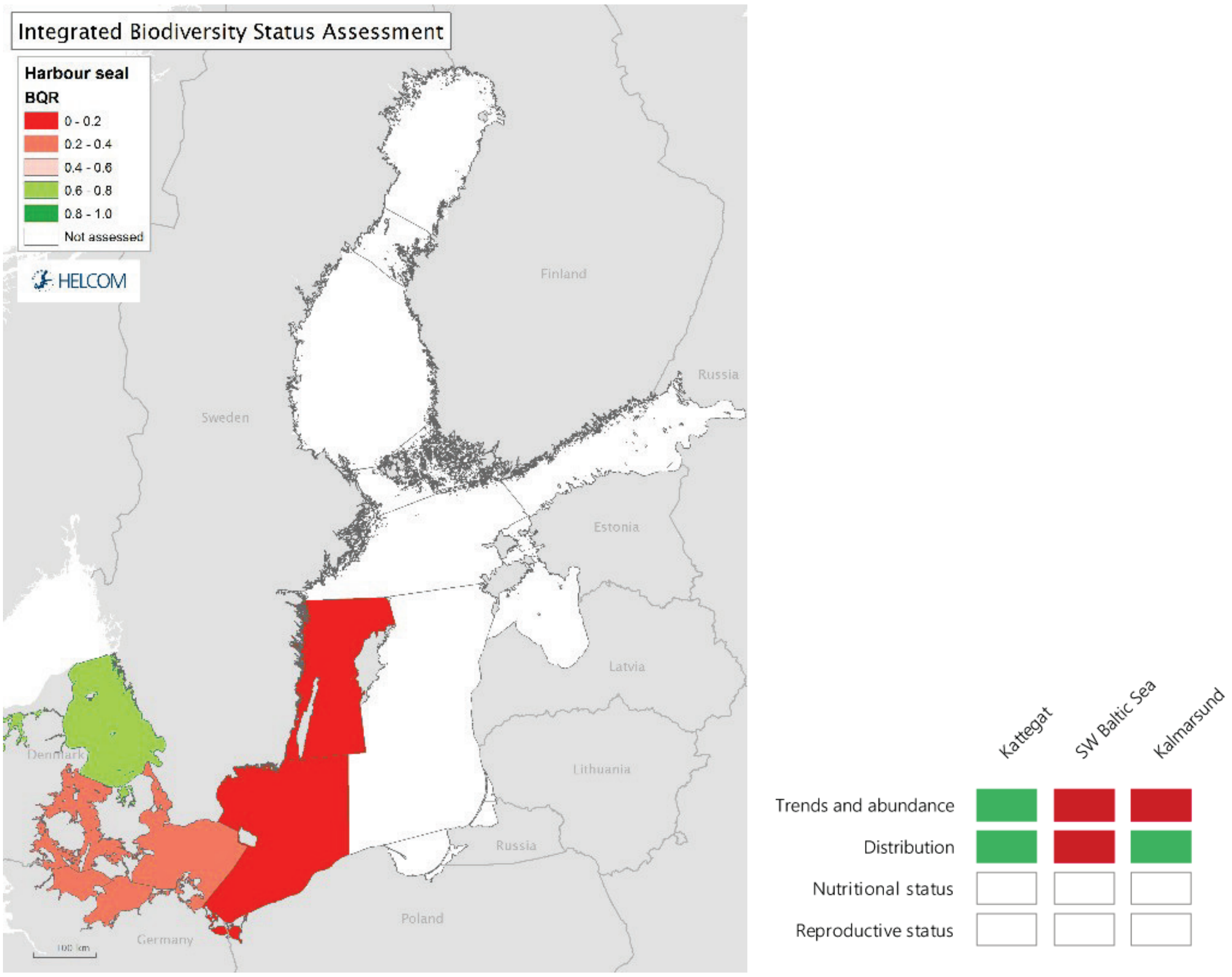


Figure 11. Integrated status of harbour seal in the Baltic Sea using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool, for those areas where the assessment is applicable. Biological Quality ratios (BQR) above 0.6 correspond to good status. The assessment is based on the one-out-all-out approach, meaning that the indicator reflecting the worst status determines the status of the species. The harbour seals belong to three different management units; the Kattegat, the southwestern Baltic Sea, and the small Kalmarsund population in the Western Gotland Basin, Bornholm Basin. The table to the right shows core indicator results for the different management units. Green denotes good status and red denotes not good status. White cells in the table denote areas not assessed due to lack of indicator.

Ringed seal (*Phoca hispida*)

The status of the ringed seal is not good (Figure 12). In areas where ringed seals occur, namely the Gulf of Bothnia, as well as the management units consisting of the Archipelago Sea, Gulf of Finland, Gulf of Riga and Estonian coastal waters, the distribution is restricted compared to pristine conditions. The size of the population is above the Limit Reference Level of 10 000 seals in the Gulf of Bothnia (where around 20 000 ringed seals reside), but the growth rate is below threshold values in both managements units. The status of the ringed seal population in the southern management unit is critical; the population is decreasing, and the eastern part of the Gulf of Finland has only around 100 animals.

