STATE OF THE BALTIC SEA

– HOLISTIC ASSESSMENT –

First version 2017

FIRST VERSION OF THE 'STATE OF THE BALTIC SEA' REPORT – JUNE 2017

TO BE UPDATED IN 2018

HELCOM – BALTIC MARINE ENVIRONMENT PROTECTION COMMISSION

The production of this report has been carried out through the HELCOM Project for the development of the second holistic assessment of the Baltic Sea (HOLAS II). The work has been financially supported through HELCOM, the EU co-financing of HELCOM coordinated projects BalticBOOST, TAPAS and SPICE as well as special contributions by Sweden, Finland, Germany (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety) and Denmark.

The basis for the assessment of status of the Baltic Sea are the HELCOM core indicators and associated threshold values. In this context the following has been agreed:

Regarding threshold values
"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 Marine Strategy Framework Directive obligations by those Contracting Parties being EU Member States that wish to do so".

Regarding testing of indicators
Note that some indicators and/or their associated threshold value are still being tested in some countries and may be further developed in HELCOM as a result of the outcome of the testing. In some cases the results may show that the indicator is not suitable for use in a specific sub-basin. These indicators are marked in the assessment report and the results should be considered as intermediate.

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Introductory note

This report contains the first version of the 'State of the Baltic Sea' report, presenting the assessment of status, pressures and impacts on the Baltic Sea marine environment as well social and economic analyses of the use of marine waters and costs of degradation. The report has been prepared by HELCOM during 2015–2017, and covers the period 2011–2015.

The report will be further updated and consolidated and a finalized version of the report will be published in June 2018. In that process, a number of revisions and improvements are planned, including addition of new and complementary data, in particular for the year 2016, extending the assessment period to 2011–2016.

During the preparation of the report, a number of additions and improvement to the report have also been identified as desired by the Contracting Parties, HELCOM working groups, and experts, but have not been feasible to fully implement and accommodate in this first version of the report. The identified remaining issues have been specified and noted. A non-exhaustive list of additional improvements is provided in the last chapter of this report. In the updated report, HELCOM also aims to include a chapter on the conclusions and a future outlook, based on an analysis of the first results and on considerations within HELCOM, in particular in association to the upcoming HELCOM Ministerial Meeting on 6 March 2018.

HELCOM is carrying out a regional consultation of the first version of the 'State of the Baltic Sea' report, encouraging international and intergovernmental organizations to give feedback on the report. The report is also available for use by the HELCOM countries in national consultation. The comments received through the regional consultation will be considered in parallel with the updating of the report or material thereof.

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Executive Summary

This first version of the State of the Baltic Sea report provides an update of the environmental situation in the Baltic Sea for the period 2011–2015[1]. The report captures a 'moment' in the dynamic life history of the Baltic Sea, aiming to support an adaptive, regionally coordinated management towards improved environmental status of the Baltic Sea.

The report highlights a broad range of aspects, covering the state of the ecosystem, environmental pressures and human well-being. Some results are based on the achievements of long-term HELCOM monitoring and assessment, whereas others are presented regionally for the first time. HELCOM core indicators form the basis for the assessment. The indicators assess the status of selected elements of biodiversity and human-induced pressures on the Baltic Sea against regionally agreed threshold values, based on current knowledge and available data for the assessment. In addition, integrated assessments for biodiversity, eutrophication and contamination status are made, based on the core indicators. For marine litter, underwater noise and seabed loss and disturbance the assessment is descriptive since HELCOM core indicators are still under development. Trends over time and spatial aspects are included, as far as data are available, in order to indicate potential future developments and geographic areas of key importance for the assessed themes. Results from economic and social analyses are included for themes where information at the regional scale is available.

The results show that, although signs of improvement in the state of the Baltic Sea are seen in some cases, the Baltic Sea Action Plan goals and ecological objectives have not yet been reached (Figure ES1). One additional conclusion is that some measures already put into operation have not been in place long enough to have an effect. For measures such as reduction of nutrient loads, it will take several decades before full effects can be measured in the environment.

The assessment provides key information for taking further steps to reach good environmental status for the Baltic Sea and strengthen the implementation of the HELCOM Baltic Sea Action Plan by 2021. The assessment may also serve as a regional baseline for implementing the UN Sustainable Development Goals as well as serve purposes of the EU Marine Strategy Framework Directive for those countries around the Baltic Sea that are EU Member States.

By mid-2018, the report will be updated to also include data from 2016. If additional threshold values or new HELCOM core indicators are agreed during 2017, they may also be included in the 2018 update.

[1] The updated version of the report will cover the assessment period 2011-2016.

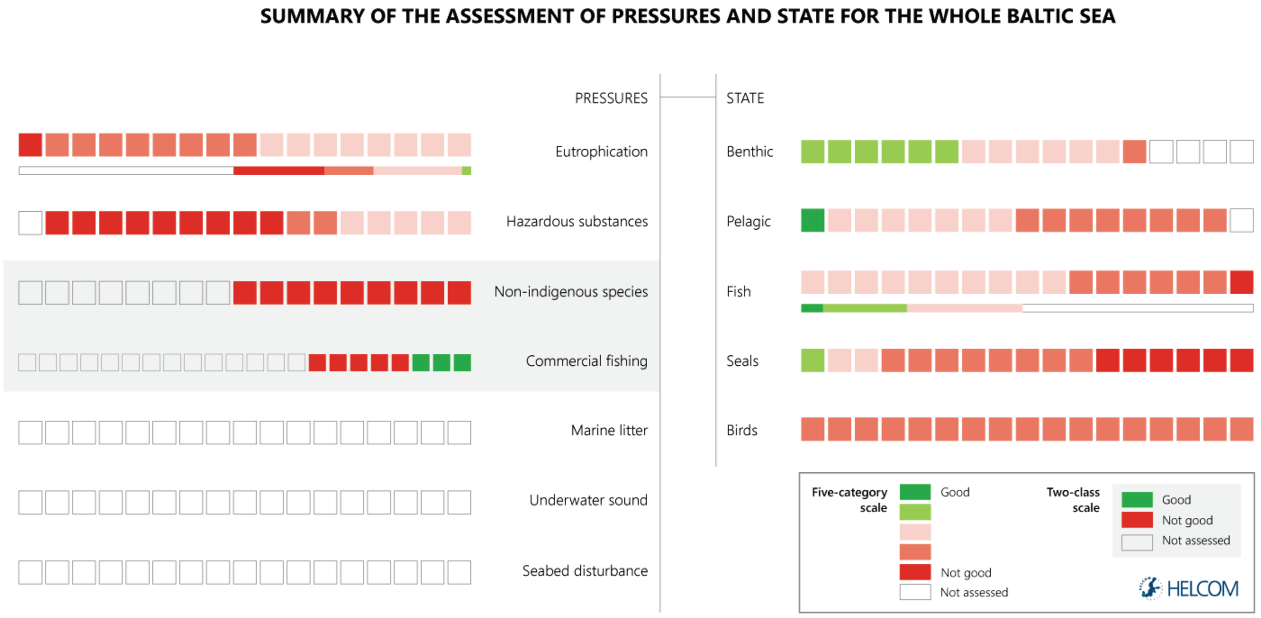
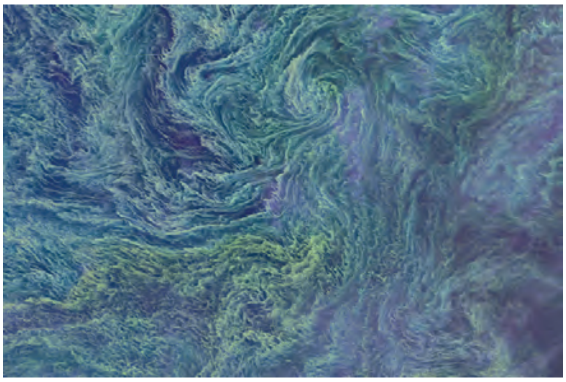


Figure ES1. Summary of the assessment of pressures and status for the Baltic Sea, showing number of sub-basins in good/not good status, with the exception of commercial fishing, which shows the number of stocks. For seals and birds, the squares represent both coastal and open-sea areas without distinguishing between them, whereas for the other components, squares represent open-sea areas. For eutrophication and fish, coastal areas are presented as stacked bars. Note that non-indigenous species and commercial fishing have been assessed in two classes (good/not good), whereas eutrophication, hazardous substances and state components have been assessed in five categories, with two categories representing good status and three representing not good status. In both scales, an empty area indicates that the status has not been assessed quantitatively.

PRESSURES ON THE BALTIC SEA

The Baltic Sea is one of the world´s largest brackish water areas. It is inhabited by both marine and freshwater species, but the number of species is low compared to most other seas due to the low salinity. The drainage area is inhabited by around 85 million people, influencing on the status of the Baltic Sea via human activities on land and sea. Due to the limited level of water exchange, nutrients and other substances from the drainage area accumulate in the Baltic Sea and are only slowly diluted. The status of seven distinct pressures on the Baltic Sea are assessed in this report (Figure ES2). In addition, a particular concern for the Baltic Sea is the wide and increasing distribution of areas with poor oxygen conditions. Climate-related increases in water temperature, and decreases in salinity due to increased input of freshwater, are further expected to affect the distribution of species over time, as well as their physiology and food availability.

Eutrophication

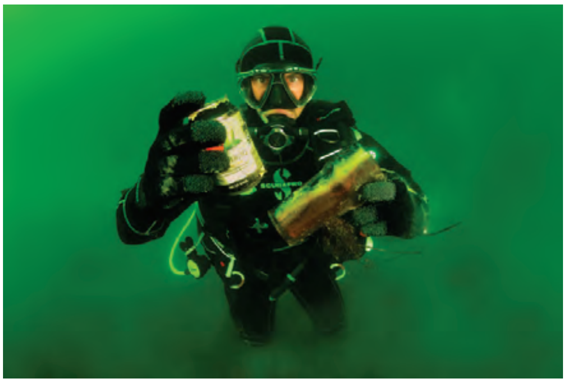


Eutrophication has been evident in the Baltic Sea for many decades, due to past high and still excessive input of nitrogen and phosphorus. Over 95 % of the Baltic Sea region[2] is affected by eutrophication. Inputs of nutrients from land have decreased, but effects of these measures are not yet generally reflected in the status of the marine environment. The eutrophication status has deteriorated in seven out of the seventeen open-sea assessment units since the last five year period (2007–2011) to the present (2011–2015), whereas it has improved in only two assessment units. Only a few coastal areas are currently unaffected by eutrophication, but an improving trend is seen in some indicators and sub-basins.

Hazardous substances

Levels of contaminants are elevated and continue giving cause for concern. However, the analysis suggests that the situation is not generally deteriorating, as reflected in slightly more improving than deteriorating trends in the monitored hazardous substances. The integrated contamination status is mainly influenced by poly-brominated flame retardants and mercury. Cesium (137Cs) deposited after the accident at the Chernobyl nuclear power plant in 1986 is now at acceptable levels in some sub-basins, and can be expected to be so in all of the Baltic Sea by 2020. Acute pollution events from oils spills have decreased.

Marine litter



HELCOM is developing core indicators for assessing marine litter, but they are not yet operational and thus no assessment of status has been possible at this time. Beach litter monitoring is ongoing in several countries, showing that the number of beach litter items ranges from around 10 to 160 per 100 m beach in the different sub-basins. Plastic litter is a special concern due to its risk to the environment and its slow rate of

[2] Baltic Sea including the Kattegat.

degradation. Around 70 % of the litter items in the Baltic Sea are derived from plastic materials.

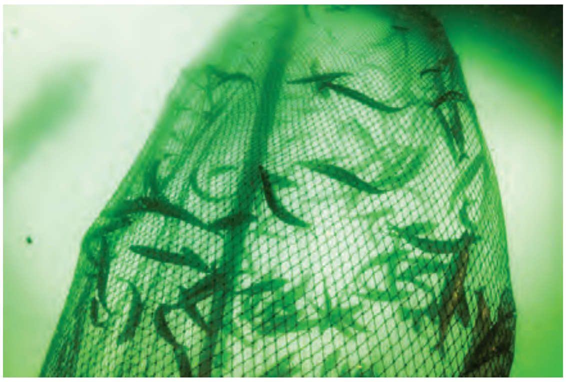
Underwater sound

Underwater sound is among the most widely-distributed pressures in the Baltic Sea, caused by various human activities. Areas with high levels of continuous sound have been mapped and they mainly coincide with areas of high vessel traffic. Out of 350 impulsive sound events registered in a newly established HELCOM registry, 167 are linked to pile driving in connection with construction activities. It is not known how many marine species are impacted and thus no assessment of status has been possible at this time.

Non-indigenous species

Around 140 non-indigenous species have so far been recorded in the Baltic Sea. Of these, 14 are new for the Baltic Sea during the assessment period (2011–2015). In addition, an unknown number of previously arrived non-indigenous species have expanded their distribution range to new sub-basins in the Baltic Sea. The regional objective is that there should be no primary introductions of non-indigenous species due to human activities during an assessment period and thus, good status is not achieved.

Species removal by fishing and hunting



Three out of eight assessed commercial fish stocks are in good status with respect to both biomass and fishing mortality rates. However, fourteen stocks are currently lacking evaluation. In addition to the targeted species, unselective fishing methods cause mortality of non-target fish species and size classes. Hunting has a relatively small role today. Seals are generally protected, but hunting is permitted in some countries, restricted to populations above a limit reference level and with a positive growth rate. Waterbirds are hunted in some countries, whereas in others they have strict protection.

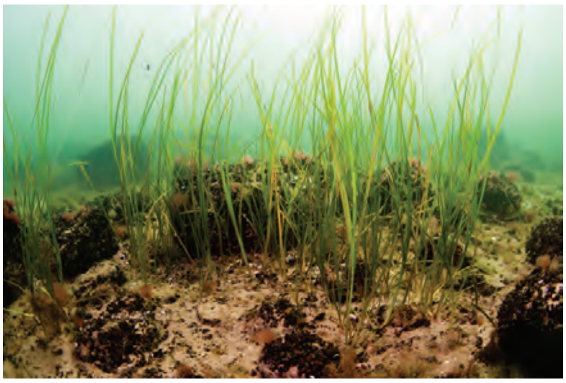
Seabed loss and disturbance

Less than one percent of the Baltic Sea seabed was estimated as potentially being lost due to human activities by 2015 while around half of the Baltic Sea seabed was estimated as potentially disturbed in the assessment period. The estimates are based on the spatial extent of human activities but have not been linked to pressure intensity. Hence, no assessment of adverse effects on the seabed has been made at this time.

BIODIVERSITY

For the biodiversity core indicators there are cases of inadequate status in all levels of the food web; only a few core indicators have acceptable levels in part of the Baltic Sea, and none of them in all assessed areas. Although the results for different indicators are not directly comparable, as their assessment methods have been developed independently, the overall result suggests that the environmental impacts on species in the Baltic Sea are wide-reaching and not restricted to certain geographic areas or certain parts of the food web (Figure ES3).

Habitats



For benthic habitats, there is indication of good status in five of twelve assessed open sea areas based on estimates limited to soft bottom habitats. Coastal areas show good status in about half of the assessed Baltic Sea region. Pelagic habitats are assessed based on core indicators representing primary productivity, and in some sub-basins also zooplankton. Based on the available indicators, good status of open-sea pelagic habitats has been achieved only in the Kattegat. Coastal areas show good integrated status in about one quarter of the assessed areas. The assessments of benthic and pelagic habitats are still under development and additional elements will be included in assessments in the future.

Fish

The assessment of fish from a biodiversity perspective indicates good status in about half of the assessed coastal areas. In the open sea, good status is not achieved in any assessment area. Two out of five assessed pelagic fish stocks (herring in the central Baltic Sea and Bothnian Sea) have good status, and one of three assessed demersal stocks (plaice in the Kattegat, Sound and Belt Sea). Demersal fish are only assessed in the Kattegat and the western Baltic Sea, and an assessment for the eastern parts of the Baltic Sea is currently lacking (Figure ES4). Core indicators for the migratory species salmon and sea trout show that good status is not achieved in most areas where they are assessed.

Mammals

Among the marine mammals, grey seals and harbour seals show increasing population sizes, but the assessment for grey seal indicates that the nutritional and reproductive status is not good. Of the three management units of harbour seals in HELCOM area, only the Kattegat population shows good status. The population of ringed seal in the Gulf of Finland is of concern. The population is sensitive to climate change, and it is decreasing and currently represented by around 100 animals. A particular concern is also the Baltic Proper population of harbour porpoise, with a population size recently estimated at around 500 animals. The Kattegat-Belt-Sea-Western Baltic subpopulation is also assessed as threatened by HELCOM, but the sub-population is estimated at around 40 500 animals and the sub-population is stable.

Waterbirds

Water birds are assessed by their abundance during the breeding and the wintering season. Both indicators failed the threshold values, particularly due to a decline in benthic feeding birds during both seasons, as well as a decline in surface feeders and waders during the breeding season, and in grazing feeders during the wintering season. Pelagic feeding birds as a group shows good status.

Food web aspects

Since species are dependent on each other (for food, and via competition, for example) it can be expected that changes in one species will also influence the status of other species. Changes in the abundance of species from different feeding groups may signal such changes at food web level. In addition, altered nutritional status, growth rate or size structure are important indications that the function of the food web may have changed. Although further work is required for an indicator-based assessment of food web status in the Baltic Sea, available data for some geographic areas and species indicate a decreased nutritional status and size structure in fish (such as Eastern Baltic cod), decreased nutritional status in mammals (such as grey seal) and decreased size structure in zooplankton, all pointing towards a deteriorating food web status.

CUMULATIVE IMPACTS AND SPATIAL ASPECTS

The indicator-based assessments of pressures show their status when assessed individually, without comparing their total impact or their level of spatial overlap with sensitive habitats. The Baltic Sea Impact Index is an assessment component that additionally describes the potential cumulative burden on the environment in different parts of the Baltic Sea, with the use of more detailed spatial information than can be provided by the core indicators. The results indicate that the highest potential environmental impacts currently occur in the southwestern parts of the Baltic Sea, and that the pressures causing most impacts on species are concentration of nutrients (representing inputs of nutrients), contamination, underwater noise, non-indigenous species, and the extraction of fish. Other pressures have high influence on specific species and species groups but are less widely distributed.

IMPACTS ON HUMAN WELL-BEING

Human activities in the Baltic Sea and its drainage area contribute to pressures that act on the Baltic Sea environment but are also in many cases dependent on a healthy state of the marine environment. The cost of degradation with respect to eutrophication in the Baltic Sea region is estimated as total losses of around 3.8–4.4 billion euros annually. In other words, the citizens' welfare would increase by this much each year if good eutrophication status was achieved (See Figure 4.1.10 in Chapter 4.1). Estimates for selected biodiversity components suggest that citizens' welfare would increase by 1.8–2.6 billion euros annually in the Baltic Sea region if the state of marine vegetation and fish stocks improved to a good status (see Chapter 5.6). The current recreational benefits of the Baltic Sea are estimated at around 15 billion euros annually, and the current losses of recreation values due to the deterioration of the marine environment are estimated to around 1–2 billion euros annually (Chapter 3).

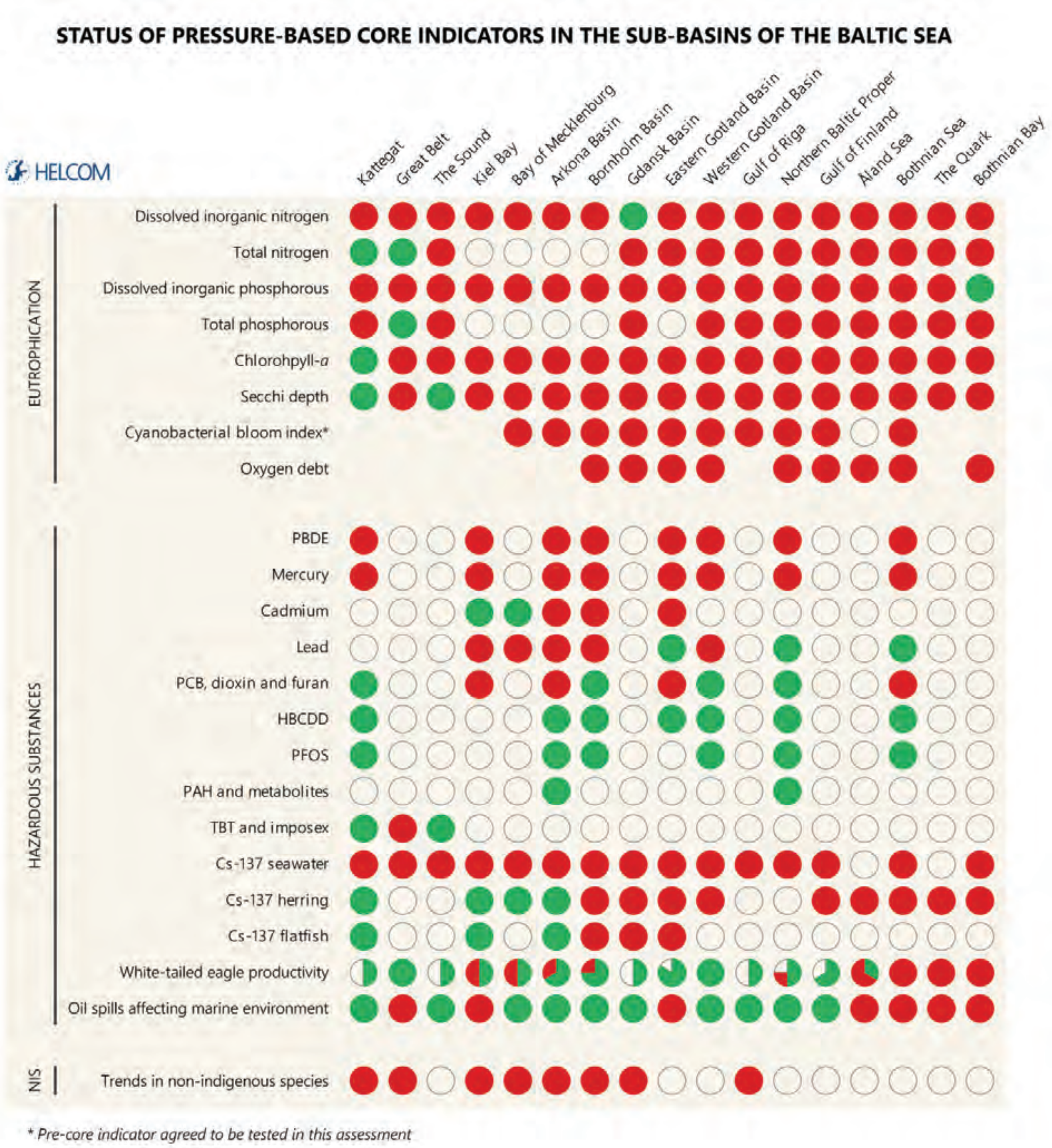


Figure ES2. Status of pressure-based core indicators for eutrophication, hazardous substances and non-indigenous species by sub-basin. Green circles indicate good status, red circles indicate not good status, and empty circles indicate that the core indicator is applicable or relevant to the sub-basin, but has not been assessed. Absent circles indicate that the indicator is not applicable or relevant. For coastal indicators, pie charts show proportion of coastal assessment units per sub-basin in good status (green), not good status (red) and not assessed (empty).