Breeding distribution is confined to suitable breeding ice, that is; compact and very close pack ice where snow can accumulate, making the ringed seal particularly sensitive to climate change (Sundqvist *et al.* 2012). The ringed seal is categorised as vulnerable on the HELCOM Red List (HELCOM 2013a).

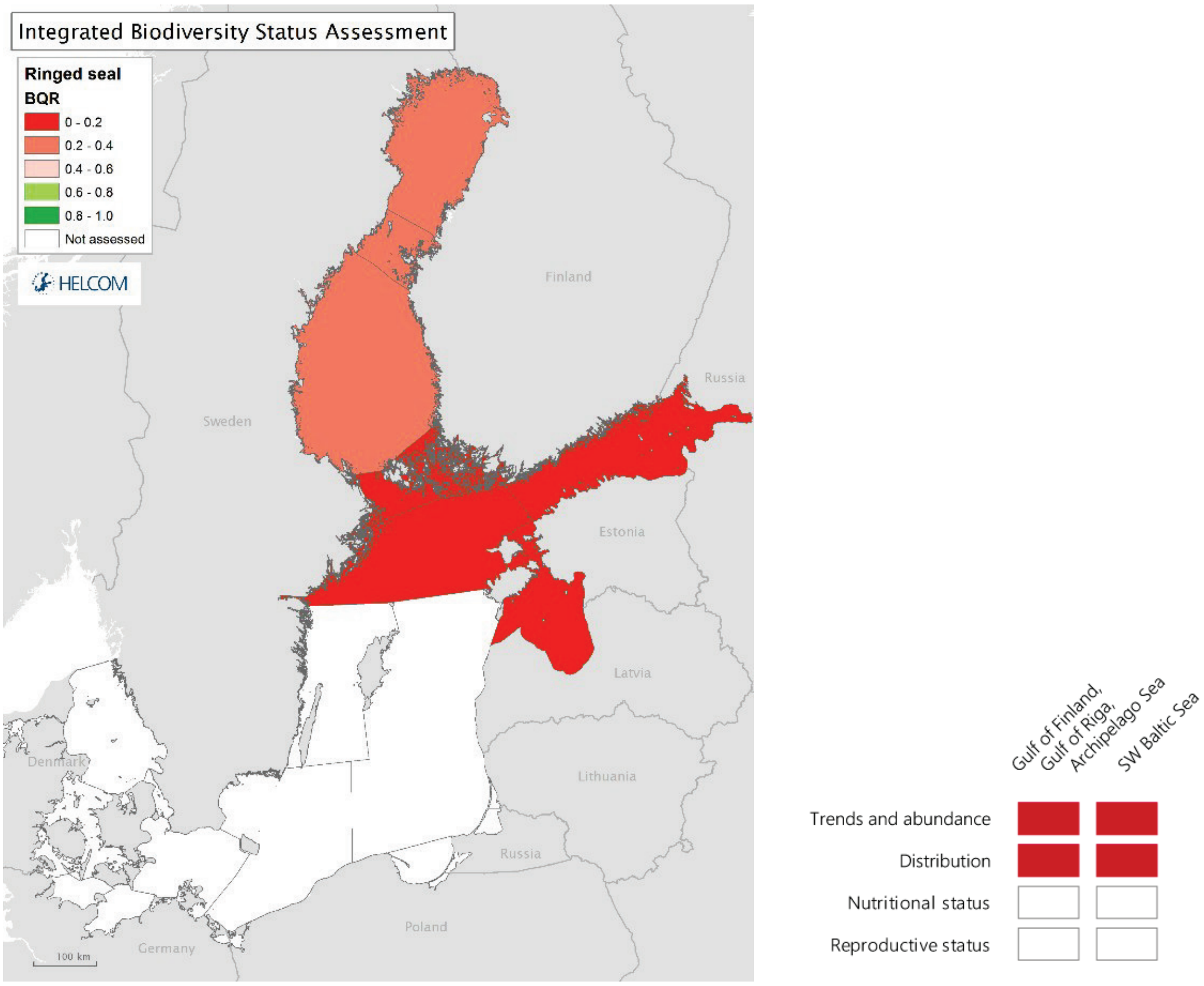


Figure 12. Integrated status of ringed seal in the Baltic Sea using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool, for those areas where the assessment is applicable. Biological Quality ratios (BQR) above 0.6 correspond to good status. The assessment is based on the one-out-all-out approach, meaning that the indicator reflecting the worst status determines the status of the species. The ringed seals belong to two different management units; Gulf of Bothnia and the Gulf of Finland populations. The table to the right shows core indicator results for the different management units. Green denotes good status and red denotes not good status. White cells in the table denote areas not assessed due to lack of indicator

4.5 INTEGRATED ASSESSMENT RESULTS FOR WATERBIRDS

None of the core indicators for waterbirds achieved good status, hence the overall integrated status was not good (Table 18). More specific results by species and species groups represented in each of these indicators are presented in the respective core indicators reports (see table 1) and in the 'State of the Baltic Sea' report.

Among the species group of birds breeding in the Baltic Sea, declines were seen in benthic feeders and surface feeders. Declines were also seen within the species group of wading birds, which was only assessed during the breeding season. Among the waterbirds wintering in the Baltic Sea, species with declined abundance belonged to the group of grazing feeders and benthic feeders.

Hence, the species group of benthic feeding birds did not achieve good status during the breeding nor the wintering season. Grazing feeders showed different results for the two seasons, achieving good status only in the breeding season, whereas surface feeders showed the opposite pattern, achieving good status only in the wintering season. Pelagic feeders as a group achieved good status in both seasons. Many pelagic feeders have increased since the 1990s.

Waterbird species with higher abundance during the assessment years compared to the baseline were the Arctic tern and the great cormorant (assessed during the breeding season), and the Slavonian grebe and smew (wintering season). Low abundances relative to the baseline were observed in common eider and great black-backed gull (assessed during the breeding season). Among the wintering birds, low abundances were seen in common pochard and clearly so in Steller's eider.

Importantly, the status of species mainly living in the open sea may not be appropriately represented, as information from monitoring in the open sea has not been included due to unresolved data issues. Hence, the core indicator results reflect the status of wintering waterbirds along the coastline. A considerable portion of the populations of Slavonian grebe, red- throated diver, black-throated diver, common eider, long-tailed duck, common scoter and velvet scoter, for example, stay in open sea areas over the winter and are therefore poorly represented in coastal counts.

Additional information is provided by the HELCOM Red List. In particular, inconsistencies are seen for the red-throated diver, long-tailed duck and velvet scoter in the Baltic Sea, which are classified as threatened in the HELCOM Red List due to strong declines (Skov *et al.* 2011, HELCOM 2013a). These declines are not reflected in the indicator results, which are only based on coastal counts.

Table 18. Output from the integrated assessment of waterbirds. The assessment was applied at the scale of the Baltic Sea, hence the assessment is given as one line in the BEAT output.

Spatial assessment unit	**BQR**	**Confidence**	**Number of indicators**	**% of area assessed**
Baltic Sea	0.56	Intermediate	2	100

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Annex 1. Details on the commercial fish indicators

Results for the assessment of commercial fish in the first version of the 'State of the Baltic Sea report - June 2017' are presented with respect to the indicators 'Fishing mortality' and 'Spawning stock biomass'. The assessments are made in relation to the reference points for maximum sustainable yield, using data as available by April 2017 (ICES 2016).

The stocks included are shown in table A1.1 below, which corresponds to the results for the assessment of commercial fish and fisheries in Chapter 4.6 of the State of the Baltic Sea report.

At the level of each stock, the indicator 'Fishing mortality' was assessed by comparison with the reference value 'F_{MSY}', which is the level of fishing mortality estimated to deliver the long term maximum sustainable yield. The indicator 'Spawning stock biomass' was assessed in relation to the associated reference value 'MSY B-trigger'. No assessment results were available for the age and size distribution.

The results are assessed based on the average results for the years 2011 to 2015[27], using reference values from 2015 as presented in ICES (2016), and are presented using the spatial delineation of subdivisions used by ICES (Figure A1.2).

The results were evaluated against the condition that the average assessment ratios for all included years should achieve a threshold value of 1 for both fishing mortality and spawning stock biomass. Based on this, three of the eight assessed stocks had too high a fishing mortality on average during 2011–2015, whereas five stocks were fished at level consistent with maximum sustainable yield. Spawning stock biomass was below the biomass reference point for three of the eight assessed stocks, indicating not good status (see also Figure A1.1 and Table A1.1) [28].

For stocks where sufficient data for analytical assessment are lacking, ICES provides fisheries advice based on trends in biomass and fishing pressure with no defined targets, applying the precautionary approach. The relative impact of fishing on biomass trends is not possible to evaluate in these cases, since the biomass is also influenced by factors other than fishing. ICES is currently introducing reference points for such data-limited stocks, which will make it possible

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[27] Based on recommendations from the HELCOM SPICE Biodiv WS 1-2017, this is preferred over only using the results from the last year of assessment, since the reference points are not defined as a levels to be exceeded with a high probability. For example for spawning stock biomass, the probability of being above this point in any single year varies from very high to approximately 50% for some stocks. In contrast, the mean over prolonged periods should have a substantially higher probability of being above MSY B-trigger. The results for both F and SSB are included in order to have consistent results between the assessment of commercial fish and the biodiversity assessment.

[28] In the assessment, reference levels and estimates of stock size and fishing mortality in individual years change over time as new data became available. Hence, a fishing mortality above F_{MSY} or a spawning stock biomass below the MSY B-trigger on average do not necessarily demonstrate that the advice from ICES on fishing opportunities was exceeded. For example, sprat fishing mortality is consistently above F_{MSY} in the period but the realized catches were below the advised catch options from ICES in three years out of five.

to evaluate the status in relation to management targets for more species and stocks in the future. Also, commercial species in coastal and transitional waters are assessed nationally and are not covered.