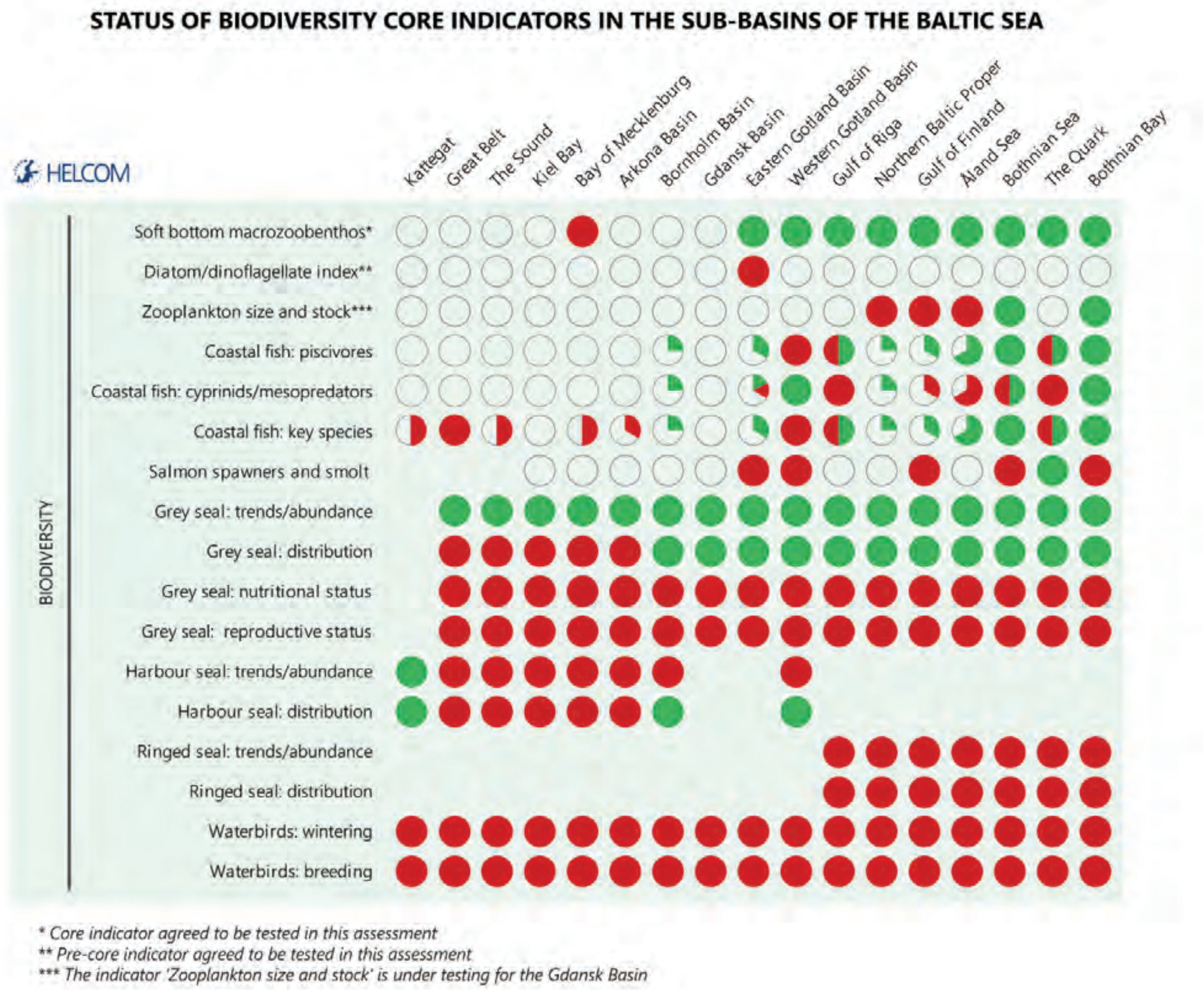


Figure ES3. Status of biodiversity core indicators by sub-basin. Green circles indicate good status, red circles indicate not good status, and empty circles indicate that the core indicator is applicable for the sub-basin, but has not been assessed. Absent circles indicate that the indicator is not applicable. For coastal indicators, pie charts show proportion of coastal assessment units per sub-basin in good status (green), not good status (red) and not assessed (empty).

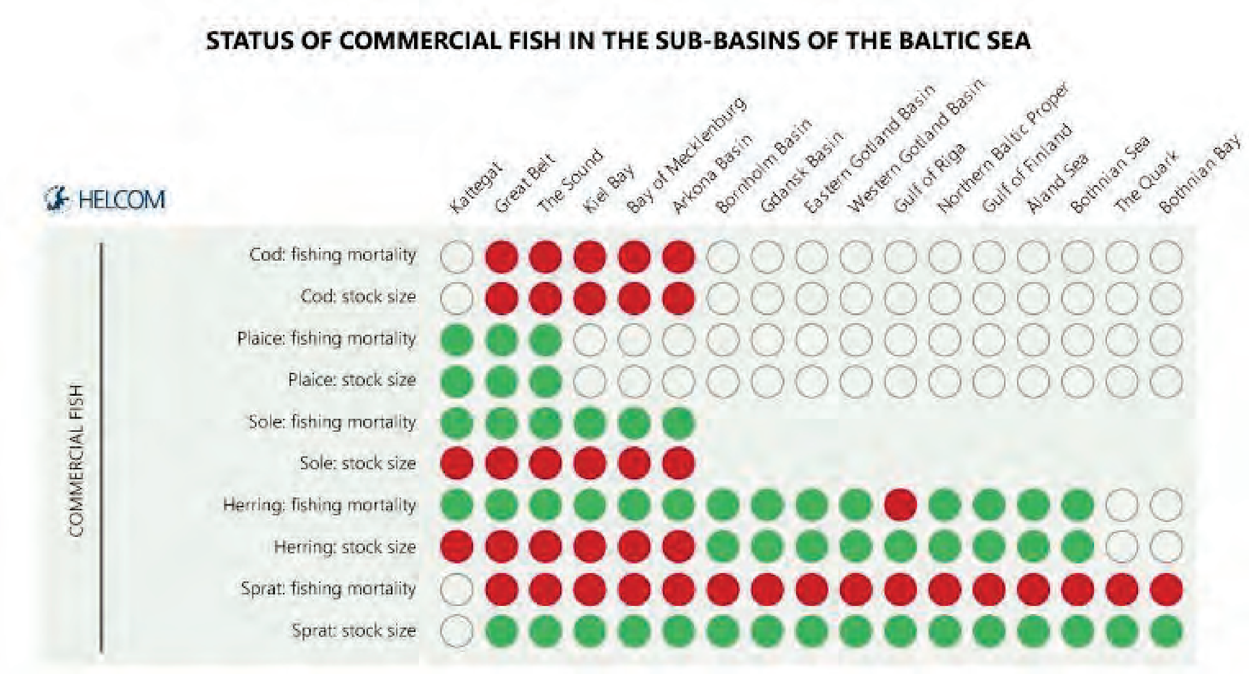


Figure ES4. Status of commercial fish assessed based on fishing mortality and stock size (spawning stock biomass) using data from ICES (2016). Green circles indicate good status, red circles indicate not good status, and empty circles indicate that the assessment is applicable for the sub-basin, but is not yet available. Absent circles indicate that the assessment is not relevant for that sub-basin. Species with no available assessment results are not included.

Chapter 1. Our Baltic Sea

The Baltic Sea in Northern Europe is surrounded by nine countries: Denmark, Germany, Poland, Lithuania, Latvia, Estonia, Russia, Finland and Sweden. As long as people have lived in the area, the Baltic Sea has provided a strong connection between these countries and a source of human livelihood. The countries also share the challenge of managing the pressures resulting from human activities, in order to lessen their impacts on biodiversity and ecosystem function. For HELCOM, maintaining good ecosystem health is a core area of regional collaboration. The State of the Baltic Sea report provides an update of the environmental state in the Baltic Sea during 2011–2015, as a basis for follow-up on environmental objectives and for creating a common knowledge base for the further development of Baltic Sea environmental management.

In support of the ecosystem approach, this second holistic regional report provides key information on the current state of the Baltic Sea environment, based on regionally agreed data and assessment methods. The report aims to answer questions such as: Which ecosystem components and areas do not achieve a good status? What are the major pressures in these areas? What are the underlying human activities? How is human welfare affected by the current state of the sea? Are there areas of risk in relation to future expansion of activities? With this information in place, existing measures can be evaluated and decisions can be taken to reach the good environmental status for the Baltic Sea that environmental policies aim for.

1.1 PHYSICAL DESCRIPTION OF THE BALTIC SEA

The Baltic Sea is one of the largest brackish water areas in the world, with a surface area of 420 000 km^2. The drainage area of the Baltic Sea is about four times larger than its surface area and is inhabited by around 85 million people (Figure 1.1). More than one third of the Baltic Sea is shallower than 30 meters, giving it a small total water volume in comparison to its surface area.

Figure 1.1. The Baltic Sea is surrounded by nine countries, covers an area of around 420 000 km^2, and has a drainage area around four times the size. Due to its strong gradient in salinity, and hence in biological features, the area is sub-divided into 17 sub-basins based on topography and hydrology. These sub-basins are also referred to in the assessments made in this report.

The Baltic Sea is relatively isolated from other seas. It has only a narrow connection to the North Sea through the Sound and the Belt Seas, so it takes approximately 30 years for the Baltic Sea waters to get fully exchanged (Stigebrandt 2001). Marine water enters the Baltic Sea predominantly during winter storms. These inflows elevate salinity in the region, and also improve oxygen conditions in the deep waters. Freshwater reaches the Baltic Sea from numerous rivers, corresponding to about one fortieth of the total water volume per year (Bergström *et al*. 2001). Together, these hydrological conditions give rise to the characteristic brackish water gradient of the Baltic Sea, where there is gradual change from a surface water salinity of 15–18 [psu] in the entrance at the Sound, 7–8 in the Baltic Proper and 0–2 in the northeastern parts (HELCOM 2016a; Figure 1.2).

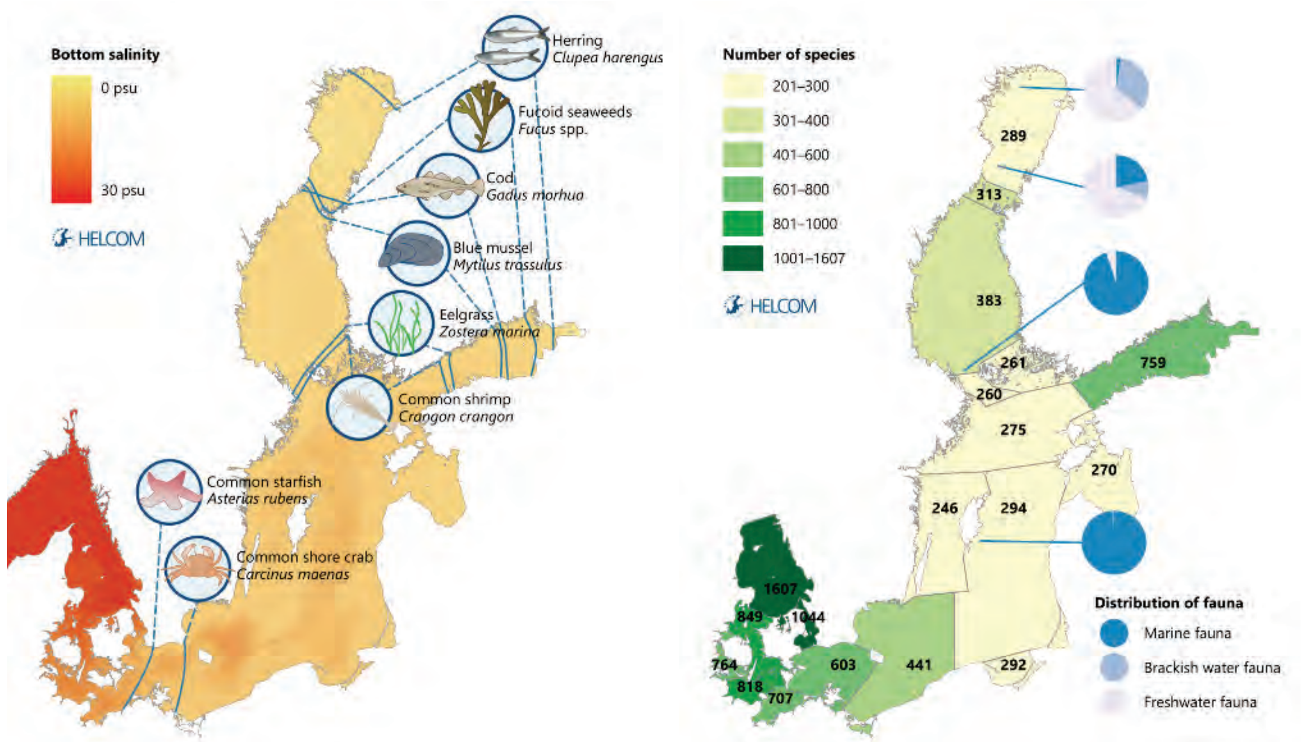


Figure 1.2. The Baltic Sea is characterised by brackish water and a decreasing salinity from its entrance in the southwest to the inner parts. This also affects the distribution of species. The map on the left shows the salinity in different areas of the Baltic Sea and the inner distribution limits of some marine species (cod and herring according to Natural Resources Institute Finland (2017), other species according to Furman *et al.* (2014) and Finnish Environment Institute (2017). The map on the right shows the number of species in the sub-basins according to HELCOM (2012) as well as the proportion of freshwater, brackish and marine fauna in different locations according to Furman *et al.* (2014).

Geologically, the Baltic Sea is very young. After the last glaciation (the Weichselian Glaciation ending around 12 000 years ago) when the Scandinavian ice sheet retreated, the Baltic Sea area has gone through a series of differing salinity phases, including both freshwater and marine/brackish water phases (Harff *et al*. 2011). The recent configuration of the Baltic Sea, with a connection to the North Sea, was established during the Littorina transgression between 7 500 and 4 000 years before present. The entrance to the North Sea was previously wider, but was narrowed due to land upheaval (Leppäranta and Myrberg 2009). The current brackish water form of the Baltic Sea was initiated only around 2 000 years ago (Emeis *et al*. 2013).

Most of the marine species that are present in the Baltic Sea originate from a time when the sea was saltier, and since then they have had limited genetic exchange with their counterparts in fully marine waters. On a Baltic-wide scale, marine species live side by side with freshwater species that reproduce in freshwater tributaries or which can tolerate the brackish conditions. The brackish water imposes physiological stress on both marine and freshwater organisms, but there are also several examples of genetic adaptation and diversification (Johannesson and André 2006). Although marine species are generally more common in the southern parts, and freshwater species dominate in the inner and less saline areas, the two groups of species create a unique food web where marine and freshwater species coexist and interact (Figure 1.3).

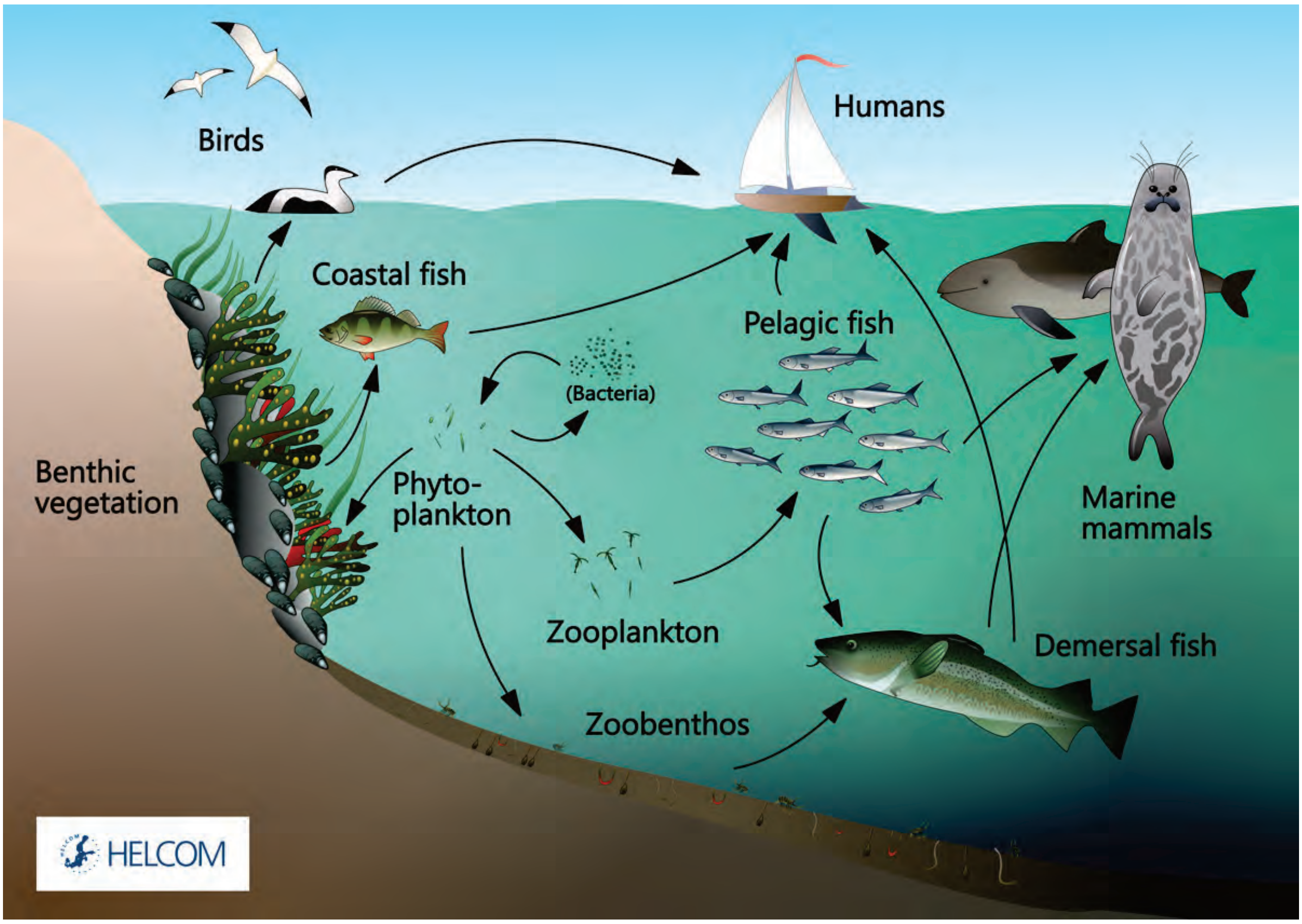


Figure 1.3. A schematic, simplified illustration of the food web structure in the Baltic Sea.

1.2 CLIMATE AND HYDROLOGY

The whole Baltic Sea region is situated in a temperate climate zone. The middle and northern areas have longer winters with stronger frosts, whilst the southwestern and southern areas have relatively moist and mild winters. Global climate change is also seen in the Baltic Sea region. The maximum extent of ice cover is lower today than the historical average, with a sharp decline in recent years, and a decrease in the mean number of ice days (Figure 1.4).

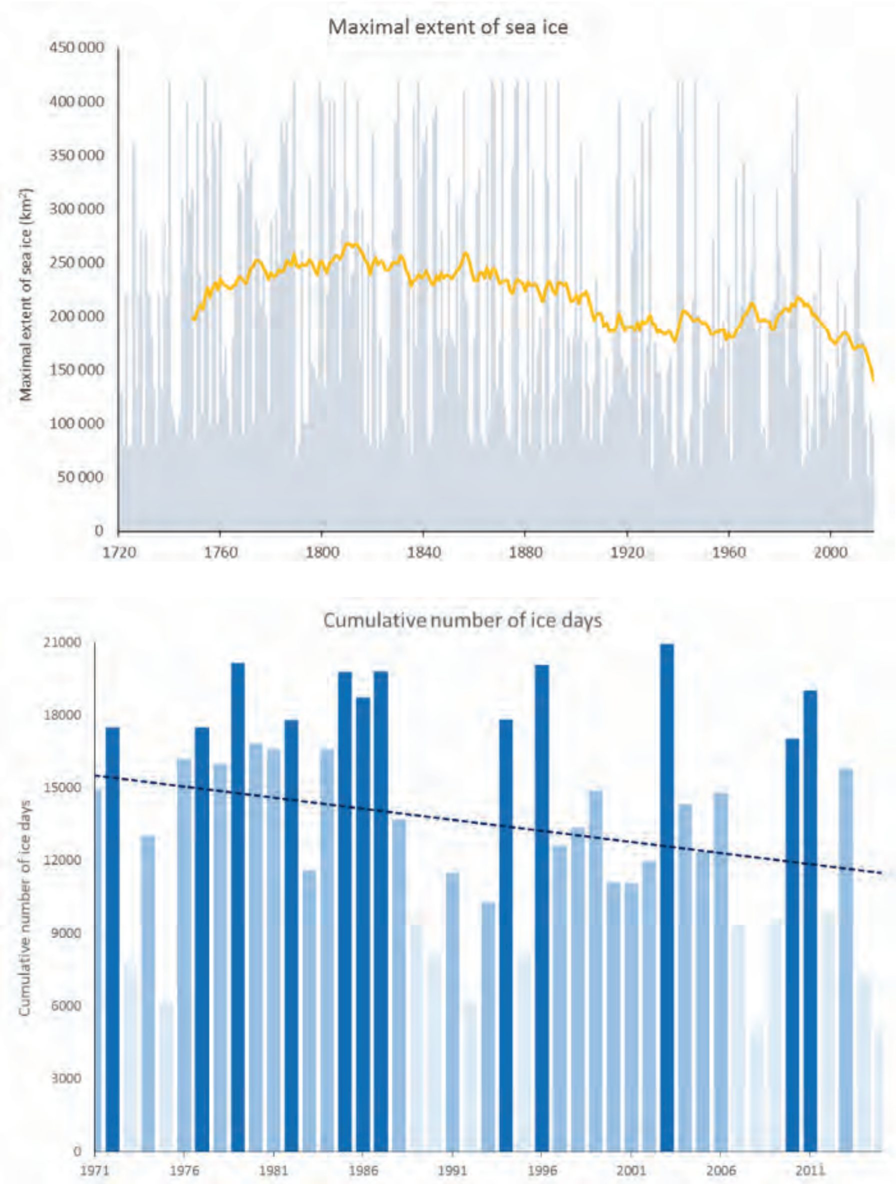


Figure 1.4. Changes over time in the maximum extent of sea ice during winter (km^2) since 1720, and in the cumulative number of ice days per winter since 1971. Yellow line shows the 30-year moving average. The extent of sea ice has clearly declined in past decades and the cumulative number of ice days show a decreasing trend. Source: Finnish Meteorological Institute.

The changing climate is also seen to affect the long term trend in water temperature (Figure 1.5), and salinity (Figure 1.6) due to increased input of freshwater to the Baltic Sea, although the large scale variability over time in temperature and salinity is also influenced by hydrodynamic factors. The increase in carbon dioxide is also expected to cause acidification, with a decreasing pH in the long term (Figure 1.7).

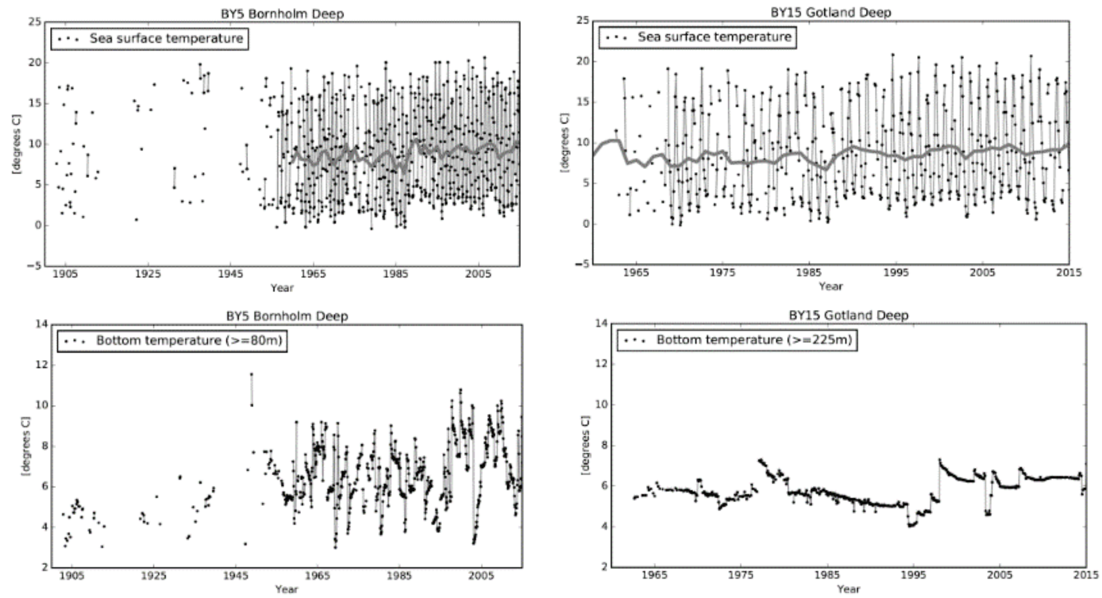


Figure 1.5. Changes over time in the seawater temperature in the Bornholm Deep and the Gotland Deep. Upper panel: The sea surface temperature oscillates over the year, approaching zero degrees in the winter and reaching 16–19 degrees in the summer. The lines show changes in the annual averages. Lower panel: In the deep water, the highest temperature recordings have been observed in recent decades in both basins. The variation in temperature in the deep water reflects the inflow of marine water from the North Sea. Based on data from the HELCOM COMBINE database.