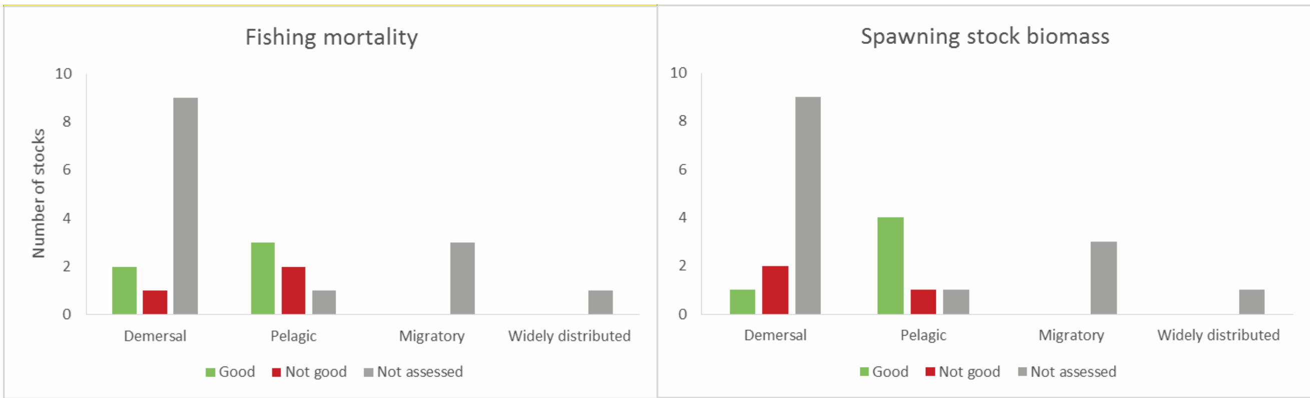

Figure A1.1. Number of Baltic Sea internationally managed fish stocks in good and not good status, by species groups. Currently non-assessed stocks are given in grey. Left: Fishing mortality, Right: Spawning stock biomass.

Table A1.1. Internationally managed fish stocks in the Baltic Sea. Status during 2011–2015 is shown based on fishing mortality (F) and spawning stock biomass (SSB) assessed in relation to the reference points for FMSY and the MSY B-trigger, respectively. Cases were the indicator does not achieve good status are shown by red cells. Green cells denote that the average value of the indicator during 2011–2015 achieves the 2015 reference point. White cells denote cases were no assessment is available. Total status is assessed based on the condition that both indicators should be in good status. Source: ICES (2016). Fourteen internationally managed stocks currently lack reference points and could therefore not be assessed.

Name	**Scientific name**	**Assessment area (ICES Sub-division)**	**F**	**SSB**	**Total**
Brill	*Scophthalmus rhombus*	North Sea, Skagerrak and Kattegat, English Channel (4, 3a, 7d,e)			
Cod	*Gadus morhua*	Western Baltic Sea (22–24)			
		Eastern Baltic Sea (25–32)			
Flounder	*Platichtys flesus*	Belt Sea and Sound (22–23)			
		West of Bornholm, S Central Baltic (24–25)			
		East of Gotland, Gulf of Gdansk (26, 28)			
		N Central and Northern Baltic Sea (27, 29–32)			
Dab	*Limanda limanda*	Baltic Sea (22–32)			
Plaice	*Pleuronectes platessa*	Kattegat, Belt Sea, Sound (21–23)			
		Baltic Sea excl. Sound and Belt Sea (24–32)			
Sole	*Solea solea*	Skagerrak and Kattegat, W Baltic Sea (3a, 22–24)			
Turbot	*Scophthalmus maximus*	Baltic Sea (22-32)			
Herring)	*Clupea harengus*	Central Baltic Sea, excl. Gulf of Riga (25–29, 32)			
		Gulf of Riga (28.1)			
		Bothnian Sea (30)			
		Bothnian Bay (31)			

		Spring spawners, Skagerrak, Kattegat, W Baltic (20-24)			
Sprat	*Sprattus sprattus*	Baltic Sea (22-32)			
Salmon)	*Salmo salar*	Baltic Sea, excluding Gulf of Finland (22-31)			
		Gulf of Finland (31)			
Sea trout	*Salmo trutta*	Baltic Sea (22-32)			
Eel	*Anguilla anguilla*	Throughout its natural range			

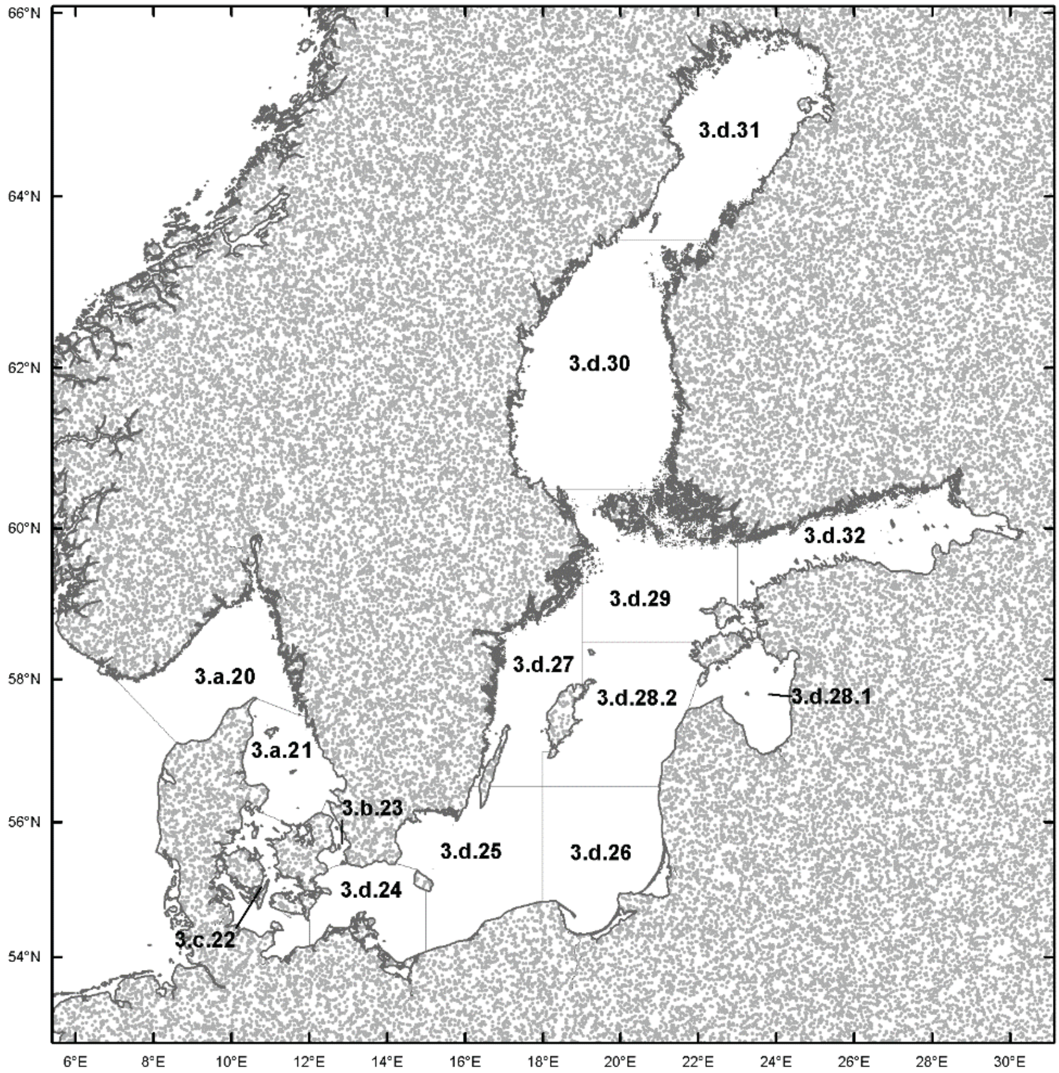

Figure A1.2. ICES statistical areas with subdivisions in the Baltic Sea. Source: ICES 2017

The results as shown in table A1.1 were applied in the integrated biodiversity assessment as shown in table A.1.2, taking into variability between years during 2011-2015. The results for the indicator achieving the lowest value (comparing F_{MSY} and SSB for each stock) was used as input data to the integrated assessment.

Table A1.2. Principles for how the assessment results for commercial fish were entered into BEAT. The assessment results were transformed into four classes in order to provide a more nuanced assessment results as compared to the alternative of only giving information on under or below the reference point. The years assessed were 2011-2015.

Input value	Definition
0.125	Threshold value not achieved in any of the years
0.375	Threshold value not achieved for the average for all years, but achieved in at least one of the years
0.625	Threshold value achieved for the average of all years, but not achieved in at least one of the years
0.825	Threshold value achieved in all years

Table A1.3. Input of commercial fish data to the BEAT assessment, based on the approach outlined above. Green=Threshold value achieved by the average value for 2011-2015 for both indicators F_{MSY} and SSB. Red= Threshold value not achieved by the average value for at least one of the indicators F_{MSY} and SSB. N= not applicable. White cells denote subdivisions not assessed due to lack of assessment result.

ICES SD	Cod	Plaice	Sole	Herring	Sprat
21		0.625	0.125	0.375	
22	0.125	0.625	0.125	0.375	0.125
23	0.125	0.625	0.125	0.375	0.125
24	0.125		0.125	0.375	0.125
25			N	0.825	0.125
26			N	0.825	0.125
27			N	0.825	0.125
28			N	0.825	0.125
28.1			N	0.375	0.125
29			N	0.825	0.125
30			N	0.675	0.125
31			N	no result	0.125
32			N	0.825	0.125

Annex 2. Guidelines for assessing indicator confidence

The guidelines are presented in tables A2.1-A2-4 below, for each assessment aspect.

Table A.2.1. 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 A.2.2. 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 A.2.3. Guidelines how to evaluate confidence of classification for the indicators for indicators that do not allow calculation of standard error for assessment evaluation. For indicators that allow calculation of standard error for assessment evaluation, this should be used instead.

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 A.2.4. 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?