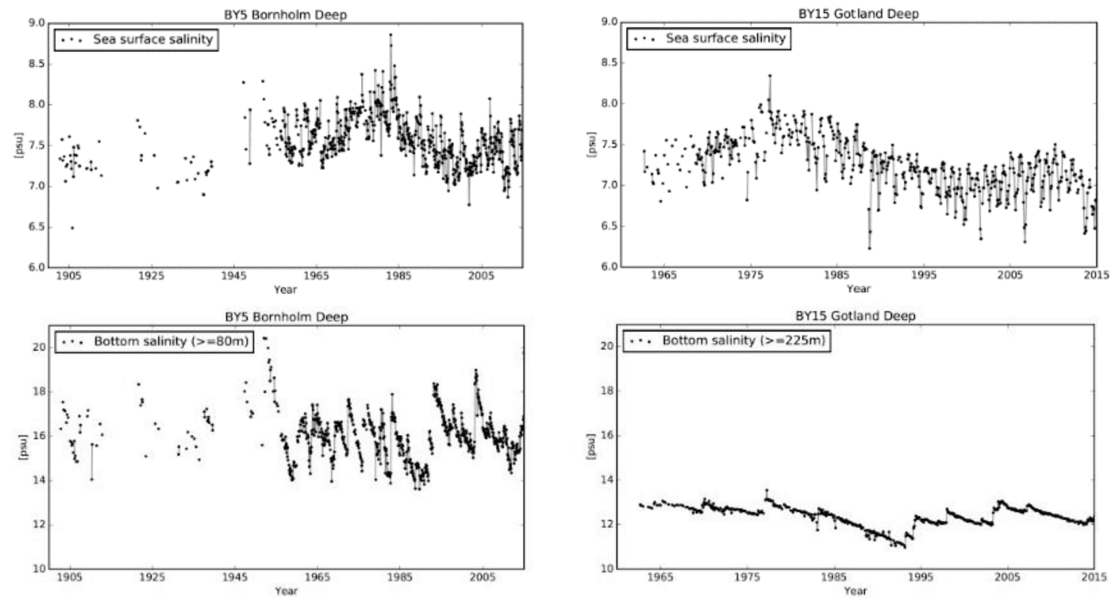


Figure 1.6. Changes over time in surface water and deep water salinity. The surface water salinity in the Bornholm Deep and the Gotland Deep, upper panel, are clearly lower now than in the 1970s. The lower panel shows the salinity in the deep water. The effects of marine water inflow are seen as oscillations, which are more pronounced inthe Bornholm Deep which is closer to the Baltic Sea entrance. Based on data from the HELCOM COMBINE database.

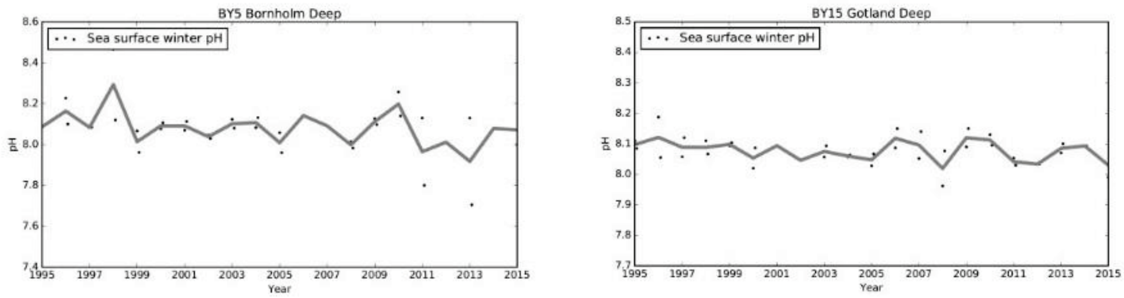


Figure 1.7. Changes in pH over time in the surface water of the Bornholm Deep and the Gotland Deep during 1995–2015, measured during winter. The line show changes in the winter averages (January and February). Based on data from the HELCOM COMBINE database.

Inflows of marine water from the North Sea occur intermittently, and lead to temporary increases in salinity in the deeper water of the Baltic Sea, as well as fluctuations in temperature (Figures 1.5–1.6). These inflows of marine water are highly important for oxygenating the deep water areas of the Baltic Sea, and for supporting the physical environment of marine species. The inflows have been rare since the 1980s, but have had a slightly higher frequency in recent years (Figure 1.8). The scarcity of high intensity inflows has been an important contributing factor to the extension of areas with poor oxygen conditions in the deep water of the Baltic Sea. The oxygen conditions are further impoverished by long term nutrient loading, leading to impacts on species and habitats.

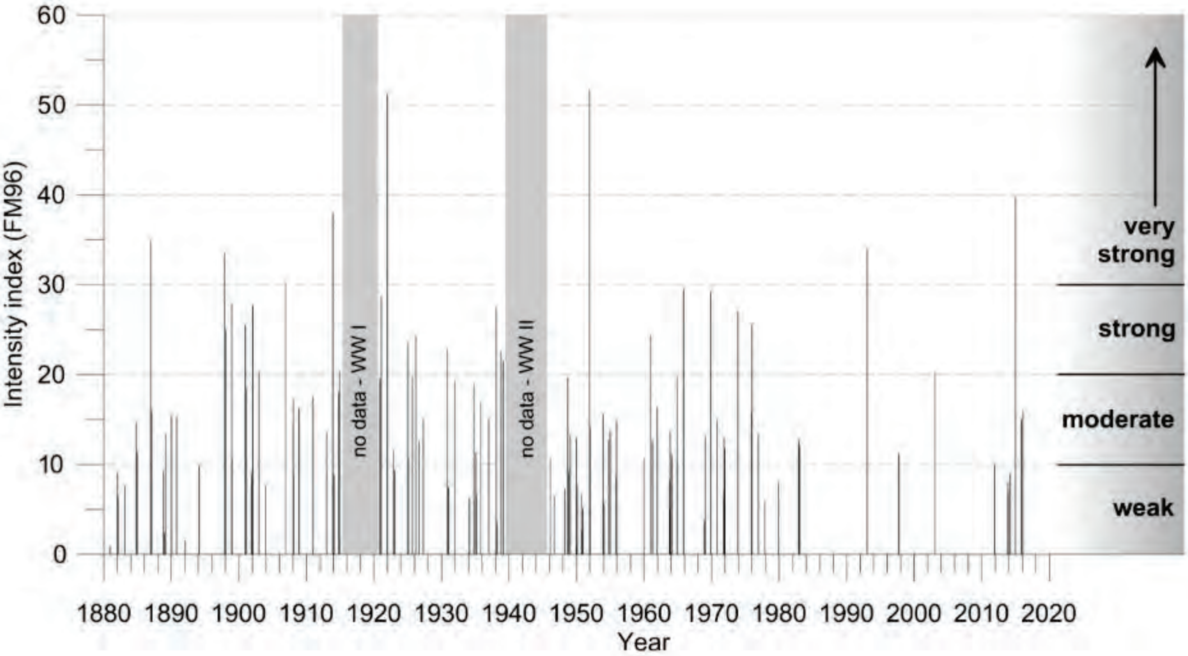


Figure 1.8. Intensity of inflow events to the Baltic Sea between 1880 and 2015. Inflows of saline water occurred regularly with six to seven events per decade until the 1980's, but their frequency has been low in recent decades. Since 2014, an intensified inflow period of several smaller events and two stronger events (so called Major Baltic Inflows) started again. The Major Baltic Inflow of December 2014 is the third largest in the history of measurements and the largest one since 1951. Source: Feistel *et al.* (2016), Mohrholz *et al.* (2015).

Figure 1.9 shows the maximum extent of oxygen deficiency in the deep-water of the Baltic Sea in the assessment period 2011–2015 (left map). Conditions of low oxygen or even anoxia are a natural phenomenon in the deeper areas of the Baltic Sea, although enhanced by nutrient loading. By contrast, seasonal oxygen deficiency in shallow areas and coastal waters is mainly steered by eutrophication. The brackish surface water layer above the halocline stays continuously oxygenated by vertical mixing and thermohaline circulation (Box 1.1).

Box 1.1 Oxygen conditions in the deeper Baltic Sea

Oxygen conditions in the deep have been improved by a series of inflow events since the end of 2013. First, a series of smaller inflow events occurred in November 2013, December 2013, and March 2014. These interacted positively and reached the deep water of the central Baltic Sea for the first time since 2003 (Naumann and Naush 2015). In December 2014, and in January 2015, a very strong inflow occurred, which transported 198 km^3 of saline water into the Baltic Sea, and was followed by smaller events. An inflow of moderate intensity also occurred between 14 and 22 November 2015. These events caused intensified oxygen dynamics in the Arkona Basin, Bornholm Basin, and Eastern Gotland Basin, but the northern parts were not affected. As a result, the near bottom oxygen concentrations in the Bornholm deep ranged from 0.08 ml/l (in November 2015) to 5.4 ml/l (in February 2015), measured at 95 m water depth. In the Gotland deep, oxygen conditions ranged from -8.75 ml/l (in November 2013) to 2.9 ml/l (in April 2015 at 235 m depth; Nausch *et al.* 2016).

Maximum ventilation occurred in May 2015. The major Baltic inflow of December 2014 caused the Bornholm Basin to become fully ventilated. Hydrogen sulphide was absent in the Gdansk Basin and Eastern Gotland Basin, and the former anoxic bottom water was replaced (See Figure 1.9, right map).

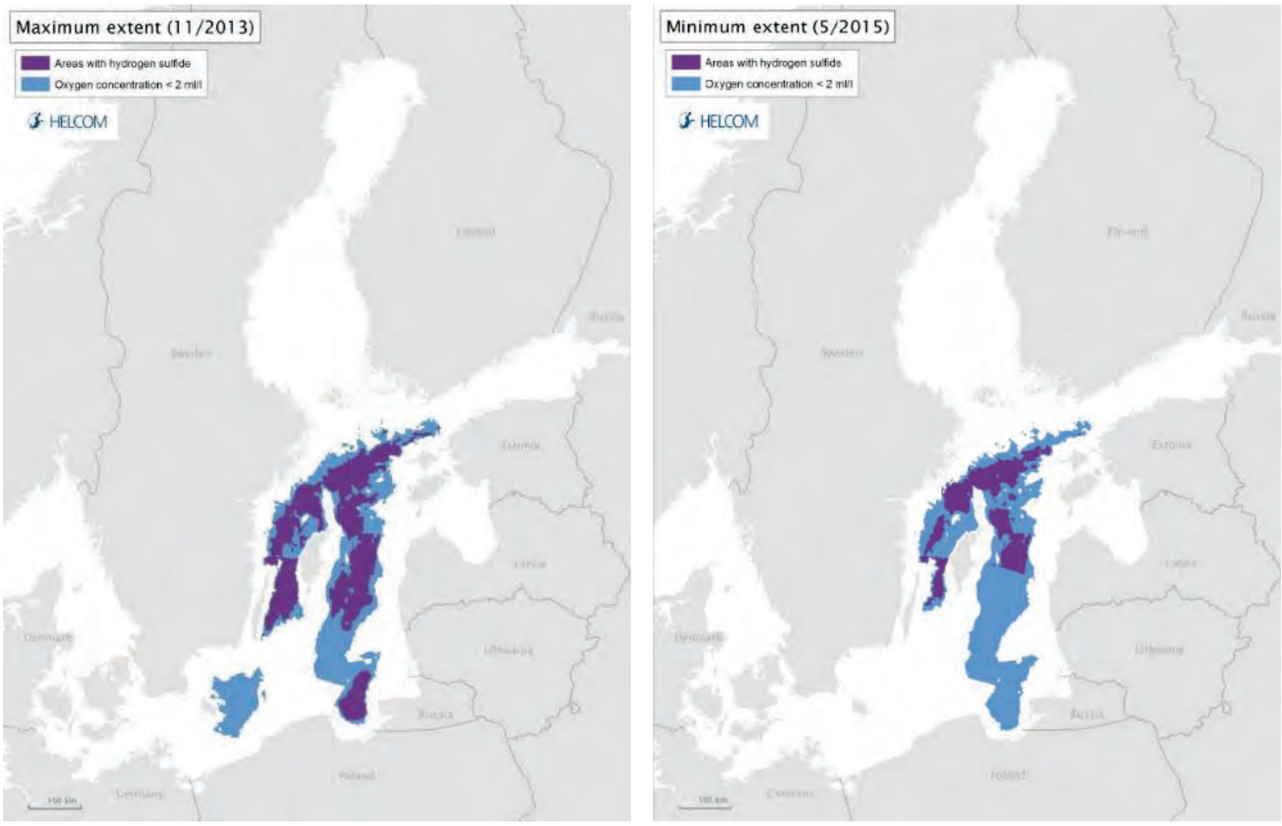


Figure 1.9. Poor oxygen conditions at the sea floor restrict productivity and biodiversity in the Baltic Sea. The maps show the minimum and maximum distribution of anoxic areas in the deep-water (where hydrogen sulphide is present) and areas with less than 2 ml/l oxygen during 2011–2015, based on point measurements and modelling. Data from Leibniz Institute for Baltic Sea Research Warnemuende. See also Feistel *et al.* (2016). Due to the range of input data used, the map may not correctly reflect the situation in the Gulf of Finland.

1.3 ENVIRONMENTAL MANAGEMENT AND THE ECOSYSTEM APPROACH

As well as being unique, the Baltic Sea is also vulnerable to environmental pressures. The long winter season limits its productivity, and the brackish water creates challenging conditions for both marine and freshwater organisms. Due to the limited water exchange with other seas, inputs of nutrients and other substances from the drainage area accumulate in the Baltic Sea and are only slowly diluted. The land-based inputs, together with pressures arising from human activities at sea, influence the status of habitats and species, and eventually also on human well-being. Typical pressures occurring in sea areas globally are also a risk to the health of the Baltic Sea, including eutrophication, contamination, marine litter, the introduction and spread of non-indigenous species, underwater sounds, fishing and hunting, as well as habitat loss and disturbance.

The ecosystem approach to management builds on incremental understanding of the effects of human-induced pressures on the environment, impacts on marine life and consequences for human well-being. In some cases the mechanisms of how species and habitats are impacted are relatively well known, but in other cases management has to be based on limited knowledge, with the aim being to increase the common level of knowledge over time. The ecosystem approach is fundamental in all HELCOM work and is used as the basis for achieving good environmental status and sustainable use of Baltic Sea resources as stated in the Baltic Sea Action Plan (HELCOM 2007). This approach sets out principles that, among others, recognizes the complexity of ecosystems. It accepts that pressures do not act in isolation and thus that management inevitably needs to consider the impacts of all relevant pressures on the marine ecosystem when managing human activities (Box 1.2). This is a challenge since management of resources, as well as regulation of human activities, tends to be localised and limited within sectors.

Box 1.2 Cumulative effects on species

One person or activity alone does not exert much pressure on the environment, but when scaled up the impact of many humans and their activities may have a considerable impact on marine species, and the different impacts act together on the environment. Additionally, single or cumulative impacts might trigger changes in the food web, with potential cascading effects further up or down in the food web.

Some species migrate far and encounter several different environments and different types of pressures during their life. Other species are local and cannot move, even if the local environment changes, and the water masses around them have travelled long distances and include substances from sources far away. The status of pressures, species and habitats is influenced by multiple connections to human activities. The linkages between human activities and pressures are outlined in Chapter 3, and the impacts of current pressures in the Baltic Sea on species and habitats are assessed using the Baltic Sea Impact index in Chapter 6. Understanding these linkages also helps reveal important knowledge gaps for setting management targets and helps us to better understand how human activities depend upon, and benefit from, marine ecosystem services.

Figure B1.2.1. Salmon eggs hatch in rivers with outflows into the Baltic Sea and spend the first parts of their lifecycle there, feeding on invertebrates and being dependent on the river water environment. After one or two years they grow into so called smolt and migrate to the Baltic Sea, where they mature into adult salmon and remain for a few years. During this time, a salmon may migrate hundreds of kilometres and encounter many different environments before returning to the river to spawn. Its health and survival is influenced by food availability, fishing pressures, and potentially also underwater sound, marine litter and the quality of available food, and it is dependent as well on the environmental quality of their spawning rivers.

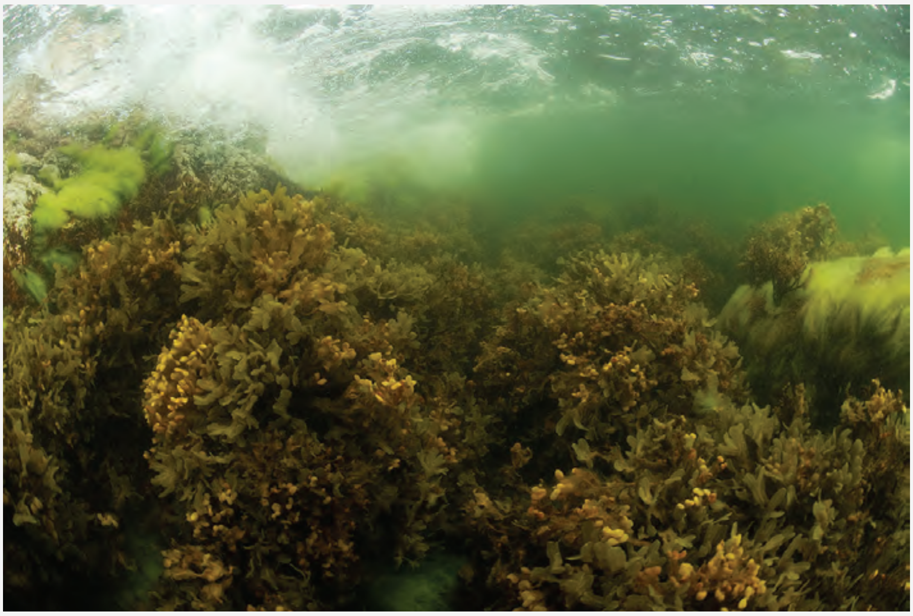


Figure B1.2.2. Bladderwrack is an important habitat-forming seaweed which colonises hard substrates in the Baltic Sea. In other seas it lives in the intertidal zone, but in the Baltic Sea it lives continuously submerged. Many small animals thrive among the structures formed by the seaweed, and it is a productive environment for small fish and benthic species. These small animals are also important for keeping the seaweed clean. The bladderwrack lives attached to the rock or other hard substrate all its life. It is sensitive to the quality of the surrounding water and hence eutrophication or changes in the food web can be damaging. When food webs are disturbed, due to a decrease of big predatory fish for example, this may also affect the number of small animals among the seaweed and the quality of this habitat.

1.4 REGIONAL COOPERATION

The Helsinki Convention encompasses the protection of the Baltic Sea from all sources of pollution from land, air, and sea based activities. It also commits the signatories to take measures to conserve habitats and biological diversity and to ensure sustainable use of marine resources. Contracting parties to the Convention are the nine countries that border the Baltic Sea and the European Union. Regional monitoring and assessments have been a core task of the inter-governmental Helsinki Commission (HELCOM), established to oversee the implementation of the Convention and to share knowledge in support of regional environmental policy.

The HELCOM Baltic Sea Action Plan (BSAP; HELCOM 2007) is a joint programme for HELCOM countries and the EU to restore the good environmental status of the Baltic marine environment by 2021. It is structured around four segments for which specific goals and objectives have been formulated; biodiversity, eutrophication, hazardous substances and maritime activities. The initial HELCOM holistic assessment (HELCOM 2010a) was the first integrated assessment made by HELCOM and provided a baseline for the BSAP implementation.

HELCOM also acts as the coordination platform for the regional implementation of the EU Marine Strategy Framework Directive (MSFD) that aims to achieve a good environmental status in European marine environments by 2020 (EC 2017a,b). Eight of nine countries around the Baltic Sea are EU Members States. Through HELCOM as the coordinating hub, the regional follow-up of the two policy frameworks can thus be met simultaneously and be carried out coherently by the countries bordering the Baltic Sea (Box 1.3).For Russia, being the only country bordering the Baltic Sea that is not an EU Member State, the Russian Maritime Doctrine defines the policy of Russia up to 2020 in the field of maritime activities. The Doctrine includes the protection and conservation of the marine environment where sustainable economic and social development, along with international cooperation, are important elements.

Other European policy frameworks, such as the Habitats Directive, Water Framework Directive and the Birds Directive (EC 1992, 2000, 2009), also share important objectives with the Baltic Sea Action Plan, for example the aim of achieving a favourable conservation status of species and habitats and good ecological quality and chemical status of coastal waters. HELCOM work is complementary to these directives and also the ecosystem based management ambitions of the Common Fisheries Policy. When relevant, and for a more complete understanding, results from assessments carried out to follow-up these policies are also used and referred to in this report. Further, the report can support follow up and implementation of other policies both on regional and global levels. It will for instance serve as a baseline scenario for implementation of the ocean-related UN Sustainable Development Goals in the Baltic Sea.

Box 1.3. Baltic Sea main policies driving the assessment

The Baltic Sea Action Plan and the Marine Strategy Framework Directive have similar goals and objectives, and thus, progress towards achieving the same regional aim, which can be assessed using the same indicators and tools. The 'State of the Baltic Sea' report covers the topics addressed by the four segments of the Baltic Sea Action Plan and its follow-up Ministerial Declarations, as well as the descriptors of the Marine Strategy Framework Directive. The assessment is organised according to Pressures on the environment (Chapter 4) and the status of Biodiversity and food webs (Chapter 5). The indicators used in the respective sub-chapters are listed in Table B.1.3.1 and Table B.1.3.2.

Marine litter and underwater sound are new components of the Baltic Sea Action Plan, taken up by HELCOM in the Ministerial Declarations (Moscow, 2010 and Copenhagen, 2013). The EU Marine Strategy Framework descriptor related to the removal of commercial fish and shellfish can be associated with the provisions of 2013 HELCOM Declaration on ecosystem-based fisheries, while hydrological conditions cannot be directly assigned to any segment of the Baltic Sea Action Plan. Maritime activities, which is a focal area of HELCOM and one of the four BSAP segments, is linked to several of the descriptors, including eutrophication, contaminants, and non-indigenous species.

Table B.1.3.1. Indicators used in Chapter 4 of this report ('Pressures'), and their relation to the segments of the Baltic Sea Action Plan (BSAP) and the descriptors of the Marine Strategy Framework Directive (MSFD). Indicators marked * have not been adopted in HELCOM yet and are currently tested. Indicators in italics are under development in HELCOM and at this time only included descriptively in the report. The indicators are presented by the segments of the Baltic Sea Action Plan: Eutrophication (green), Hazardous substances (orange) and Maritime activities (blue), and the follow-up declarations (yellow). All indicators on eutrophication and hazardous substances are also relevant for the maritime segment of the Baltic Sea Action Plan.

BSAP SEGMENT:	**Baltic Sea unaffected by eutrophication**
MSFD DESCRIPTOR:.	**5 – Eutrophication**
SUB-CHAPTER IN THIS REPORT:	**4.1 Eutrophication**
– Dissolved inorganic nitrogen – Dissolved inorganic phosphorus – Total nitrogen – Total phosphorus – Chlorophyll-a – Cyanobacterial bloom index* – Secchi depth during summer – Oxygen debt – State of the soft-bottom macrofauna community* (some areas) Coastal waters: indicators developed under the Water Framework Directive	

BSAP SEGMENT:	Baltic Sea undisturbed by hazardous substances
MSFD DESCRIPTOR:	**8 – Contaminants 9 – Contaminants in fish and seafood**
SUB-CHAPTER:	**4.2 Hazardous substances**

- Hexabromocyclododecane (HBCDD)
- Metals (Cadmim, Lead, Mercury)
- Polybrominated biphenyl ethers (PBDE)
- Polychlorinated biphenyls (PCB) and dioxins and furans
- Polyaromatic hydrocarbons (PAH) and their metabolites
- TBT and imposex
- Perfluorooctane sulphonate (PFOS)
- Radioactive substances
- White-tailed eagle productivity (coastal waters only)

BSAP SEGMENT:	Environmentally friendly maritime activities	
MSFD DESCRIPTOR:	**8. Contaminants**	**2. Non-indigenous species**
SUB-CHAPTER:	**4.2 Hazardous substances**	**4.5 Non-indigenous species**
	– Operational oil spills from ships	– Trends in arrival of new non-indigenous species

BALTIC SEA ACTION PLAN FOLLOW-UP DECLARATIONS (2010, 2013):	Prevent and reduce marine litter from land and sea-based sources	No negative impact on marine life	Maintain or restore fish stocks above levels capable of producing Maximum Sustainable Yield (MSY)	Assess impacts on the seabed
MSFD DESCRIPTORS:	**10 – Marine litter**	**11 – Introduction of energy**	**3 – Commercially exploited fish and shellfish**	**6 – Seafloor integrity**
SUB-CHAPTER:	**4.3 Marine litter**	**4.4 Underwater sound**	**4.6 Species removal by fishing and hunting**	**4.7 Seabed loss and disturbance**
	– *Beach litter* – *Litter on the seafloor* – *Microlitter*	– *Continuous low frequency anthropogenic sound* – *Distribution in time and space of loud low- and mid-frequency impulsive sound*	– Fishing mortality – Spawning stock biomass (of cod, dab, sole, herring, sprat)	*No indicator. Descriptive approach.*

Table B.1.3.2 Indicators used in Chapter 5 of this report ('Biodiversity'), relating to the biodiversity segment of the Baltic Sea Action Plan (BSAP) and descriptor 1 of the Marine Strategy Framework Directive (MSFD). Indicators marked * have not been adopted in HELCOM yet and are currently tested. Indicators in italics are under development in HELCOM and at this time only included descriptively in the report.

BSAP SEGMENT:	**Favourable status of Baltic Sea biodiversity**
MSFD DESCRIPTOR:	**1 – Biodiversity**
SUB-CHAPTER:	**5.1 Benthic habitats**
	– State of the soft-bottom macrofauna community* (some areas) – Oxygen debt
SUB-CHAPTER:	**5.2 Pelagic habitats**
	– Zooplankton mean size and total stock* – Chlorophyll-a – Cyanobacterial bloom index* – Diatom/Dinoflagellate index*
SUB-CHAPTER:	**5.3 Fish**
	– Abundance of key coastal fish species – Abundance of coastal fish key functional groups – Abundance of seatrout spawners and parr – Abundance of salmon spawners and smolt Commercial fish: indicators from ICES; – Spawning stock biomass (for cod, dab, sole, herring, sprat) – Fishing mortality (for cod, dab, sole, herring, sprat)
SUB-CHAPTER:	**5.4 Marine mammals**
	– Population trends and abundance of seals – Nutritional status of seals – Reproductive status of seals – Distribution of Baltic seals – *Number of drowned mammals and waterbirds in fishing gear*
SUB-CHAPTER:	**5.5 Waterbirds**
	– Abundance of waterbirds in the breeding season – Abundance of waterbirds in the wintering season – *Number of drowned mammals and waterbirds in fishing gear*

Chapter 2. Overview of the holistic assessment

The HELCOM State of the Baltic Sea Report has built upon experience gained from the HELCOM initial holistic assessment in 2010. This initial assessment provided for the first time a coherent assessment of the Baltic Sea ecosystem and its pressures from a holistic perspective, based on available data and prevailing knowledge. The regional development of indicators and assessment methods has continued since then and made the improvements in the current report possible. Through the HELCOM coordinated work of hundreds of experts, 28[3] *regionally agreed core indicators have been operationalised since the initial assessment, and are included in this assessment to reflect the status of the Baltic Sea environment, together with 4 indicators agreed to be used as test.*

The HELCOM holistic assessment is a multi-layered product; this summary report is supported by supplementary reports, several supporting HELCOM assessment reports, core indicator reports and spatial data fact sheets (Figure 2.1). Ninety-six spatial data sets at regional scale have been collated using regular HELCOM processes or dedicated data calls, to evaluate the geographical distribution of human activities, pressures, species and habitats.

The foundation of the assessment is the core indicators, which are based on the HELCOM coordinated monitoring programme and regionally agreed threshold values. The core indicators were assessed according to defined assessment units representing different level of detail, in a regionally agreed nested system. Four assessment unit levels were used, from coastal water bodies to the entire region, to enable assessing each core indicator at its most relevant spatial scale and making comparisons across indicators and geographical areas. Assessment tools with the core indicators were used to produce thematic integrated assessment results on hazardous substances (CHASE), eutrophication (HEAT) and biodiversity (BEAT; see Box 2.1).

The current assessment focuses on the time period 2011–2015[4]. In addition, data showing the temporal development have been provided in order to understand long-term trends and evaluate the direction of ongoing changes. The focus of the assessment has been to show results of relevance at the regional scale, and large-scale patterns between geographic areas.

[3] Not including two pre-core indicators that are currently being tested
[4] The assessment period for the updated State of the Baltic Sea report will be 2011–2016.

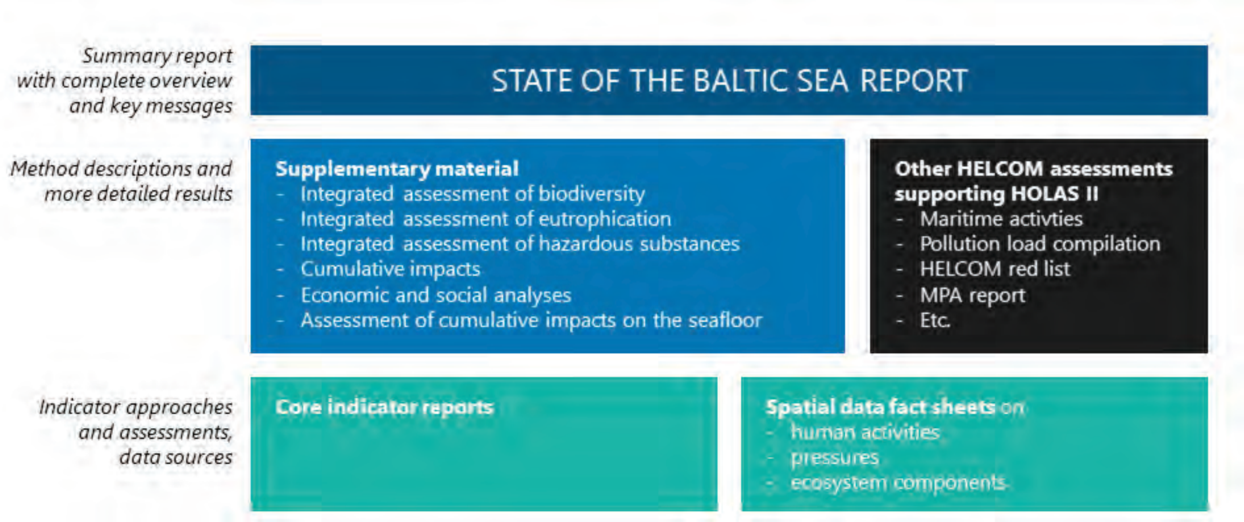


Figure 2.1. Overview of publications produced within or supporting the HELCOM second holistic assessment; State of the Baltic Sea. The supplementary material is referred to as HELCOM 2017A-F in this report. The supplementary report for cumulative impacts includes the Baltic Sea Impact index and the Baltic Sea Pressure Index. The core indicator reports are identified where they are cited in the text. Other references: Maritime Activities: to be provided; Pollution load compilation: to be provided (see also HELCOM 2015d); HELCOM red list: HELCOM 2013b; MPA report: HELCOM 2016b. All material can be downloaded at http://stateofthebalticsea.helcom.fi. The spatial data fact sheets are available at http://metadata.helcom.fi/.

Box 2.1. The core indicator based assessment

This assessment uses core indicators to measure the status of the Baltic Sea marine environment on the basis of selected and representative elements. The HELCOM core indicators cover both biodiversity and human induced pressures and impacts on the Baltic Sea ecosystem. The core indicators were selected according to a set of principles including ecological and policy relevance, measurability with the monitoring data and linkage to anthropogenic pressures (HELCOM 2013c). The HELCOM core indicators evaluate the observed status in relation to a regionally agreed threshold value, in many cases using data from regionally coordinated monitoring. Hence, the results indicate whether status is good or not according to each of the core indicators.

Furthermore, integrated assessments of biodiversity, eutrophication and hazardous substances, are made based on the core indicators using the BEAT, HEAT and CHASE assessment tools. The integrated tools were also used in the initial holistic assessment (HELCOM 2010a) and have been developed further in the second holistic assessment. The integrated assessments do not only show whether status is good or not, but also indicate the distance to good status by use of five categories; two representing good status and three representing not good status.

The assessments are performed at the spatial scale of HELCOM assessment units, which have four different levels; each core indicator being assessed at its most relevant scale. For example, birds are assessed at level 1 which is the whole region, salmon and sea trout, as well as zooplankton are assessed at level 2 which further subdivides the Baltic Sea into sub-basins. Level 3 separates the sub-basins also into coastal and offshore areas, and level 4 uses a finer subdivision of coastal areas in line with national management practices such as water bodies as designated under the EU Water Framework Directive.

The assessment is based on currently available core indicators. For some elements, operational indicators are still lacking or limited such as for benthic and pelagic habitats, health of marine mammals and food webs. The further development of core indicators to reach a more complete assessment is a prioritised HELCOM activity.

Chapter 3. Human activities and the ecosystem

Every one of us has a personal relationship with the Baltic Sea marine environment. We gain benefits when we use the sea for recreation and transportation, we harvest its resources, and some of us obtain direct employment and income from marine activities. The uses influence the state of the environment, sometimes reducing its ability to provide goods and services for human well-being. The importance of the Baltic Sea marine environment to society, to national and regional economies and for the well-being of current and future generations is shown by economic and social analyses, illustrating that use of marine waters brings significant contribution to the economies and the welfare of citizens.

Hundreds of years ago, fishing was vital for the survival of people around the Baltic Sea, often combined with farming and hunting. Shipping played an essential role in the transportation of people and goods. These activities are still of key importance today, although hunting is no longer a source of livelihood. More advanced technology is used and the traditional usages of the sea are accompanied by new ones, such as offshore energy production, extraction of sand and gravel, aquaculture, and tourism and recreation. Overall, the presence of human activities has increased, and more parts of the sea are accessible to human activity.

Activities in the Baltic Sea and its coastal areas bring employment and economic benefits to national economies, and also affect people's welfare directly, for example, by providing recreational space. The first holistic assessment included some case study results of the costs and benefits of improving the state of the Baltic Sea (HELCOM 2010a). The present assessment deepens our understanding of the connection between the marine environment and human welfare, by presenting regional economic and social analyses of these impacts, both from the use of marine waters and deterioration of the marine environment (see also supplementary report: HELCOM 2017A).

The economic contribution from the current use of marine waters is measured by economic and social indicators (Box 3.1). In this report, the economic contribution from the following activities is included: fish and shellfish harvesting, marine aquaculture, tourism and leisure (including recreation), renewable energy generation, and marine transport and infrastructure. The activities are selected based on data availability, with the aim of presenting data that is regionally representative. They also represent a subset of human activities that are of importance in the Baltic Sea as either well-established or emerging (Figure 3.1). These human activities are described in more detail in the forthcoming HELCOM Maritime Assessment.

Box 3.1: Use of marine waters: Economic benefits from the use of the sea

Economic and social analysis of the use of marine waters examines the economic contribution to regional and national economies from using marine waters in their current state. This contribution is measured with economic and social indicators. These indicators describe the importance of the marine activities to the economy, for example by estimating 'value added' or 'employment', or the direct economic value from the use of the marine environment to the citizens' living in the coastal countries. In this report, the information is derived mainly from existing statistics, except for marine and coastal recreation, where statistics are complemented with data on economic value to citizens.

The indicators do not capture the negative economic impacts that marine uses may have on the quality of the marine environment and thus potentially on other uses of the marine environment, but are a piece of the overall picture of how society and the marine environment are linked.

Further improving our understanding of the economic contribution from marine activities will require harmonised data across all coastal countries, reporting data separately for different sea areas (Baltic and North Seas), and differentiating between land activities, freshwater activities and marine activities, particularly for tourism.

3.1 ACTIVITIES, PRESSURES, AND WELFARE IMPACTS

Human activities in the Baltic Sea and in its surroundings are responsible for pressures on the environment. The size of the catchment area of the Baltic Sea is four times the size of its surface area, and is currently inhabited by around 85 million people. Inputs from human activities in the catchment area, such as nutrient loading and release of hazardous substances, add to pressures from human activities at sea, causing cumulative impacts to the status of the marine environment.

Environmental management to reduce pressures from human activities and minimize negative impacts needs to take into account the complexity of linkages. Typically, one human activity may give rise to a number of pressures, with different impacts on the environment, and one pressure may reflect the sum from several human activities. Current important pressures on the Baltic Sea environment are shown in Figure 3.1, together with links to the many human activities that may contribute to them. The figure reflects the multiple ways in which pressures may enter the marine environment and impact on species, habitats and human well-being.

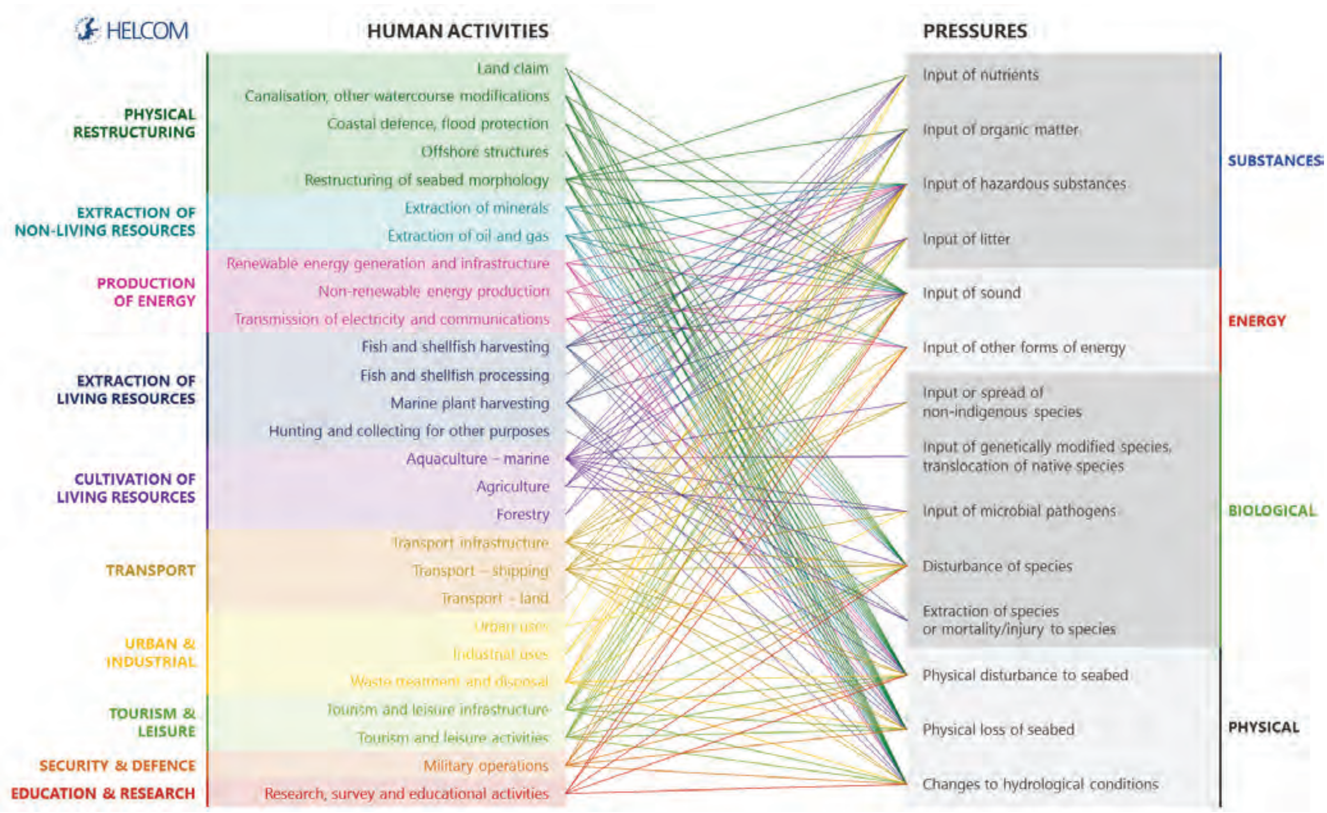


Figure 3.1. Human activities in the Baltic Sea and their connection to pressure types. The lines show which pressures are potentially induced by a certain human activity, without inferring the magnitude of the pressure in each case, nor its potential impacts on the environment. The figure illustrates the level of complexity potentially involved in the management of environmental pressures.

The ways in which pressures may affect species and habitats are sometimes well-known but often include indirect or cascading effects, so that impacts on one species may lead to secondary impacts on other species. From the perspective of human welfare, the deterioration of the environment decreases the economic contribution from human activities that are dependent on the state of the sea, and also reduces the value that people place on the marine environment. Cost of degradation analysis measures the reduction in human welfare caused by the deterioration of the marine environment (Box 3.2). The relationship between the two components of economic and social analyses (the use of marine waters and cost of degradation) is outlined in a simplified way in Figure 3.2.

Box 3.2 Losses in human well-being from the degradation of the marine environment

Degradation of the environment causes many adverse effects that reduce the economic benefits (or welfare) that people obtain from the marine environment, including increased water turbidity and more frequent blue-green algal blooms, reduction and changes in fish stocks, contamination of fish and seafood, increased litter on the beaches and in the sea, and loss of marine biodiversity. The benefits that are lost if the sea does not reach a good environmental status are called the cost of degradation (see Figure B3.2.1).

The losses in human welfare can be assessed in monetary terms based on economic valuation studies that estimate the effect on citizens' benefits from changes in the quality of the marine environment. The focus can be either on degradation themes, such as eutrophication, or ecosystem services, such as recreation.

Baltic Sea wide studies with value estimates for each coastal country give the best estimates at regional level. When no such data are available, value transfer can be used, so that estimates from a subset of Baltic Sea countries are transferred also to other countries. Results from currently available analyses are presented in this chapter for recreation (Box 3.3), in Chapter 4.1 for eutrophication (Box 4.12) and in Chapter 5.6 for selected biodiversity aspects (Box 5.6.1; see also supplementary report: HELCOM 2017A).

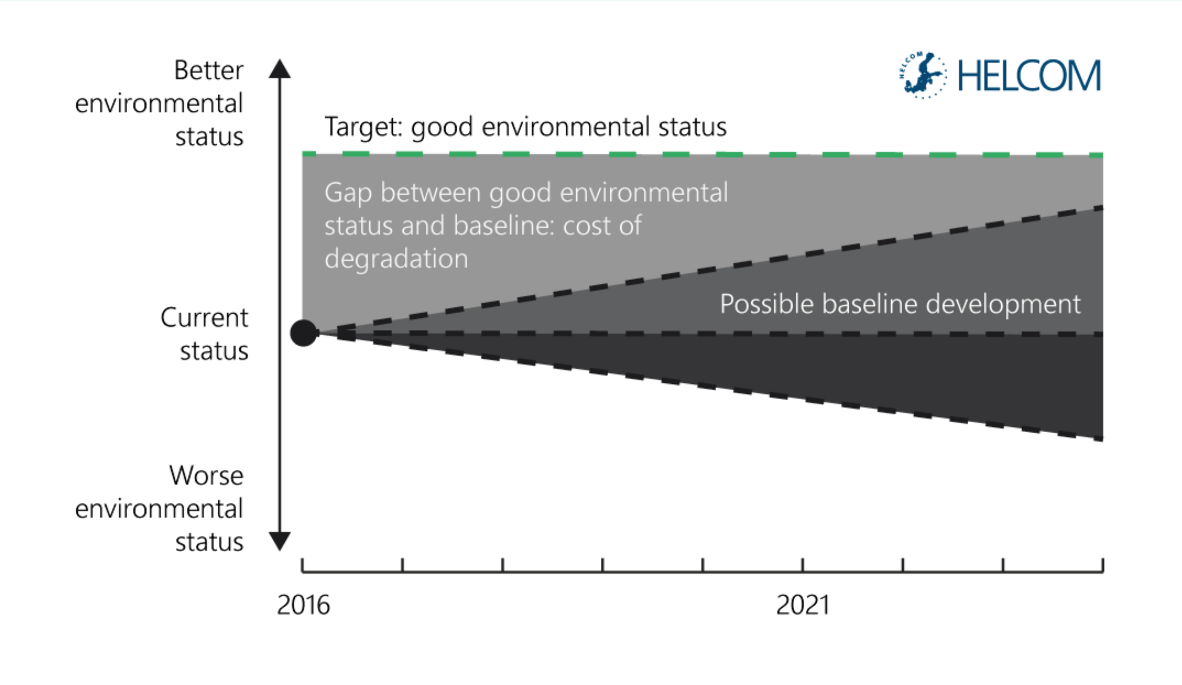


Figure B3.2.1. Illustration of the cost of degradation concept. Cost of degradation results from the difference between the current/baseline environmental status and the good environmental status.

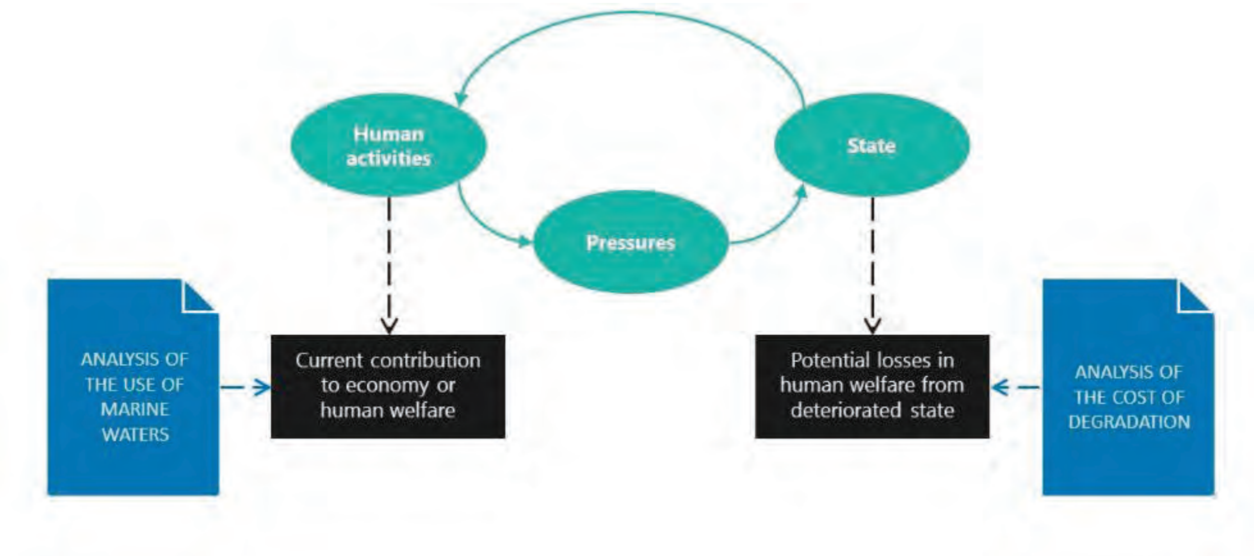
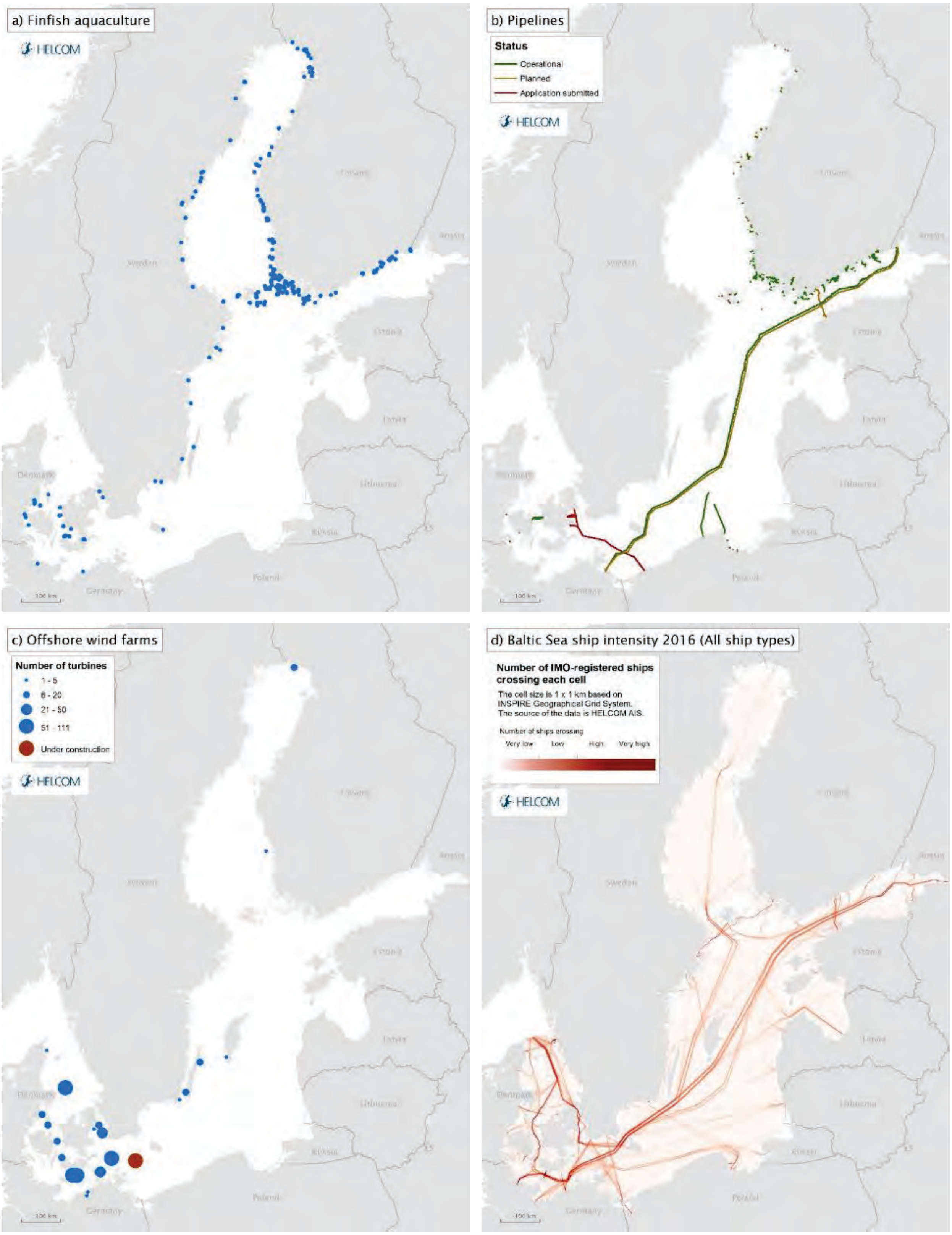


Figure 3.2. Roles of economic and social analyses in the holistic assessment. The human activities contribute to the national and regional economies and human welfare, which is measured in the economic and social analysis of the use of marine waters (Box 3.1). The state of the marine environment affects human welfare. The welfare losses from not being in a good environmental status are estimated in the cost of degradation analysis (Box 3.2). The status also affects the economic contribution from many activities, such as recreation and fish and shellfish harvesting, as shown by the link back from 'state' to 'activity'.