Annex 3. Guidance for providing required minimum and maximum values for the indicators

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 A.3.1. 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 A.3.2).
- 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).

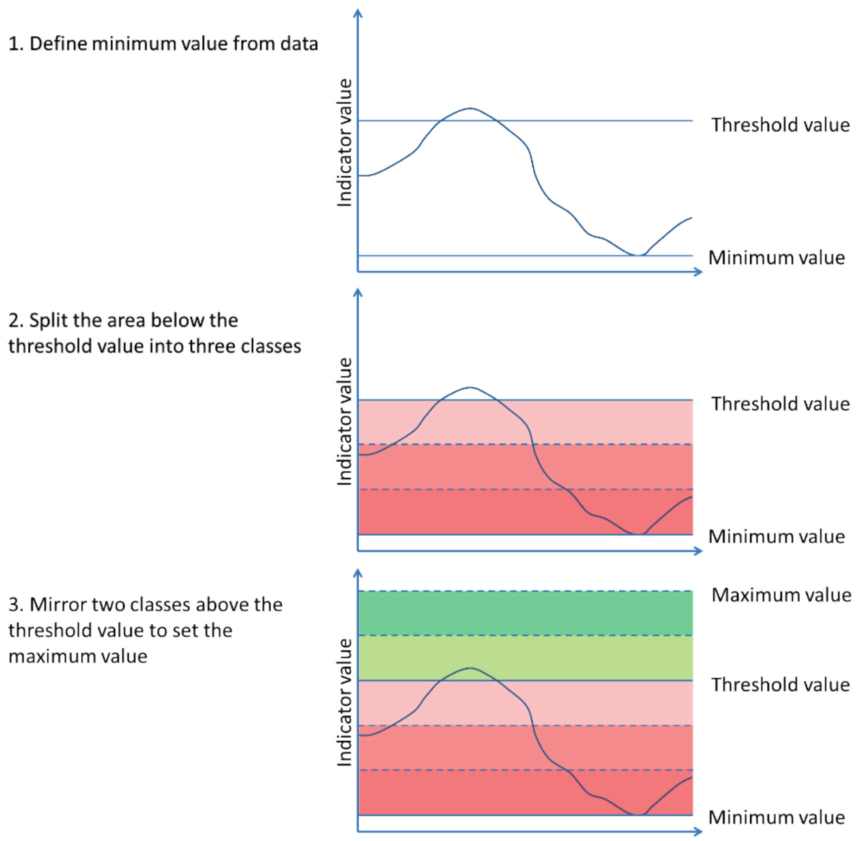

Figure A.3.1. Example for an indicator with threshold value and data available for deteriorated conditions, assuming linearity.

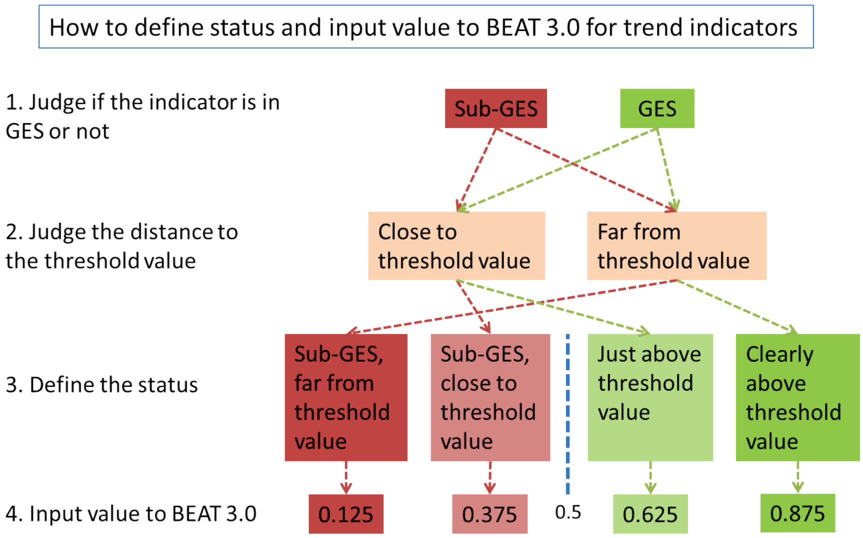

Figure A.3.2. The general approach for how to include indicators with a trend-based assessment in BEAT 3.0.

In the assessment of pelagic and benthic habitats, eutrophication core indicators indicating habitat condition are also included (see Table 2). For these indicators, either the ecological quality ratio (EQR) was used, or where available the actual indicator value. The indicator results and minimum and maximum values were provided by the HELCOM intersessional network on eutrophication. Indicators developed for the EU Water Framework Directive were scaled based on their assessment status class boundaries (Bad/Poor = 0.2, Poor/Moderate = 0.4, Moderate/Good = 0.6 and Good/High = 0.8) in order to improve the comparability between countries.

Annex 4. Assessment results for coastal benthic habitats

Table A.4.1 Output from BEAT for the integrated assessment of benthic habitats in coastal areas. The confidence is given at integrated indicator level, not including any overall penalty. BQR= Biological quality ratio. NA= not applicable due to no indicators assessed.