Data to simultaneously assess both components is currently scarce at the regional scale, but one example is provided in Box 3.3. The results from the study (Czajkowski *et al.* 2015) show the current value of marine and costal recreation to be around 15 billion euros annually, and the relative loss of value caused by deterioration of the environment to be around 1–2 billion euros each year.

Examples of human activities of importance in the Baltic Sea and their spatial distribution are shown in Figure 3.3.


a) Finfish aquaculture
HELCOM
b) Pipelines
Status
Operational
Planned
Application submitted
HELCOM
c) Offshore wind farms
Number of turbines
1 - 5
6 - 20
21 - 50
51 - 111
Under construction
HELCOM
d) Baltic Sea ship intensity 2016 (All ship types)
Number of IMO-registered ships crossing each cell
The cell size is 1 x 1 km based on INSPIRE Geographical Grid System. The source of the data is HELCOM AIS.
Number of ships crossing
Very low
Low
High
Very high
HELCOM

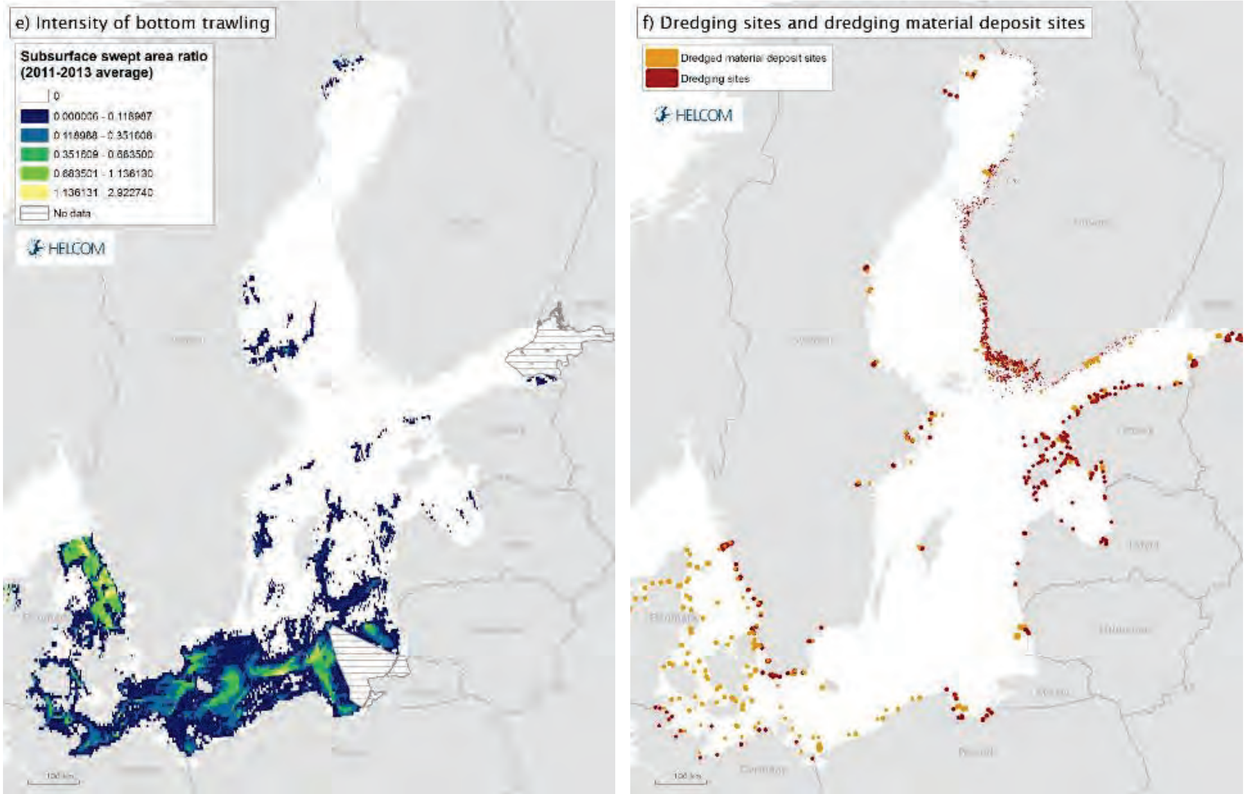


Figure 3.3. Examples of human activities of importance in the Baltic Sea and their spatial distribution: a) finfish aquaculture sites, b) location of pipelines, c) location of offshore wind farms, d) shipping intensity, and e) intensity of bottom trawling, f) dredging sites and dredging material deposit sites. The spatial distribution of the activities are dependent, for example, on the distribution of underlying resources and topography. Fishing activities have the highest intensity in areas where the target species are most abundant, depth and seabed properties determine suitable locations for sand extraction or wind farms, and shipping routes need to be planned in relation to travel distances and safety. However, the distribution of certain activities, such as aquaculture, is a result of regulatory and cultural differences. Marine spatial planning has an emerging role in using these different aspects to manage human activities at sea, as well as mitigating negative effects on the environment.

Box 3.3 Example of economic and social analyses: recreation

Marine and coastal recreation is an activity which is dependent on the state of the Baltic Sea environment. Thus, it is possible to assess both the current economic value of recreation, and the losses in recreation values due to the deterioration of the marine environment. Results are available from a recent extensive study on Baltic Sea recreation that covers all coastal countries (Czajkowski *et al.* 2015).

The value of current Baltic Sea recreation visits represents the economic benefits from the activity. The estimates are based on information about travel costs and the number of recreational visits people make to the Baltic Sea and its coast. They measure the total value of Baltic Sea recreation visits during a year. The total recreational benefits of the Baltic Sea are around 15 billion euros annually (Table B3.1).

Table B3.1. Annual value of marine and coastal recreation and average number of annual recreational trips to the Baltic Sea. Data from the year 2010. Source: Czajkowksi *et al.* (2015).

Country	Annual value of Baltic Sea recreation visits (million EUR)	Average number of annual recreational visits to the Baltic Sea per person
Denmark	720	6.0
Estonia	150	1.8
Finland	1 040	4.0
Germany	5 140	1.2
Latvia	110	2.6
Lithuania	190	1.7
Poland	2 070	1.1
Russia	940	0.5
Sweden	4 430	6.4
TOTAL	**14 790**	

The losses in Baltic Sea recreation values due to the deterioration of the marine environment are measured based on a change in citizens' recreation values from a one-step change in the perceived status of the Baltic Sea marine environment. The perceived environmental status was measured on a 5-step scale from 'very bad' to 'very good', with the average being 'neither bad nor good', and thus, a one-step change means an improvement from 'neither bad nor good' to 'rather good'. The change in recreation values stems from the predicted change in the expected number of trips to the Baltic Sea when the perceived environmental conditions change, based on econometric modelling. The losses of recreation values due to the deterioration of the marine environment are estimated to be 1–2 billion euros annually (see Figure B3.3.1).

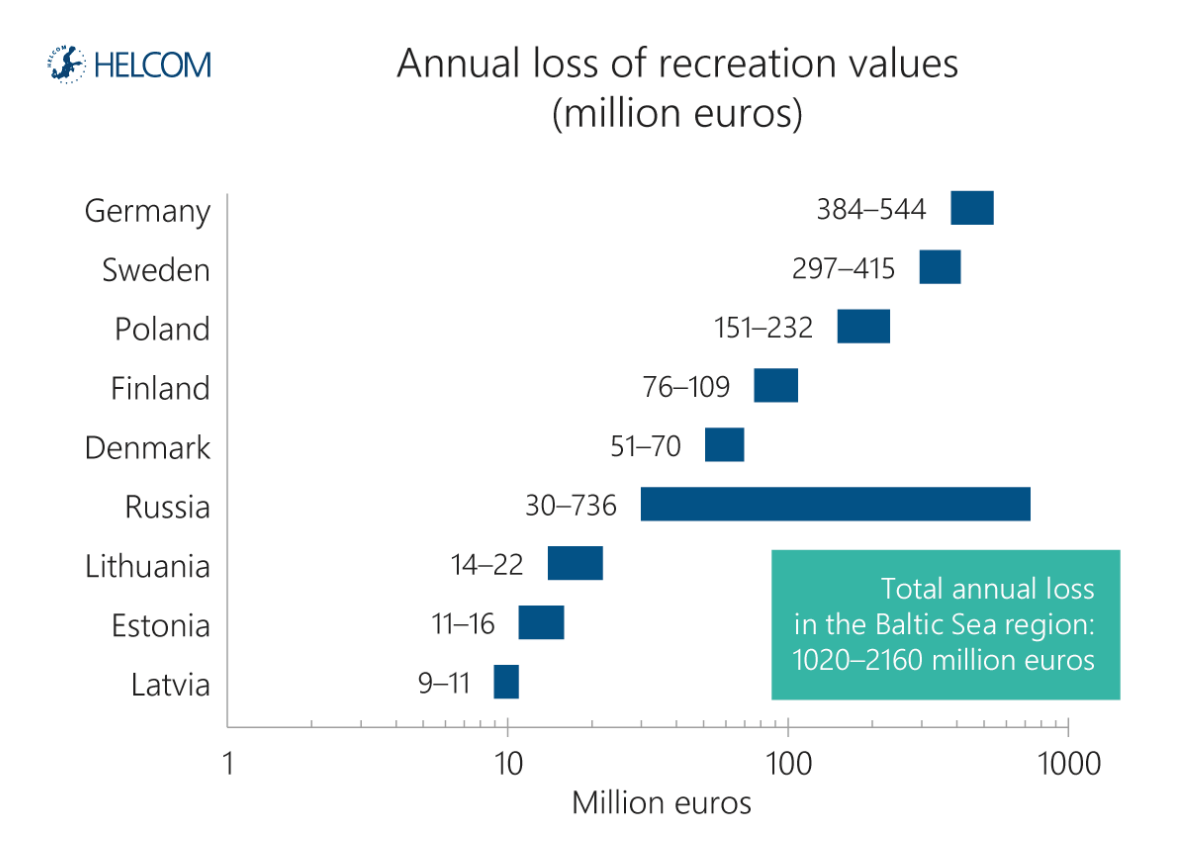


Figure B3.3.1 Lost recreation benefits due to deterioration of the marine environment. The total losses of recreation values are 1–2 billion euros annually for the Baltic Sea region. Value estimates are in purchasing power parity adjusted 2015 euros. Source: Czajkowski *et al.* (2015).

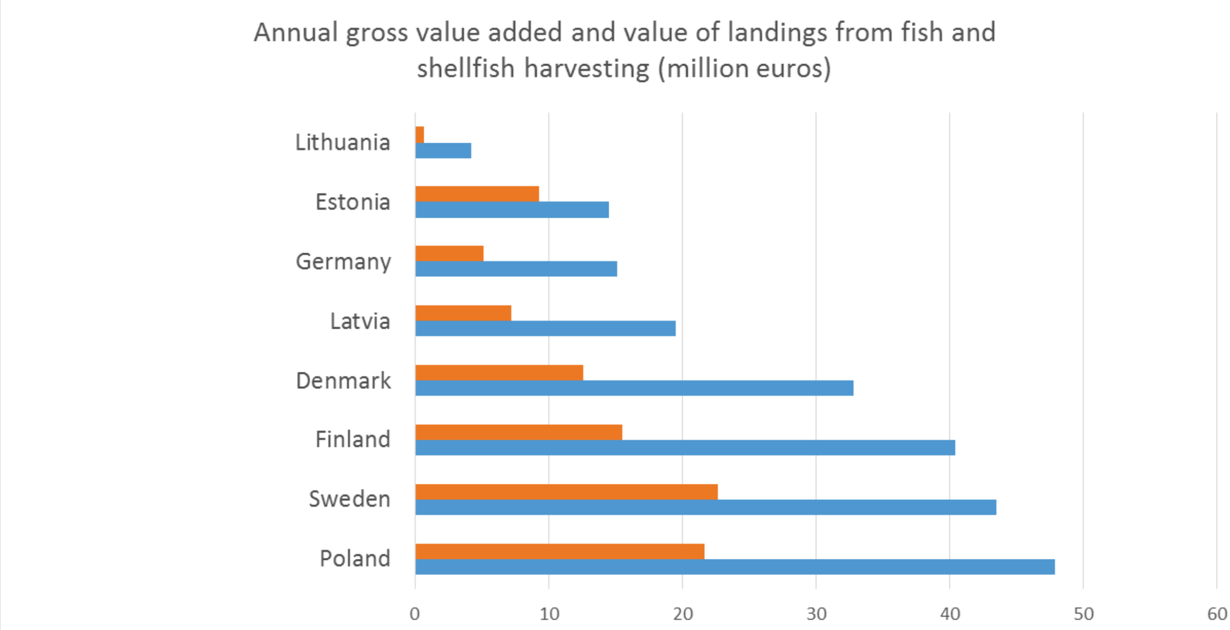
3.2 USE OF BALTIC MARINE WATERS

Fish and shellfish harvesting

Fish and shellfish harvesting is a sector involved in the extraction of living resources. The socio-economic data describes commercial small-scale and large-scale fleet fishing which takes place within the Baltic Sea waters. The small-scale fishing fleet uses vessels shorter than twelve meters, while the large-scale fleet includes vessels larger than twelve meters. The data originates from the 2016 Annual Economic Report on the EU Fishing Fleet (STECF 2016a), for all countries except Russia. Due to the reduced number of vessels and/or enterprises in Germany and the Baltic States, data which are considered sensitive (on distant-water fleets) were not delivered to STECF. This has an impact on the regional level analysis.

The number of active vessels in the Baltic Sea was estimated at 6 500 in 2014, and 6 256 in 2013 (STECF 2015). The Finnish fleet was the largest (1 764 vessels). Among the EU Member States, Estonian, Finnish and Latvian marine fisheries are fully dependent on the Baltic Sea region, while other EU Member States vessels operate also in other marine fishing regions. Only vessels operational in the Baltic Sea are included in the statistics (Figures 3.4 and 3.5). The value of landings in the Baltic Sea region totalled 218 million euros in 2014, compared to 260 million euros in 2012. The highest total values for fish and shellfish landed by national fleets from the Baltic Sea waters were by the Polish, Swedish and Finnish fleets, and the lowest total values by the Estonian and Lithuanian fleets. The value of landings is similar in size to the value of estimated revenue.

The gross value added for the Baltic Sea area was 95 million euros in 2014 compared to 121 million euros in 2012. The highest values were for Sweden and Poland, and the lowest values for Lithuania and Germany. In terms of employment, the commercial fishing sector related to the Baltic Sea waters employs an estimated 9 450 people. It should be noted that the full-time equivalent employment is almost half of this number (5 076), as the full-time equivalent estimates are different from the number of persons employed in all countries other than Poland. Poland, Estonia and Finland have a clearly higher number of persons employed in their fleets operating in the Baltic Sea region, compared to the other countries. There is employment also in related sectors, such as fish and shellfish processing, but this is not covered in Figure 3.5. The spatial distribution of fish harvesting in the Baltic Sea is illustrated in Figure 3.6 by the spatial distribution of commercial landings of cod, herring and sprat.



	Poland	Sweden	Finland	Denmark	Latvia	Germany	Estonia	Lithuania
Estimated annual gross value added (million euros)	21,7	22,7	15,5	12,6	7,2	5,1	9,3	0,7
Annual value of landings (million euros)	47,9	43,5	40,4	32,8	19,5	15,1	14,5	4,2

Figure 3.4. Economic indicators related to fish and shellfish harvesting (data from the year 2014). Source: Scientific, Technical and Economic Committee for Fisheries (STECF 2016a). All monetary values have been adjusted for inflation; constant prices (2015). STECF does not report on Russia.

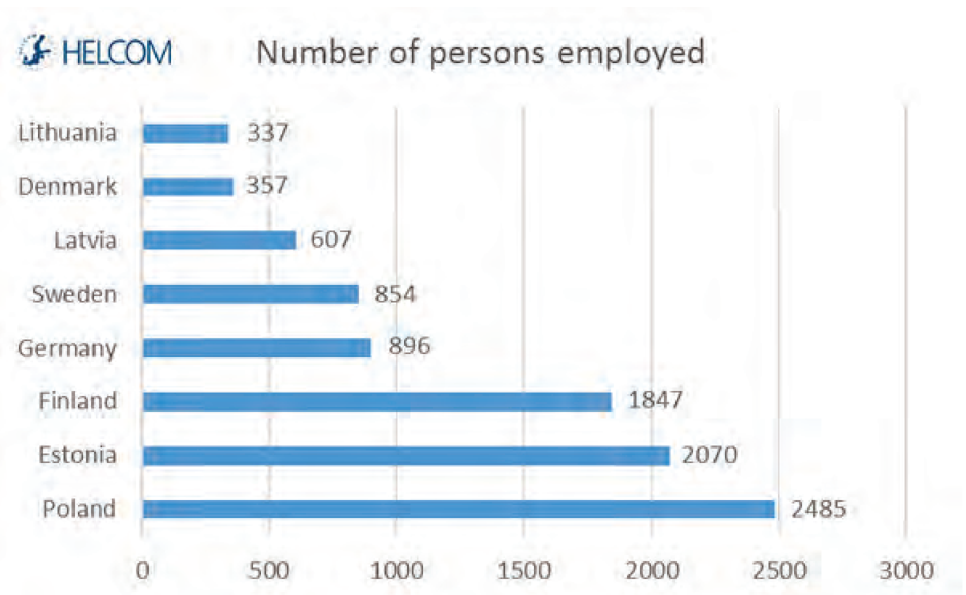


Figure 3.5. Employment in fish and shellfish harvesting (data from the year 2014). Source: Scientific, Technical and Economic Committee for Fisheries (STECF 2016a). All monetary values have been adjusted for inflation; constant prices (2015). STECF does not report on Russia.

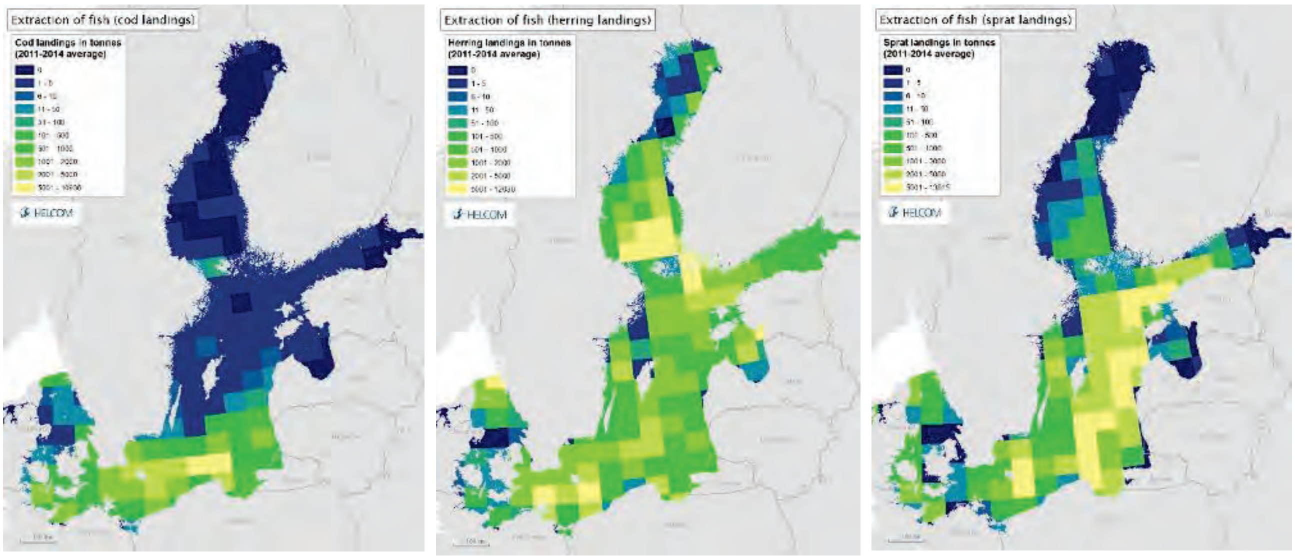
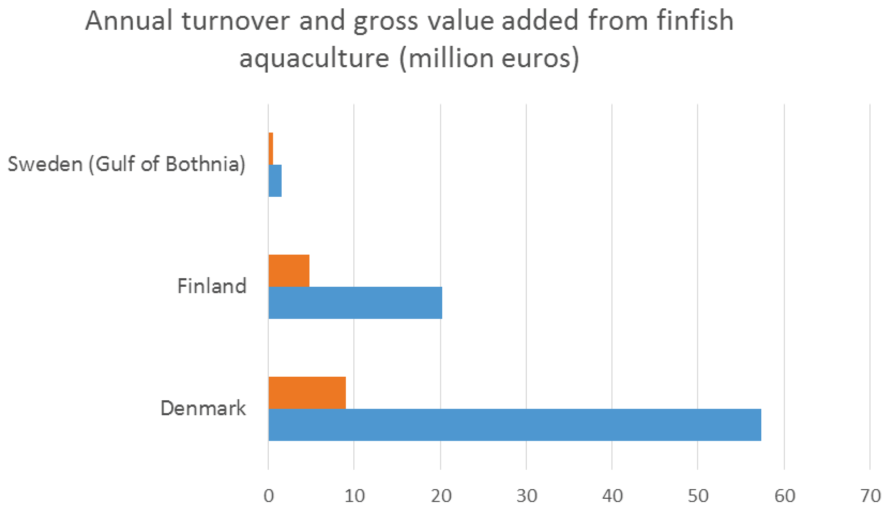


Figure 3.6. Spatial distribution of commercial landings of cod, herring and sprat in the Baltic Sea.

Marine aquaculture

Marine aquaculture is a sector involved in the cultivation of living resources in the marine environment. Economic impacts from aquaculture are presented only for Finland, Denmark and Sweden (STECF 2016b, Statistics Sweden 2017). There is one finfish and one shellfish farm in the German waters of the Baltic Sea, but the production volumes and other types of economic data are confidential, and thus there is information only on the location of the farms. For all the other countries, the production is assumed to be zero (and thus the turnover, gross value added and employment), based on the national production and sales data reported to the European Scientific, Technical and Economic Committee for Fisheries (STECF). Shellfish aquaculture is not included in the figures. Of the Baltic Sea countries, Denmark, Germany and Sweden are involved in shellfish aquaculture, but it has a lower significance in the Baltic Sea than finfish aquaculture. For example, Denmark produces blue mussels in the Baltic Sea with an annual turnover of 1.3 million euros.

Marine finfish aquaculture had a total turnover of 79 million euros in 2014, divided mainly between Finland and Denmark (Figure 3.7). The whole value for Denmark, Finland and Sweden can be attributed to the Baltic Sea. In Denmark, marine production of rainbow trout and trout eggs in sea cage farms is the second most important type of aquaculture after land based production of trout. The Danish marine production of rainbow trout is located in the Baltic Sea along the southern cost of Jutland and a few production sites along the cost of Zealand. In Finland, marine aquaculture consists of rainbow trout production in cages.



	Denmark	Finland	Sweden (Gulf of Bothnia)
Annual gross value added (million euros)	9	4,8	0,535
Annual turnover (million euros)	57,4	20,2	1,6

Figure 3.7. Economic indicators related to finfish aquaculture (data from the year 2014). Sources: for Finland and Denmark: STECF 2016b, for Sweden: SwAM 2017.

Tourism and leisure

The coastal and marine tourism sector covers a wide range of sub-sectors including accommodation, food and drink, and leisure activities, such as boating and fishing. In many cases, it is difficult to separate the extent of the Baltic Sea tourism from tourism that is not dependent on the marine and coastal environment, as the activities are not limited only to those which take place in the sea, but also includes those at the coast. However, marine tourism and recreation are dependent on the state of the sea, which is not true for all tourism activities taking place along the coast.

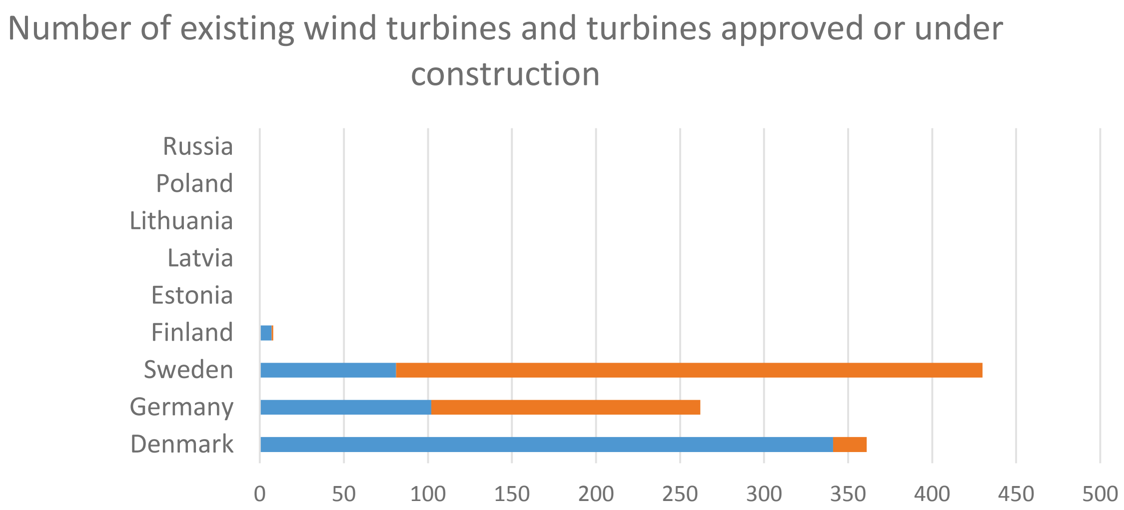
The tourism sector is an important employer, providing employment to almost 180 000 people in the coastal areas (Eurostat defines coastal areas as 'municipalities bordering the sea or having half of their territory within 10 km from the coastline' (Eurostat 2016a, 2016b). However, all of this employment cannot be attributed to the Baltic Sea, as only a portion of tourism in coastal areas is dependent on the marine environment. Information about the economic importance of Baltic Sea recreation is presented in Box 3.3. The total recreational benefits of the Baltic Sea are around 15 billion euros annually.

Renewable energy generation

Offshore wind energy is a sub-sector of the renewable energy production sector which takes place in the sea. Offshore wind energy refers to the development and construction of wind farms in marine waters and the conversion of wind energy into electricity (EC 2013a). It is a new industry that is considered to have significant growth potential.

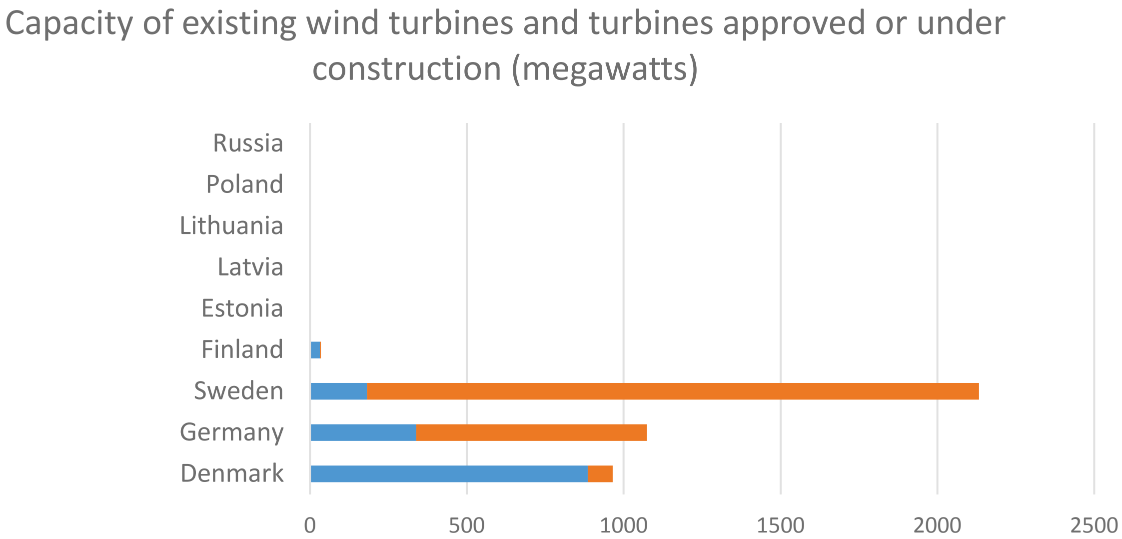
For offshore wind energy, non-monetary figures are used to describe the sector as there are no other socio-economic indicators available. The number and capacity of existing offshore wind turbines show the current situation, while the offshore wind turbines approved or under construction illustrate future development (Figures 3.8 and 3.9). In addition to these, there are dozens of proposed windfarm areas for the Baltic Sea. For example, according to the data, there are no existing offshore wind turbines in Poland, but 40 have been proposed.

While the data have been accepted by the countries, the year the data originates from is not clear in all cases. This makes the numerals on the planned wind turbines rather uncertain.



	Denmark	Germany	Sweden	Finland	Estonia	Latvia	Lithuania	Poland	Russia
Number of existing offshore wind turbines	341	102	81	7	0	0	0	0	
Number of offshore wind turbines approved or under construction	20	160	349	1					

Figure 3.8. Number of existing offshore wind turbines and turbines approved or under construction. Source: HELCOM (2017a). Empty data cells indicate missing information.



	Denmark	Germany	Sweden	Finland	Estonia	Latvia	Lithuania	Poland	Russia
Capacity of existing offshore wind power (megawatts)	885	339	182	32	0	0	0	0	
Capacity of offshore wind turbines approved or under construction (megawatts)	80	735	1951	3					

Figure 3.9. Capacity of existing offshore wind turbines and turbines approved or under construction in megawatts. Source: HELCOM (2017a). Empty data cells indicate missing information.

Marine transport and related infrastructure

Marine transport can be divided into transport infrastructure and shipping, which includes both shipping of passengers and freight. These two sectors are interrelated as shipping utilises transport infrastructure.

Transport infrastructure includes ports, as well as activities done in relation to ports, such as dredging, cargo handling, and the construction of water projects. The shipping transport infrastructure can be seen to cover shipbuilding and repair industry. Some data are available for all coastal countries, and some for the EU Member States.

Transport infrastructure

There is no monetary data available for evaluating transport infrastructure (ports). In many countries, port authorities are public bodies and economic statistics are not available for this sector. Transport infrastructure is characterised with non-monetary data, including the number of ports, total port traffic, gross weight of goods handled in all ports and passengers embarking and disembarking in all ports (Figures 3.10, 3.11, and 3.12). As there is no harmonised reporting method between countries, some countries report ports which belong to a cluster individually and others as a cluster (Wahlström *et al.* 2014).

While Russia has a low number of ports in the Baltic Sea compared to Finland and Sweden, it has the three largest ports in terms of total traffic. Also, most of the high traffic ports are on the Eastern part of the Baltic Sea (Wahlström *et al.* 2014).

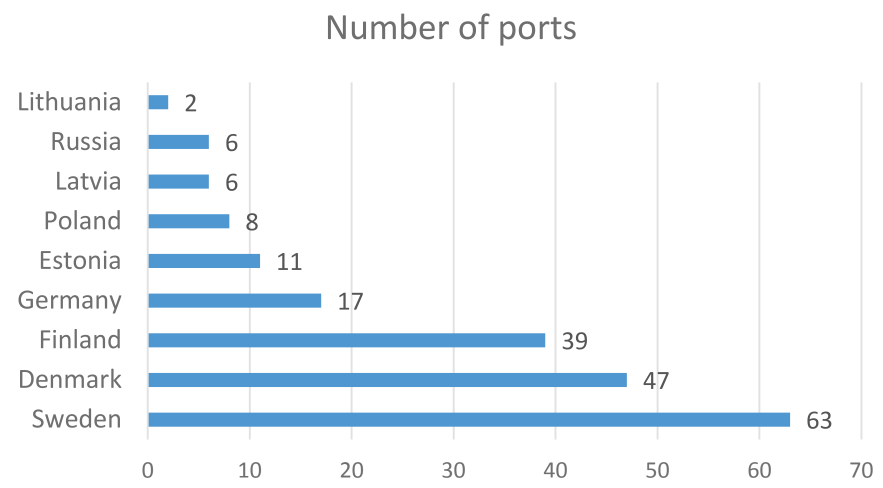
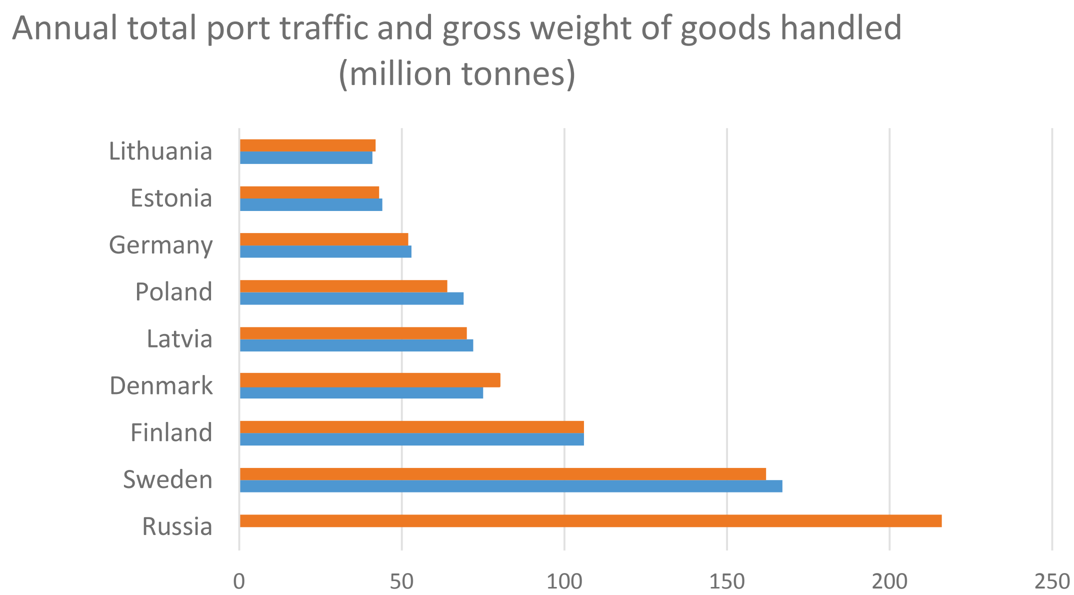


Figure 3.10. Number of ports in the Baltic Sea in 2013. Source: Wahlström *et al.* (2014).



	Russia	Sweden	Finland	Denmark	Latvia	Poland	Germany	Estonia	Lithuania
Total port traffic (million tonnes, 2013)	216	162	106	80	70	64	52	43	42
Gross weight of goods handled in all ports (million tonnes, 2014)		167	106	75	72	69	53	44	41

Figure 3.11. Annual total port traffic and gross weight of goods handled in all ports (million tonnes). Sources: For 'Total port traffic': Wahlström *et al.* (2014), for 'Gross weight of goods handled in all ports': Eurostat (2016c), except for Denmark (Statistics Denmark 2017) and Germany (Federal Statistical Office of Germany 2017a). Empty data cells indicate missing information.

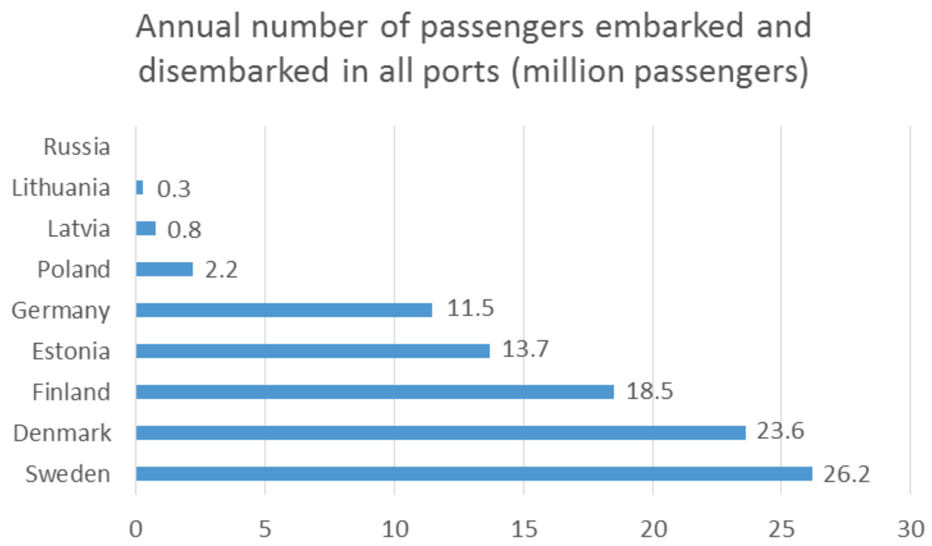
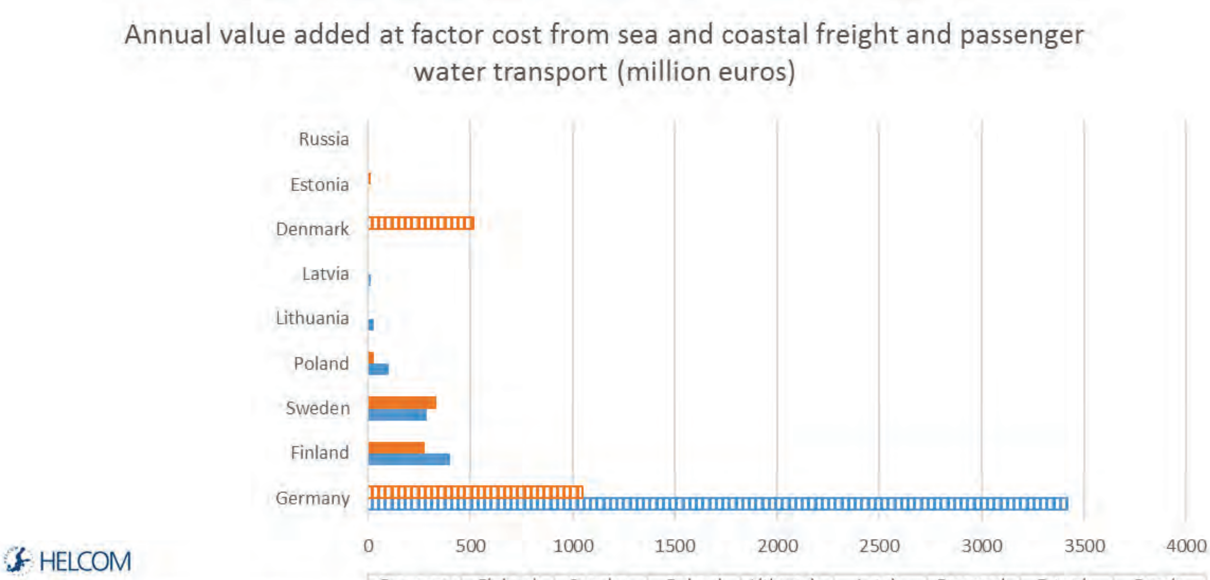


Figure 3.12. Annual number of passengers embarked and disembarked in all ports (million passengers, 2014). Source: Eurostat (2016d), except Denmark (Statistics Denmark 2017) and Germany (Federal Statistical Office of Germany 2017b). Empty data cells indicate missing information.

Transport – shipping

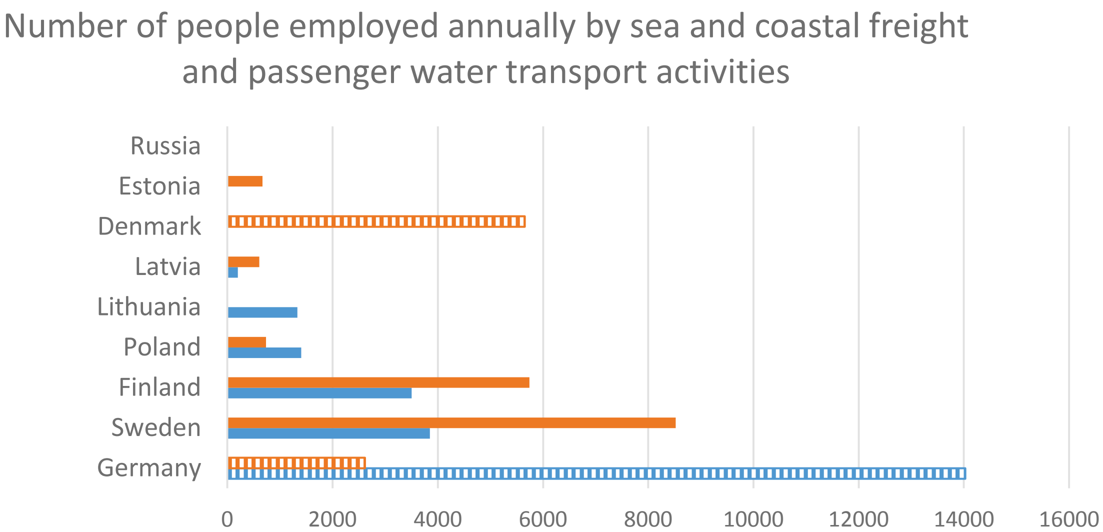
The socio-economic indicators for the shipping transport sector include both the value added from and the number of people employed by the sea and coastal freight and passenger transport (Figures 3.13 and 3.14). The total value added for the region from freight transport is 4.3 billion euros and from passenger transport 2.2 billion euros. For value added from sea and coastal freight water transport, Germany has the highest value added with 3.4 billion euros, but this includes all marine shipping and is not specific to the Baltic Sea. Finland has the next highest at 403 million euros. Latvia and Lithuania have the lowest values. For value added from sea and coastal passenger water transport, the numbers are more evenly spread, with Sweden having the highest value added followed by Finland and Denmark. The total number of people employed is 24 300 for freight transport and 24 500 for passenger transport. In 2011, there were an estimated 42 million international ferry passengers in the Baltic Sea (HELCOM 2015a).

Around 25 % of the shipping in the Baltic Sea takes place under the flag of one of the Baltic Sea coastal countries, according to HELCOM data from the automatic identification system for vessels (AIS). It should be noted, however, that the numbers for Germany and Denmark relate to all shipping transport, not just the Baltic Sea. No data for Russia are available for the indicators based on Eurostat. Also, many countries do not report shipping statistics when the data 'allow for statistical units to be identified' (EU 2009), for example when there are too few actors to ensure anonymity of the data. In this case, data have been marked as confidential by countries. Together, these issues affect the regional totals.



	Germany	Finland	Sweden	Poland	Lithuania	Latvia	Denmark	Estonia	Russia
Passenger water transport (million euros)	1049	278,6	333,2	27,3			517,3	11,7	
Freight water transport (million euros)	3420	403	287	100	30	12			

Figure 3.13. Annual value added at factor cost from sea and coastal freight and passenger water transport in 2014 (million euros). 'Value added at factor cost' is defined by Eurostat as the 'gross income from operating activities after adjusting for operating subsidies and indirect taxes'. Value adjustments (such as depreciation) are not subtracted. Source: Eurostat (2016e). Empty data cells indicate missing or confidential information. Danish and German numbers include both the North and Baltic Sea.



	Germany	Sweden	Finland	Poland	Lithuania	Latvia	Denmark	Estonia	Russia
Passenger water transport	2615	8519	5739	734		606	5653	670	
Freight water transport activities	14027	3847	3502	1403	1333	197			

Figure 3.14. Number of people employed annually by sea and coastal freight and passenger water transport in 2014 (million euros). Source: Eurostat (2016a) (sbs_na_1a_se_r2). Empty data cells indicate missing or confidential information. Danish and German numbers include both the North and Baltic Seas.

Chapter 4. Pressures

Today 85 million people inhabit the drainage area of the Baltic Sea. The sea is one of the world's largest brackish water areas and is inhabited by both marine and freshwater species. A mix of land-based human activities, such as agricultural, industrial, and urban activities exert a wide variety of pressures on the sea. The sea itself experiences busy shipping between its surrounding countries and is an important or emerging resource for fishing, fish farming, gravel extraction and wind energy, to name a few, and is being used for leisure and tourism. Some of the pressures on the Baltic Sea are exacerbated by the limited level of water exchange, which means that nutrients and other substances from the drainage area accumulate in the Baltic Sea and are only diluted slowly. HELCOM has identified seven distinct pressures, which are assessed in this chapter.

4.1 EUTROPHICATION

The Baltic Sea still suffers from eutrophication. Excessive input of nutrients to the marine environment enhances the growth of phytoplankton, leading to reduced light conditions in the water, oxygen depletion at the sea floor (as excessive primary producers are degraded), and a cascade of other ecosystem changes. 97 % of the region was assessed as eutrophied in 2011–2015 according to the integrated status assessment. Nutrient inputs from land have decreased as a result of regionally reduced nutrient loading, but the effect of these measures are not yet detected by the integrated status assessment. Although signs of improvement are seen in some areas, effects of past and current nutrient inputs still predominate the overall status.

Eutrophication has been evident in the Baltic Sea since the mid-1900s, accompanied by increasing severity of symptoms in the ecosystem (Larsson *et al.* 1985, Bonsdorff *et al.* 1997). Early symptoms of eutrophication are increased primary production (expressed through increased chlorophyll-*a* concentrations in the water column or growth of opportunistic benthic algae) and changes in the metabolism of organisms. The increased primary production leads to increased deposition of organic material which in turn leads to increased oxygen consumption. These changes may in turn affect species composition and food web interactions (as species that benefit from the eutrophied conditions are favoured directly or via effects on habitat quality and feeding conditions; Cloern 2001).

Concentrations of the main triggers of eutrophication (nitrogen and phosphorus) increased in many areas of the Baltic Sea up until the late 1980s, attributed to increased nutrient loading from land since the 1950s onwards (Figure 4.1.1, Gustafsson *et al.* 2012). As a result of locally improved waste water treatment, decreases in nutrient loading occurred in some local areas during the 1980s and 1990s, and in the 1990s the first effects of reducing loss of nutrients from agriculture were also seen. Since the late 1990s, the role of nutrient runoff from cultivated land has been recognised as a highly significant nutrient source in the Baltic Sea (HELCOM 1996). Nutrient inputs to the Baltic Sea have significantly decreased since the late 1990s, and in some sub-basins strong reductions have taken place recently (Figure 4.1.1-2, Box 4.1.2).