Assessment unit	BQR	Confidence	Number of indicators included
GER-001	0.44	high	2
GER-002	0.51	high	3
GER-003	0.46	high	3
GER-004	0.44	high	3
GER-005	0.40	high	3
GER-006	0.38	high	2
GER-007	0.18	high	3
GER-008	0.40	high	3
GER-009	0.33	high	3
GER-010	0.44	high	3
GER-011	0.48	high	3
GER-012	0.40	high	3
GER-013	0.45	high	3
GER-014	0.21	high	3
GER-015	0.43	high	3
GER-016	0.23	intermediate	2
GER-017	0.22	high	2
GER-018	0.43	high	3
GER-019	0.32	high	2
GER-020	0.26	high	3
GER-021	0.33	high	3
GER-022	0.48	high	3
GER-023	0.45	high	2
GER-024	0.53	high	3
GER-025	0.44	high	3
GER-026	0.40	high	3
GER-027	0.25	high	3
GER-028	0.49	high	3
GER-029	0.36	high	3
GER-030	0.50	high	2

GER-031	0.31	high	2
GER-032	0.43	high	3
GER-033	0.54	high	3
GER-034	0.50	high	3
GER-035	0.48	high	2
GER-036	0.45	high	3
GER-037	0.50	high	3
GER-038	0.51	high	3
GER-039	0.54	high	2
GER-040	0.40	high	3
GER-041	0.39	high	3
GER-042	0.25	intermediate	1
GER-043	0.38	high	3
GER-044	0.21	intermediate	1
GER-111	0.35	high	3
FIN-001	0.33	intermediate	3
FIN-002	0.38	intermediate	3
FIN-003	0.22	intermediate	2
FIN-004	0.31	intermediate	3
FIN-005	0.41	intermediate	2
FIN-006	0.33	intermediate	2
FIN-007	0.34	intermediate	2
FIN-008	0.44	intermediate	2
FIN-009	0.38	intermediate	2
FIN-010	0.51	intermediate	2
FIN-011	0.46	intermediate	2
FIN-012	0.44	intermediate	3
FIN-013	0.58	intermediate	3
FIN-014	0.58	intermediate	3
LAT-001	0.66	intermediate	3
LAT-002	0.53	intermediate	2
LAT-003	0.50	intermediate	3
LAT-004	0.54	intermediate	3
LAT-005	0.60	intermediate	2
POL-001	0.27	intermediate	1
POL-002	0.41	intermediate	3

POL-003	0.44	intermediate	3
POL-004	0.51	intermediate	4
POL-005	0.58	intermediate	4
POL-006	0.69	intermediate	3
POL-007	0.44	intermediate	3
POL-008	0.50	intermediate	3
POL-009	0.42	intermediate	3
POL-010	0.68	intermediate	3
POL-011	0.74	intermediate	3
POL-012	0.43	intermediate	3
POL-013	0.44	intermediate	3
POL-014	0.57	intermediate	3
POL-015	0.64	intermediate	4
POL-016	0.60	intermediate	3
POL-017	0.63	intermediate	3
POL-018	0.47	intermediate	3
POL-019	0.45	intermediate	3
SWE-001	0.62	intermediate	4
SWE-003	0.68	intermediate	4
SWE-004	0.65	intermediate	4
SWE-005	0.65	intermediate	4
SWE-006	0.66	intermediate	4
SWE-007	0.69	intermediate	4
SWE-008	0.70	intermediate	4
SWE-009	0.64	intermediate	4
SWE-010	0.66	intermediate	4
SWE-011	0.69	intermediate	4
SWE-012	0.66	intermediate	4
SWE-013	0.48	intermediate	4
SWE-014	0.65	intermediate	4
SWE-015	0.70	high	3
SWE-016	0.59	intermediate	4
SWE-017	0.68	intermediate	4
SWE-018	0.70	intermediate	4
SWE-019	0.70	intermediate	4
SWE-020	0.68	intermediate	3

SWE-021	0.71	intermediate	3
SWE-022	0.77	intermediate	3
SWE-023	0.79	intermediate	3
SWE-024	0.50	intermediate	2
SWE-025	0.54	intermediate	3
LIT-001	NA	NA	0
LIT-002	0.65	high	1
LIT-003	0.26	high	2
LIT-004	0.39	high	1
LIT-005	0.47	high	1
LIT-006	0.65	high	1
RUS-001	NA	NA	0
RUS-002	NA	NA	0
RUS-003	NA	NA	0
DEN-001 to DEN-108	NA	NA	0
EST-003	0.56	high	5
EST-004	0.49	high	4
EST-005	0.61	high	5
EST-006	0.65	high	5
EST-007	0.51	high	4
EST-008	0.64	high	5
EST-002	NA	NA	0
EST-001	0.66	high	1

Annex 5. Assessment results for coastal pelagic habitats

Table A.5.1 Output from BEAT for the integrated assessment of pelagic habitats in coastal areas. The confidence is given at integrated indicator level, not including any overall penalty. BQR= Biological quality ratio. NA= not applicable due to no indicators assessed.