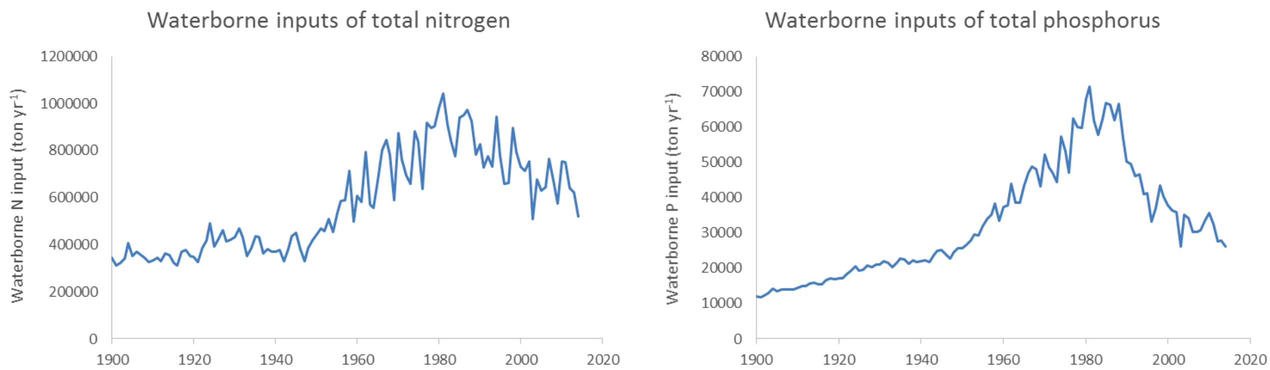
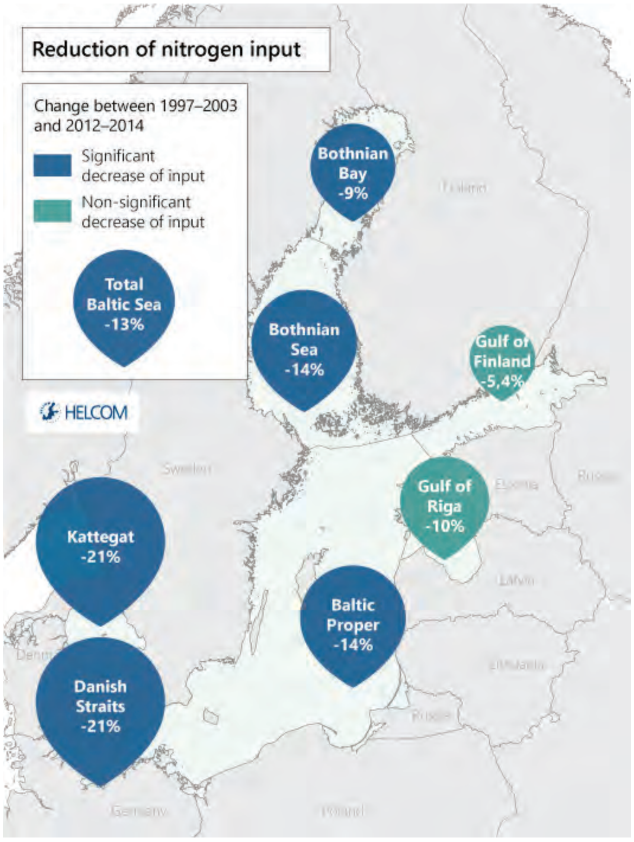


Figure 4.1.1. Temporal development of waterborne inputs of total nitrogen (left) and total phosphorus (right) to the Baltic Sea. Sources: HELCOM (2015d, 2017b), Gustafsson *et al*. (2012), Savchuk *et al*. (2012).

The goal of the Baltic Sea Action Plan is to a reach a Baltic Sea unaffected by eutrophication. Several eutrophication assessments have been carried out since its agreement (HELCOM 2009, 2010a, 2014a). Compared to previous HELCOM eutrophication assessments, this assessment was conducted with some new indicators and refined threshold values for evaluating status, leading to an approach which increasingly enables evaluation of progress towards improved status.



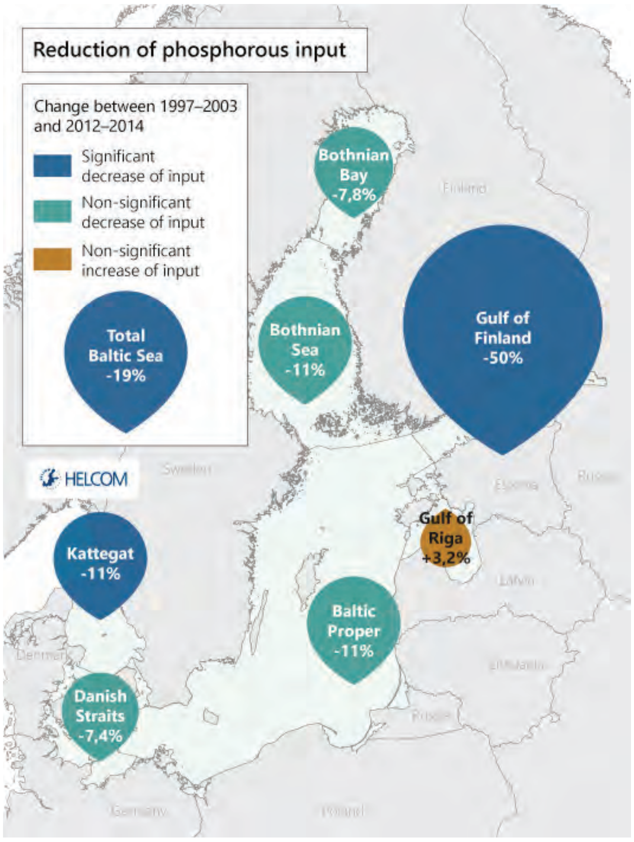


Figure 4.1.2. The inputs of nitrogen and phosphorous to the Baltic Sea sub-basins have decreased significantly in recent years. The drop shapes show the relative change in annual average normalised net nutrient input to the sub-basins, including riverine, direct and airborne inputs comparing the years 2012–2014 with the reference period 1997–2003. Drop shapes pointing downwards show sub-basins where inputs have decreased, and shapes pointing upwards show sub-basins where inputs have increased. The size of each drop shape is proportional to the amount of change. Significance is determined based on the whole series of observations, starting from 1995. Source: HELCOM 2017b.

Indicators used in the assessment

Eutrophication status was evaluated in open-sea areas by assessing core indicator within three criteria: nutrient levels, direct effects and indirect effects of eutrophication (Core indicator reports: HELCOM 2017c-k).

To asses nutrient levels, core indicators on the concentrations of nitrogen and phosphorous, which primary producers need for growth, were used. *Dissolved* inorganic nitrogen and phosphorous are directly utilizable for phytoplankton, and are measured in the winter season when primary productivity is low. Measurements of *total* nitrogen and total phosphorous also include nutrients that are bound in phytoplankton, or in particles in the water. Thus, they describe the total level of nutrient enrichment in the sea. Including estimates of total nutrients makes it possible to take climate change into account in the assessment, since increased winter temperatures are expected to lead to the production of phytoplankton all year round, and thus to higher shares of nutrients being bound in phytoplankton biomass compared to dissolved forms.

To assess the direct effects of eutrophication, indicators on chlorophyll-a concentrations and water clarity (measured by the indictor 'Secchi depth during summer') were used. In addition, the 'Cyanobacterial bloom index' was included as a test indicator.

To assess indirect effects of eutrophication, the core indicator 'Oxygen debt' was used. This core indicator measures the volume-specific oxygen debt, which is the oxygen debt below the halocline divided by the volume. Hence, the indicator estimates how much oxygen is 'missing' from the Baltic Sea deep water. In addition, the indicator 'State of the soft-bottom macrofauna community'[5] was used to assess indirect effects of eutrophication in the open sea Gulf of Bothnia.

The coastal areas in eight countries were assessed by national indicators used in the Water Framework Directive, used to evaluate biological quality elements such as phytoplankton (chlorophyll-a), benthic invertebrate fauna and macrophytes (macroalgae and angiosperms), and supporting physical and chemical elements such as concentrations of nitrogen, phosphorus, and water clarity. Different indicators were used in different countries.

The integrated assessment of eutrophication was done using the HEAT tool which aggregates the indicator results into a quantitative estimate of overall eutrophication status (Supplementary report: HELCOM 2017B).

Box 4.1.1 HELCOM work on eutrophication

HELCOM has been a major driver in the regional approaches to reduce nutrient loads to the Baltic Sea. The management of the Baltic Sea eutrophication has been advanced with the Baltic Sea Action Plan (HELCOM 2007), which includes a complete management cycle aiming for specified improved conditions in the Baltic Sea, based on the best available scientific information and a model-based decision support system.

Core indicators with associated threshold values representing good status with regard to eutrophication are established primarily from monitoring data, which is interpreted through statistical analysis. In a following step, the relationships between changes in the inputs of nutrients to the Baltic Sea and the core indicators are established by physical-biogeochemical modelling. These relationships differ across sub-basins because of differences in water circulation, ecosystem characteristics, and inputs, for example. The model results give estimates of the maximum allowable input of nutrients to the different sub-basins in order for the core indicators to achieve their threshold values over time, recognizing that this might take many years.

The input reductions necessary to reach the basin-wise maximum inputs of nutrients are allocated to the HELCOM countries as country-wise reduction targets. In addition, certain reduction potential is indicated for upstream countries and distant sources (HELCOM 2013d). The allocation is done according to the 'polluter pays' principle of the Helsinki Convention. Progress in reaching nutrient reduction targets is evaluated based on annual compilations of the nutrient inputs to the Baltic Sea (HELCOM Pollution Load Compilation).

[5] Included as a test indicator.

Integrated status assessment

The updated integrated eutrophication status assessment for 2011–2015 shows that the Baltic Sea is still affected by eutrophication (Figure 4.1.3). Out of the 247 assessment units included in the HELCOM assessment covering both coastal and open water bodies, only 17 achieved good status, showing that 97 % of the surface area in the Baltic Sea, from the Kattegat to the inner bays, is eutrophied[6] (Figure 4.1.3). About 15 % of the surface area had eutrophication ratios in the category furthest away from good status. Only a few coastal areas are unaffected by eutrophication.

In most of the open-sea areas, good status was not achieved for the nutrient levels or the direct and indirect effects of eutrophication (Figures 4.1.4–4.1.5). Nutrient levels were in good status only in the Great Belt, and direct effects in the Kattegat (Figure 4.1.4). Indirect effects were in good status in the Bothnian Sea and the Quark, which cover 18 % of the open-sea area (Figures 4.1.4–4.1.5). The nutrient levels were generally furthest away from good status, and thus had highest overall influence on the integrated assessment results. Integrated eutrophication status had improved in only one but deteriorated in seven of the 17 open-sea assessment units since the last five year period (2007–2011).

Most coastal areas in the Baltic Sea failed to achieve good status based on nutrient levels and direct eutrophication effects, with exceptions mainly in the coastal areas of the Gulf of Bothnia and the Kattegat (Figure 4.1.4). Indirect effects achieved good status in many of the coastal areas, including the Swedish and Estonian coasts and Finnish coast of the Bothnian Sea.

[6] Results showing % of sea area in good status within separate national territories is provided in HELCOM (2017B).

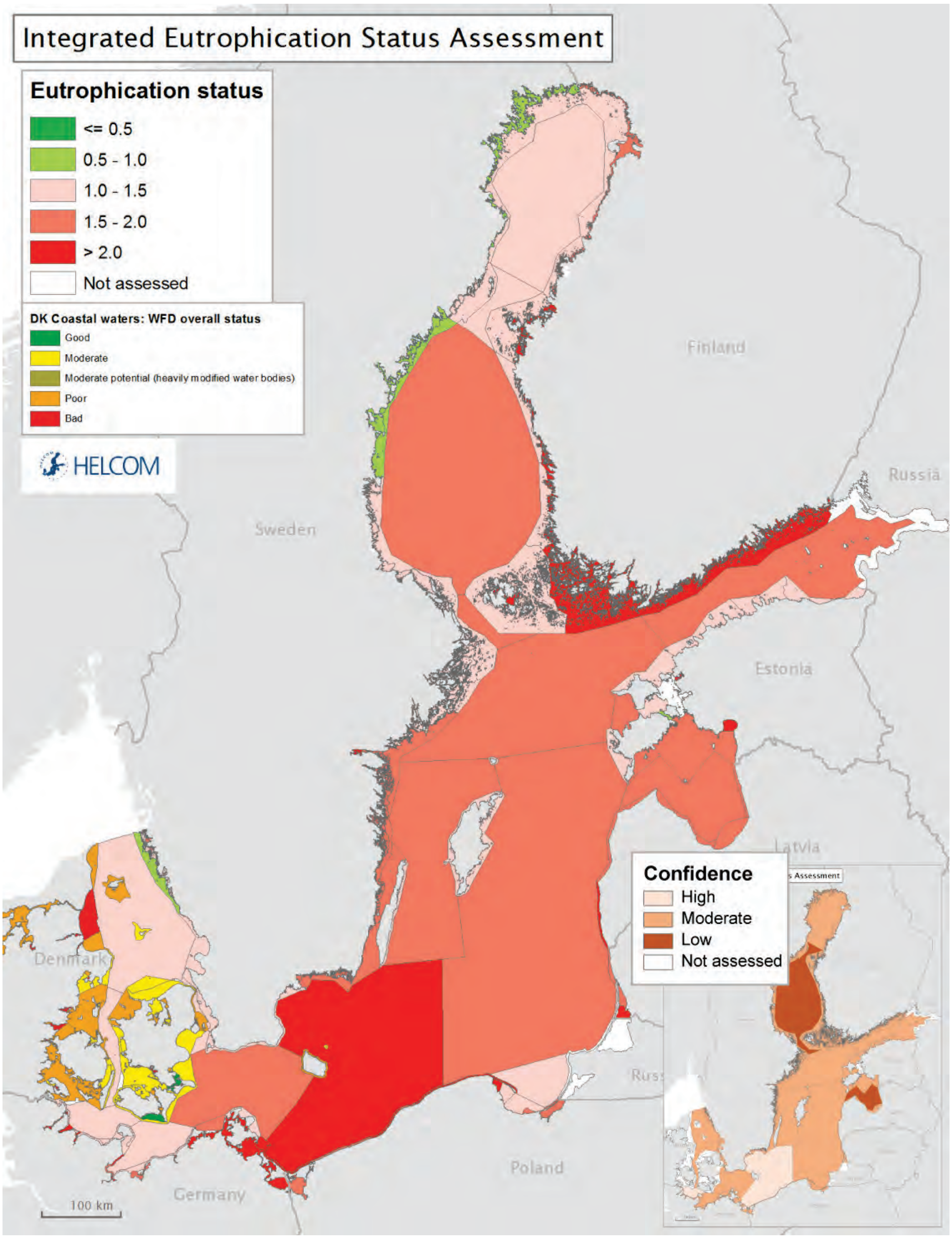


Figure 4.1.3. Integrated status assessment of eutrophication. Each assessment unit shows the status of the criteria group in the worst status (see Table 4.1.1). Note that the integrated status of Swedish coastal areas in the Kattegat differs from corresponding results in the OSPAR intermediate assessment. In coastal areas HELCOM utilises national indicators used in the Water Framework Directive to arrive at status of coastal assessment units for eight countries[7]. White areas denote that data has not been available for the integrated assessment[8].

[7] Danish coastal water WFD-classification differs from the open sea classification. Hence, the colours are not directly comparable.
[8] The Gdansk Basin has been assessed solely with Polish data.

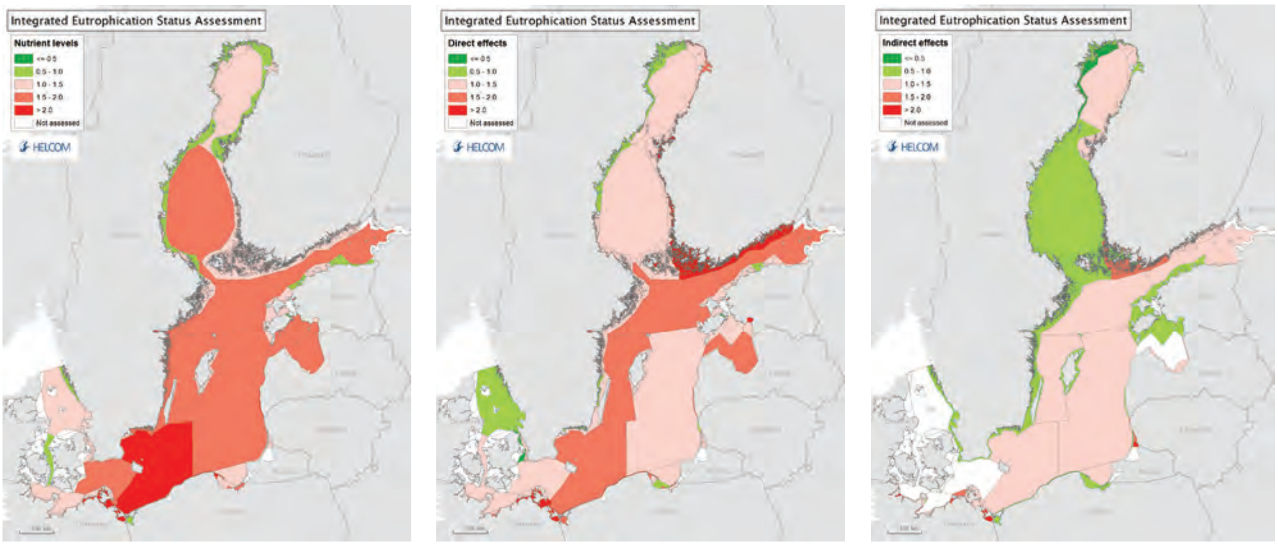


Figure 4.1.4. Integrated status assessment results for eutrophication, shown by criteria groups: left: nutrient levels, middle: direct effects, right: indirect effects. Note that the integrated status of Kattegat coastal areas differs from corresponding results in the OSPAR intermediate assessment[9]. In coastal areas HELCOM utilizes national indicators used from the Water Framework Directive to arrive at status of coastal areas assessment units for eight countries. White areas denote that data has not been available for the integrated assessment[10].

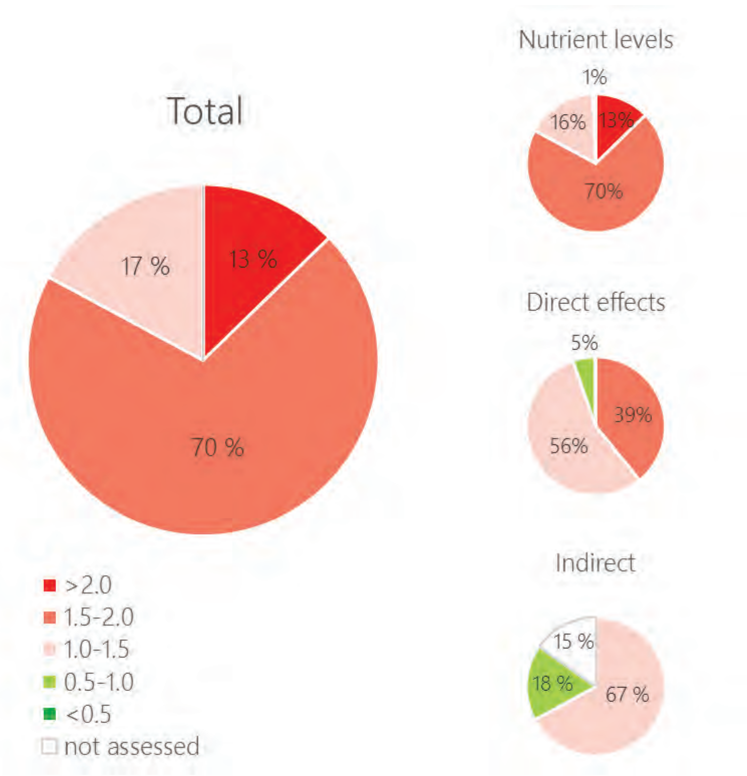


Figure 4.1.5. Proportion of open sea areas in the HELCOM region in each of the five status categories of the integrated assessment of eutrophication. White denotes areas not assessed due to lack of indicators (see Table 4.1.1).

[9] Danish coastal water WFD-classification differs from the open sea classification. Hence, the colours are not directly comparable.
[10] The Gdansk Basin has been assessed solely with Polish data.

Core indicator results

Table 4.1.1 shows the core indicator results for eutrophication in the open sea, and the integrated status assessment result for each of the open sea sub-basins.

Table 4.1.1. Core indicator results for eutrophication in the open sea, and the integrated status assessment result by sub-basin (IA status, shown in the last column). Green cells denote good status and red not good status. The arrows reflect if the eutrophication ratio (of the indicator or integrated status, as estimated in HEAT) has changed since the last eutrophication assessment, comparing years 2007–2011 with 2011–2015. A change equal to or more than15 % was considered to be substantial. Upward arrows ↗ indicate an increased eutrophication ratio between the two periods (deteriorating condition), downward arrows ↘ indicate a decreased ratio (improving condition), and ↔ indicates less than 15 % difference between the two compared time periods. This information is not available for the core indicator 'State of the soft bottom macrofauna community' (Zoob). White cells denote that the sub-basin was not assessed due to the lack of agreed threshold value or commonly agreed indicator methodology. An 'N' is shown for cases where the indicator is not applicable. Abbreviations used in the table: DIN = 'Dissolved inorganic nitrogen', TN= 'Total nitrogen', DIP= 'Dissolved inorganic phosphorus', TP = 'Total phosphorus', Chla= 'Chlorophyll-a', Secchi= 'Secchi depth during summer', Cyano = 'Cyanobacterial bloom index', and O_2 = 'Oxygen debt'. Indicators marked * have not been adopted in HELCOM yet and are currently tested. The indicator 'State of the soft-bottom macrofauna community' was only included in the Gulf of Bothnia. For more details, see core indicator reports: HELCOM 2017c-k.

	Core indicator results									
	Nutrient levels				Direct effects			Indirect effects		
	DIN	TN	DIP	TP	Chla	Secchi	Cyano*	O_2	Zoob*	
Assessment unit	Dec–Feb	All year	Dec–Feb	All year	Jun–Sep	Jun–Sep	20 Jun–31 Aug	All year	May–Jun	IA status
Kattegat	↔	↔	↔	↔	↘	↔	N	N		↔
Great Belt	↘	↔	↔	↔	↘	↘	N	N		↘
The Sound[11]	↗	↔	↔	↗	↘	↔	N	N		↗
Kiel Bay	↘		↔		↔	↘	N	N		↔
Bay of Mecklenburg	↔		↔		↔	↔	↗	N		↔
Arkona Basin	↔		↔		↔	↔	↔	N		↔
Bornholm Basin[12]	↗		↔		↗	↔	↔	↔		↗
Gdansk Basin	↘	↔	↘	↔	↘	↔	↘	↔		↘
Eastern Gotland Basin	↔	↔	↔		↘	↔	↔	↔		↔
Western Gotland Basin	↔	↔	↔	↔	↘	↔	↔	↔		↔
Gulf of Riga	↗	↔	↗	↗	↗	↔	↗	N		↗
Northern Baltic Proper	↗	↔	↗	↘	↗	↔	↔	↔		↗
Gulf of Finland	↔	↔	↔	↗	↗	↔	↔	↔		↗
Åland Sea	↔	↔	↗	↔	↘	↔	N			↔
Bothnian Sea	↔	↔	↗	↔	↔	↗	↔			↗
The Quark	↔	↔	↗	↔	↔	↔	N	N		↗
Bothnian Bay	↔	↔	↔	↔	↔	↗	N			↔

[11] Result may be changed due to planned changes in input data.
[12] Result for the Bornholm Basin many be subject to change, to be clarified.

Water nutrient levels

The concentrations of dissolved inorganic nitrogen and total nitrogen did generally not achieve the threshold value. The threshold values were only achieved in the Kattegat and the Great Belt for total nitrogen[13] and in the Gdansk Basin for dissolved inorganic nitrogen. The eutrophication ratios for dissolved inorganic nitrogen were highest in the Gulf of Riga and the Gulf of Finland. In addition, average concentrations were high in the Bornholm Basin due to influence from shallow stations in the Pomeranian Bay, which is influenced by the Odra plume[14].

Winter concentrations of dissolved inorganic nitrogen showed an increasing trend until the mid-1990s. They started declining in the late 1990's, especially in the southwestern Baltic Sea and Kattegat (Figure 4.1.6). Compared to the previous five year period (2007–2011), dissolved inorganic nitrogen concentrations have increased substantially in four and decreased in three out of 17 sub-basins (Table 4.1.1). Concentrations of total nitrogen have remained at the same level since the period 2007–2011 in all sub-basins (Table 4.1.1).