Assessment unit	BQR	Confidence	Number of indicators included
GER-001	0.36	Intermediate	2
GER-002	0.49	Intermediate	2
GER-003	0.51	Intermediate	2
GER-004	0.61	Intermediate	2
GER-005	0.39	Intermediate	2
GER-006	0.58	Intermediate	2
GER-007	0.19	Intermediate	2
GER-008	0.28	Intermediate	2
GER-009	0.05	Intermediate	2
GER-010	0.67	Intermediate	2
GER-011	0.38	Intermediate	2
GER-012	0.34	Intermediate	2
GER-013	0.34	Intermediate	2
GER-014	0.06	Intermediate	2
GER-015	0.50	Intermediate	2
GER-016	0.37	Intermediate	2
GER-017	0.34	Intermediate	2
GER-018	0.48	Intermediate	2
GER-019	0.38	Intermediate	2
GER-020	0.38	Intermediate	2
GER-021	0.51	Intermediate	1
GER-022	0.59	Intermediate	1
GER-023	0.59	Intermediate	1
GER-024	0.60	Intermediate	1
GER-025	0.22	Intermediate	1
GER-026	0.00	Intermediate	1
GER-027	0.00	Intermediate	1
GER-028	0.60	Intermediate	1
GER-029	0.59	Intermediate	1
GER-030	0.67	Intermediate	1

GER-031	0.59	Intermediate	1
GER-032	0.47	Intermediate	1
GER-033	0.67	Intermediate	1
GER-034	0.67	Intermediate	1
GER-035	0.67	Intermediate	1
GER-036	1.00	Intermediate	1
GER-037	1.00	Intermediate	1
GER-038	0.65	Intermediate	1
GER-039	0.67	Intermediate	1
GER-040	0.60	Intermediate	1
GER-041	0.59	Intermediate	1
GER-042	0.42	Intermediate	1
GER-043	0.36	Intermediate	1
GER-044	0.29	Intermediate	1
GER-111	0.12	Intermediate	2
FIN-001	0.59	High	1
FIN-002	0.58	High	2
FIN-003	0.57	High	1
FIN-004	0.57	High	2
FIN-005	NA	NA	0
FIN-006	0.56	High	1
FIN-007	0.59	High	2
FIN-008	0.58	High	1
FIN-009	0.69	High	2
FIN-010	0.58	High	1
FIN-011	0.59	High	2
FIN-012	0.28	Intermediate	1
FIN-013	0.57	Intermediate	1
FIN-014	NA	NA	0
LAT-001	0.42	Intermediate	2
LAT-002	0.71	Intermediate	2
LAT-003	0.32	Intermediate	2
LAT-004	0.50	Intermediate	2
LAT-005	0.31	Intermediate	2
POL-001	NA	NA	0
POL-002	NA	NA	0

POL-003	0.34	High	1
POL-004	0.00	High	1
POL-005	0.63	High	1
POL-006	0.59	High	1
POL-007	0.00	High	1
POL-008	0.45	High	1
POL-009	0.50	High	1
POL-010	0.00	High	1
POL-011	0.07	High	1
POL-012	NA	NA	0
POL-013	0.05	High	1
POL-014	0.00	High	1
POL-015	0.00	High	1
POL-016	0.00	High	1
POL-017	0.00	High	1
POL-018	0.15	High	1
POL-019	0.00	High	1
SWE-001	0.67	Intermediate	1
SWE-003	0.87	Intermediate	2
SWE-004	0.79	Intermediate	2
SWE-005	0.65	Intermediate	1
SWE-006	0.54	Intermediate	1
SWE-007	0.62	Intermediate	1
SWE-008	0.65	Intermediate	1
SWE-009	0.39	Intermediate	1
SWE-010	0.46	Intermediate	1
SWE-011	0.46	Intermediate	2
SWE-012	0.47	Intermediate	2
SWE-013	0.33	Intermediate	2
SWE-014	0.45	Intermediate	2
SWE-015	0.44	Intermediate	2
SWE-016	0.61	Intermediate	2
SWE-017	0.58	Intermediate	2
SWE-018	0.59	Intermediate	2
SWE-019	0.61	Intermediate	1
SWE-020	0.58	Intermediate	2

SWE-021	0.46	Intermediate	1
SWE-022	0.69	Intermediate	2
SWE-023	0.56	Intermediate	1
SWE-024	0.56	Intermediate	2
SWE-025	0.32	Intermediate	1
LIT-001	0.28	High	1
LIT-002	0.49	High	1
LIT-003	0.30	High	1
LIT-004	0.19	High	1
LIT-005	0.15	High	1
LIT-006	0.33	High	1
RUS-001	NA	NA	0
RUS-002	NA	NA	0
RUS-003	NA	NA	0
DEN-001 to DEN-108	NA	NA	0
EST-003	0.71	Intermediate	2
EST-004	0.50	Intermediate	1
EST-005	0.57	Intermediate	2
EST-006	0.60	Intermediate	2
EST-007	0.13	Intermediate	2
EST-008	0.50	Intermediate	2
EST-002	99.00	NA	0
EST-001	99.00	NA	0