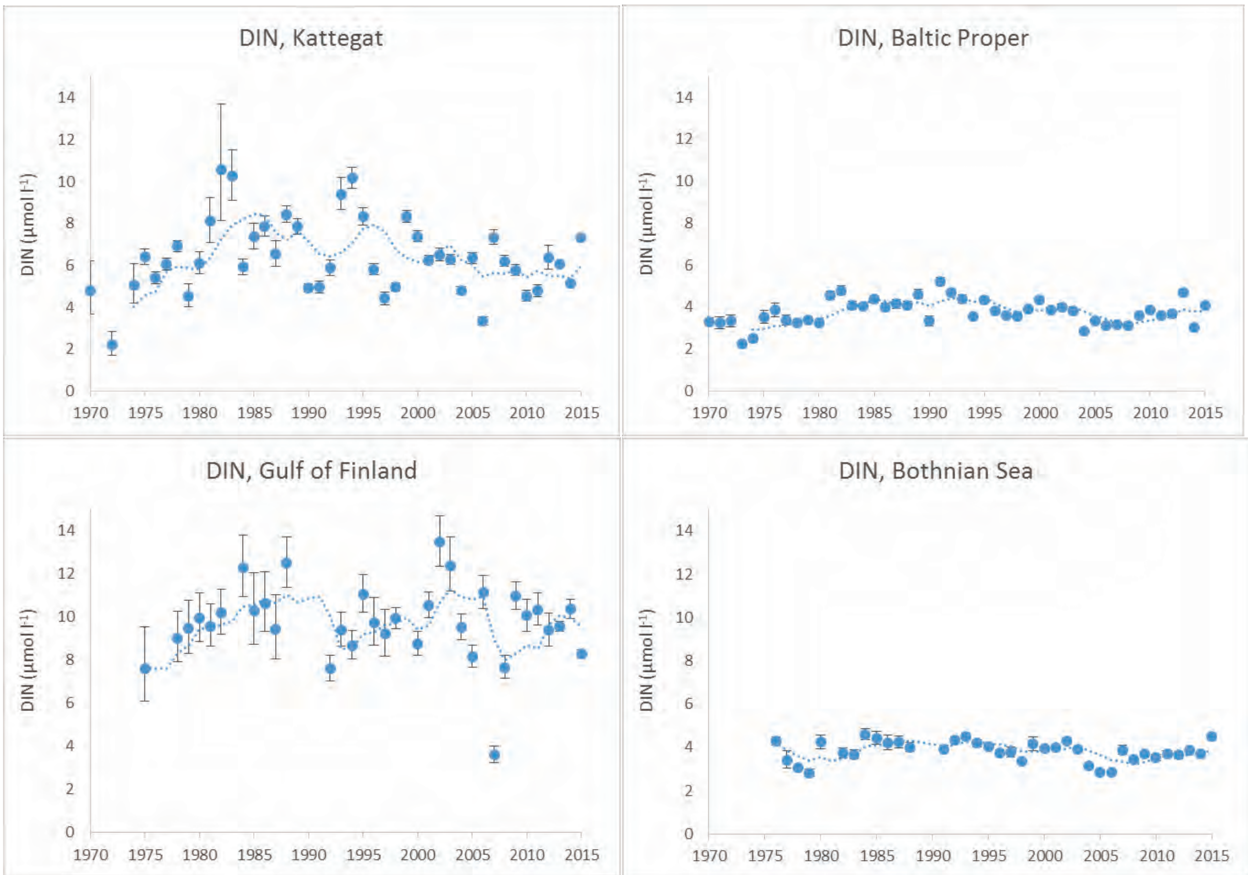


Figure 4.1.6. Example of long term trends in nutrient levels in the Baltic Sea: Temporal development of winter dissolved inorganic nitrogen concentrations in the Kattegat, Baltic Proper, Gulf of Finland and Bothnian Sea. Dashed lines show the five-year moving averages and error bars the standard errors.

[13] This refers to the HELCOM threshold values, which are not identical to the OSPAR threshold values.
[14] Reflecting a not uniform distribution of samples, with more sampling in shallow than deeper stations.

For phosphorous, the indicator on dissolved inorganic phosphorous only achieved the threshold value in the Bothnian Bay, and the indicator on total phosphorous achieved it only in the Great Belt.

Dissolved inorganic phosphorus concentrations increased notably in the 1960s and 70s, and have shown relatively large fluctuations over time. A decrease from the high values in the mid-1980s to the present has been seen in the Kattegat, Danish Straits, Gulf of Riga and Bothnian Bay, but not in the Gulf of Finland or the Bothnian Sea. In these two sub-basins, dissolved inorganic phosphorus concentrations have increased since the early 2000s, despite decreases in the waterborne inputs from land (Figure 4.1.7). In the Baltic Proper, the concentrations decreased in the late 1990s, but increased again since then.

These recent increases probably reflect the release of phosphorus from anoxic sediments (Conley *et al*. 2002, 2009). Since the period 2007–2011, dissolved inorganic phosphorus concentrations have increased substantially in five sub-basins and decreased only in Gdansk Basin (Table 4.1.1). Within the same period, total phosphorus concentrations have increased substantially in three sub-basins.

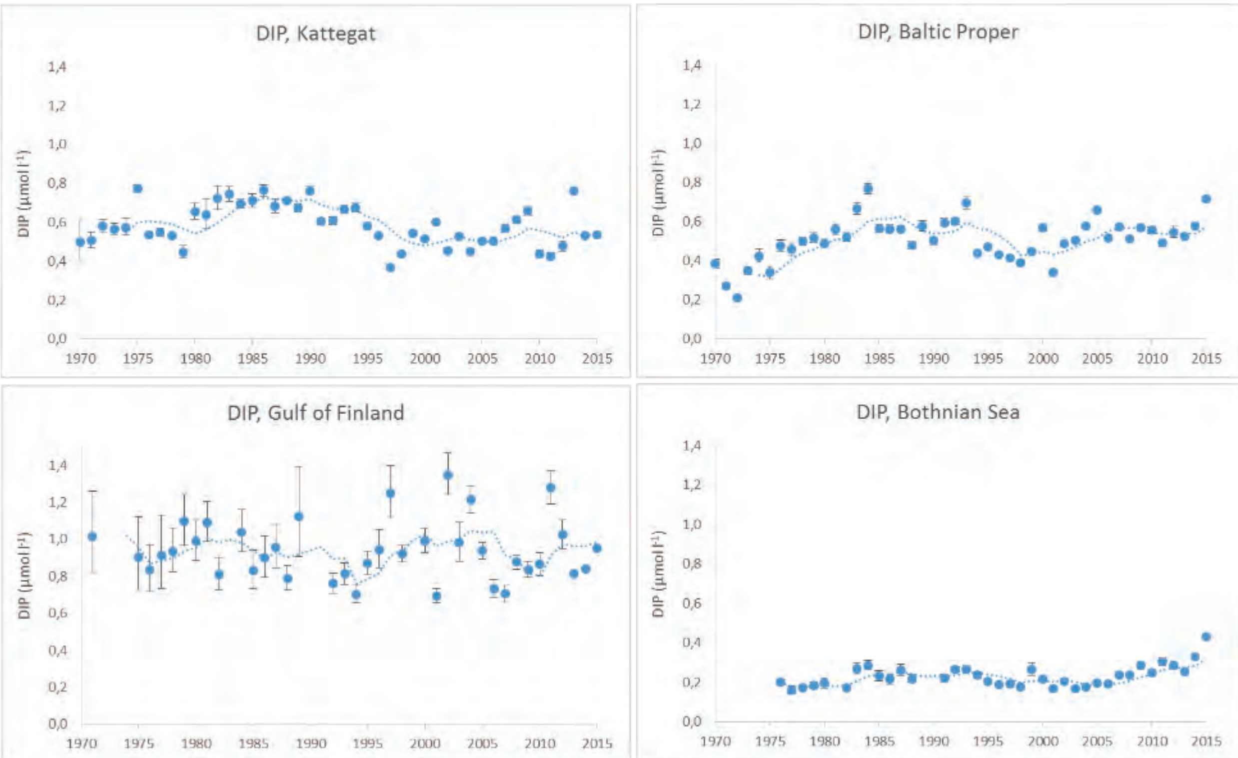


Figure 4.1.7. Example of long term trends in nutrient levels in the Baltic Sea: Temporal development of dissolved inorganic phosphorus concentrations in winter in the Kattegat, the Baltic Proper, the Bothnian Sea and the Gulf of Finland. Dashed lines show the five-year moving averages and error bars are the standard errors.

Direct effects

The core indicators for direct effects ('Chlorophyll-a' and 'Secchi depth during summer' and additionally 'Cyanobacterial bloom index'[15]) did not achieve the threshold value in any open sea sub-basin east of the Sound. West of the Sound, the chlorophyll-a core indicator achieved the threshold value in the Kattegat, and water clarity in the Kattegat and the Sound.

The longer term trend shows that chlorophyll-a concentrations have increased from the 1970's to the present in most of the inner Baltic Sea (Figure 4.1.8). In the Kattegat and the Danish Straits, the chlorophyll-a concentration has been decreasing since the late 1980s (Figure 4.1.8). Compared to the previous five year period (2007–2011), the chlorophyll-a concentrations have decreased in seven sub-basins, but increased in the Bornholm Basin, Northern Baltic Proper, Gulf of Finland and Gulf of Riga (Table 4.1.1).

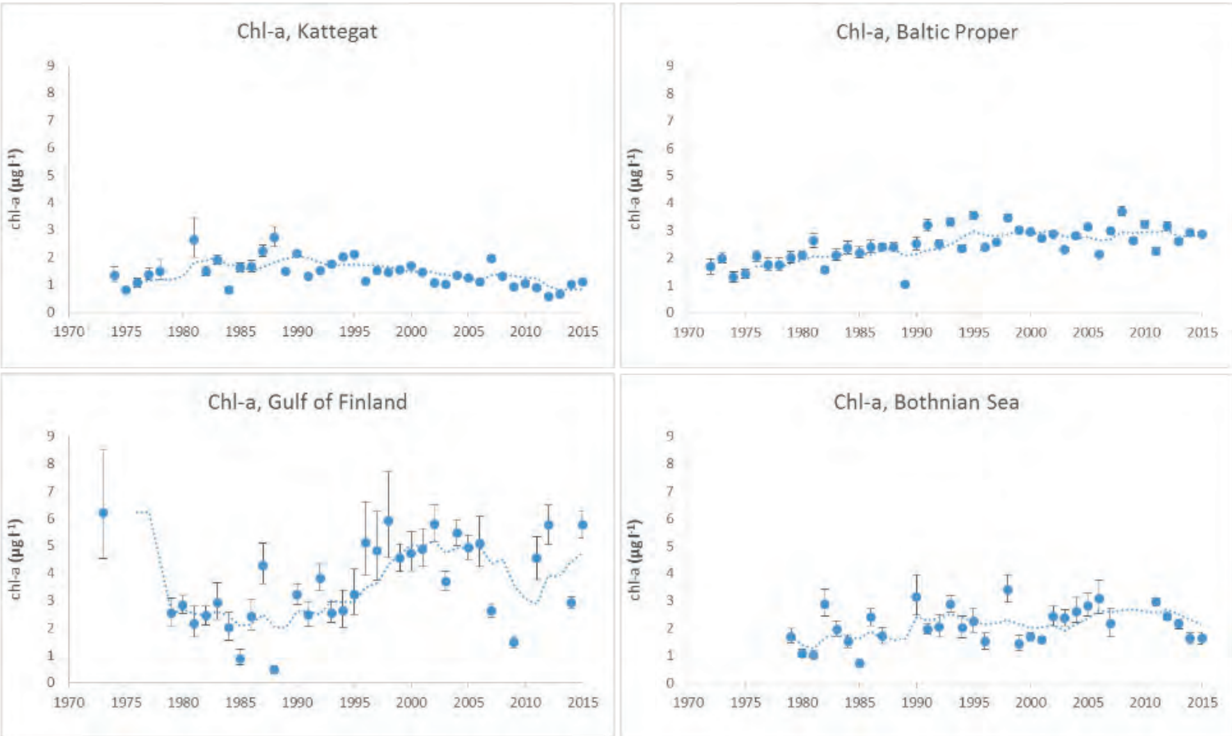


Figure 4.1.8. Example of long term trends in the direct effects of eutrophication in the Baltic Sea: Temporal development of chlorophyll-a concentrations in summer in the Kattegat, the Baltic Proper, the Bothnian Sea and the Gulf of Finland. Dashed lines show the five-year moving averages and error bars are the standard errors.

The longest time series available for water clarity have been recorded since the early 1900s in the Baltic Proper. The results show a steadily deteriorating situation over several decades (Figure 4.1.9). In more recent years, however, the decrease in water clarity has levelled off across most of the Baltic Sea, and the water clarity has remained on the same level since the period 2007–2011 in most of the sub-basins (Table 4.1.1). The water clarity reflects changes in the

15 Included as a test indicator.

eutrophication-related abundance of phytoplankton, but is also affected by the presence of coloured dissolved organic matter and suspended particles.

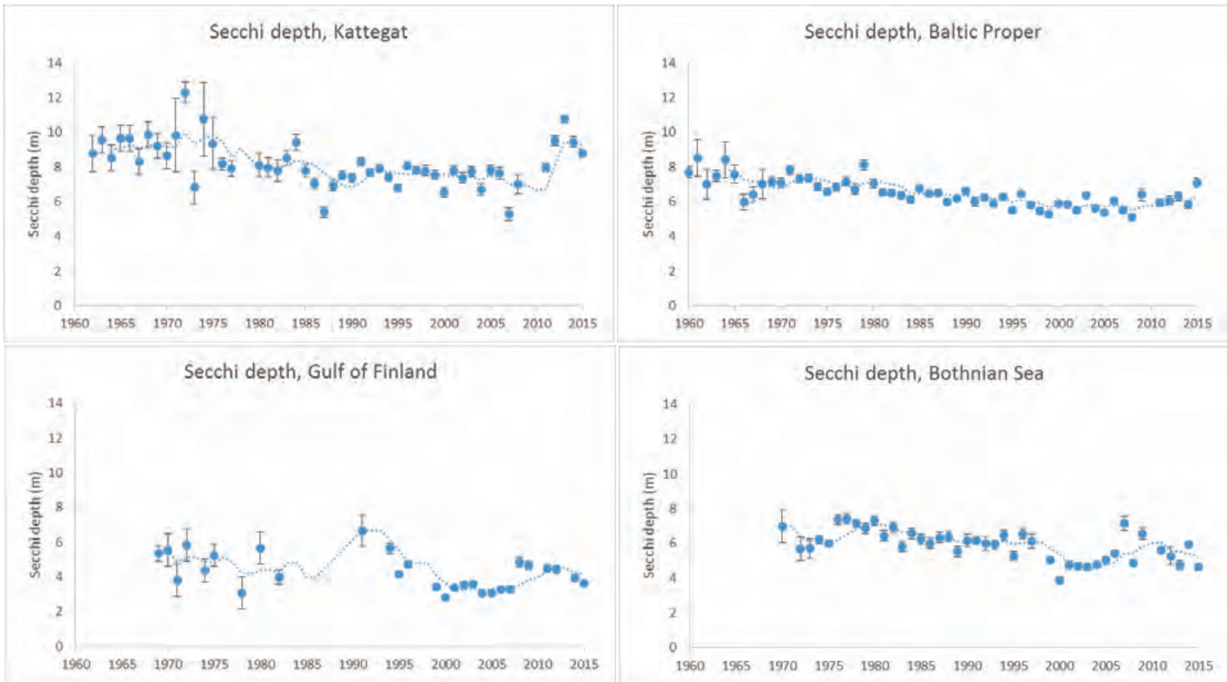


Figure 4.1.9. Example of long term trends in the direct effects of eutrophication in the Baltic Sea: Temporal development of water clarity (measured as Secchi depth in summer) in the Kattegat, the Baltic Proper, the Bothnian Sea and the Gulf of Finland. Dashed lines show the five-year moving averages and error bars the standard errors.

The cyanobacterial bloom index was used as a test indicator in ten sub-areas, showing the worst status in the Gulf of Riga, the Northern Baltic Proper and the Bothnian Sea. The index has remained at the same level since the previous five year period 2007–2011 in most of the sub-basins (Table 4.1.1).

Indirect effects

The core indicator 'Oxygen debt' did not achieve the threshold values in any open sea sub-basin. Oxygen debt has increased over the past century (Figure 4.1.10). It plateaued from the early 1980's to the early 1990's, but has subsequently increased again. Since the last assessment period (2007–2011), the oxygen debt has remained at the same level (Table 4.1.1). North of the Baltic Proper, the indicator 'State of the soft-bottom macrofauna community' was also included, to estimate the condition of the animal community at the seafloor[16]. The core indicators achieved the threshold value in these areas suggesting the bottom fauna to be in good condition.

[16] Included as a test indicator.

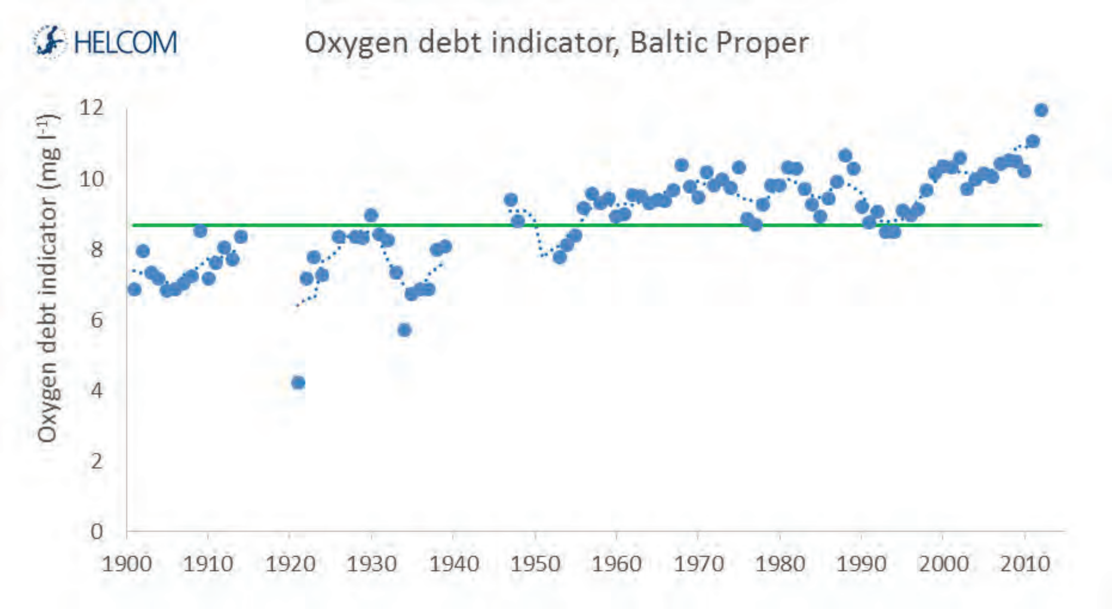


Figure 4.1.10. Example of long term trends in the indirect effects of eutrophication in the Baltic Sea: Temporal development in the core indicator 'Oxygen debt' in the Baltic Proper, showing the volume specific oxygen debt below the halocline. Dashed line shows the five-year moving average and green line the threshold for good status. The increasing trend in oxygen debt signifies deteriorating oxygen conditions.

Box 4.1.2. Costs of eutrophication

Eutrophication causes many adverse effects on the marine environment which also reduce the welfare of citizens. These include decreased water clarity, more frequent cyanobacterial blooms, oxygen deficiency in bottom waters, changes in fish stocks and loss of marine biodiversity. These effects decrease the environmental benefits from the Baltic Sea, both in terms of use-related values and non-use values.

Examples of use values are opportunities for and enjoyment from marine and coastal recreation. Non-use values stem from knowing that the marine environment is healthy and available to others in the same and future generations, for example.

Reaching a good eutrophication status for the Baltic Sea will bring about increased human welfare and economic benefits to citizens in the coastal countries. The benefits that are lost if the Baltic Sea does not reach a good environmental status are called the cost of degradation. The monetary benefits of reducing eutrophication have been assessed in a Baltic-wide stated preference contingent valuation study in 2011 (Ahtiainen *et al.* 2014). The results represent the value of reaching good eutrophication status in the Baltic Sea, based on citizens' stated willingness to pay in a survey for achieving the target status. The study captured a variety of eutrophication effects, including water clarity, cyanobacterial blooms, underwater meadows, fish species composition and oxygen deficiency at the sea bottom. The change in eutrophication was described using all of these effects.

The study covers all nine coastal countries and considers a change in the condition of the entire Baltic Sea. The target state in the study corresponds closely to that of achieving a good environmental status of the sea, stating that all sub-basins except the Northern Baltic Proper have achieved good status. The time frame in the study is somewhat longer than in current policies, as it is set to the year 2050. Reaching a good status earlier than 2050 might bring about even greater benefits, as people generally place more value on goods and services that they obtain sooner.

Figure B4.1.2 presents the estimates of how benefits would be lost if eutrophication is not reduced in the Baltic Sea. The total losses are estimated at 3.8–4.4 billion euros annually for the Baltic Sea region. In other words, citizens' welfare would increase by this much each year if good eutrophication status was achieved. See also Supplementary report: HELCOM 2017A.

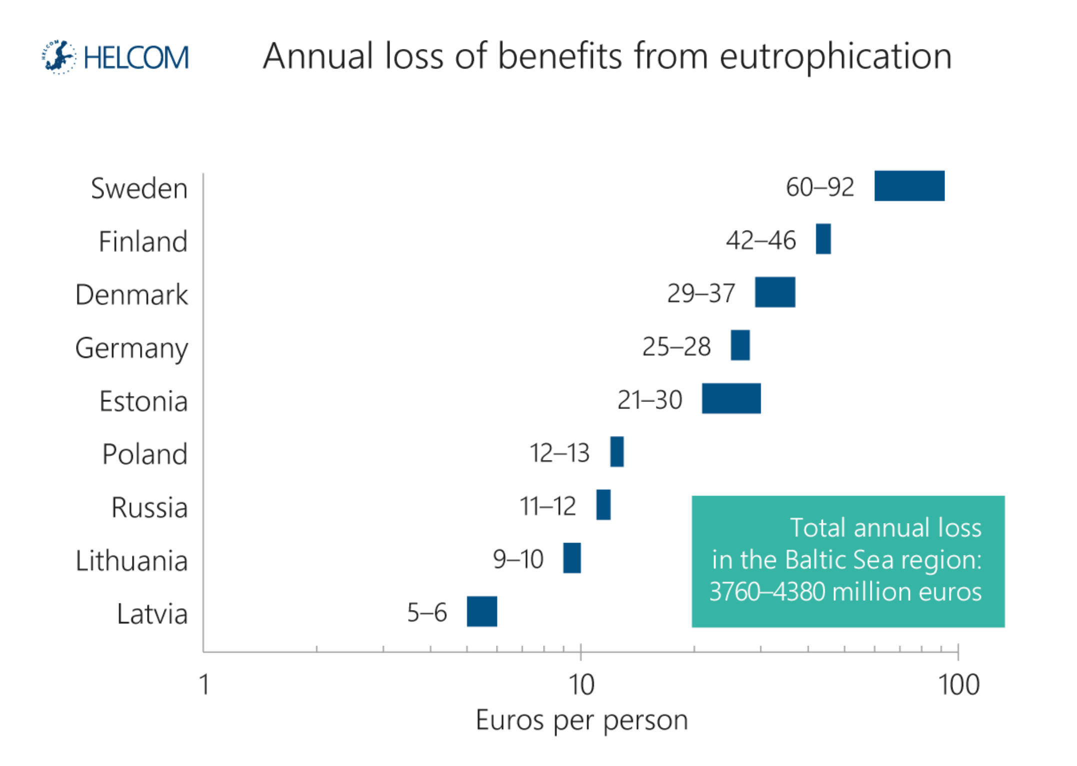


Figure B4.1.2. Annual benefit losses from eutrophication (euros per person) and total in the Baltic Sea region (million euros). The ranges show the 95 % confidence intervals for the value estimates reported in the original study. Value estimates are in purchasing power parity adjusted 2015 euros. Source: Ahtiainen *et al.* (2014).

Impacts and recovery

Primary production is a key process in the ecosystem as it provides energy for all organisms, but nutrient enhanced excessive primary production leads to eutrophication symptoms and reduces the function of the food web in many cases. An increased intensity and frequency of phytoplankton blooms typically leads to decreased water clarity and increased sedimentation. These conditions further limit the distribution of submerged vegetation, such as macroalgae and macrophytes, and reduces the habitat quality of coastal areas. Increased sedimentation and microbial degradation of organic matter increases oxygen consumption and depletes oxygen conditions in areas with poor water exchange, including deep water areas.

By the 1960s the soft bottom fauna was already disturbed in some parts of the Baltic Sea, attributed to eutrophication. Human induced nutrient inputs have contributed to the enhanced distribution of areas with poor oxygen conditions seen today, including deep waters. It should be noted, however, that in areas with vertical stratification and low water exchange, eutrophication acts on top of naturally low oxygen levels. Life in these deep water habitats is also highly dependent on aeration provided by inflows of marine water from the North Sea (see Chapter 1, Figure 1.1.9).

Even though some positive development in the eutrophication status is seen in the current assessment, such as a decrease in nutrient concentrations, improved water clarity in parts of the Baltic Sea, and a decrease in chlorophyll concentrations in some areas, the results show that the Baltic Sea is still highly affected by eutrophication and that the impacts on organisms and human well-being will continue. The reductions of nutrient inputs according to the HELCOM Baltic Sea Action Plan are foreseen to be effective in decreasing the eutrophication symptoms in the long term (Figure 4.1.2). Large scale responses to reduced loading are slow, and recently achieved reductions are not visible in the assessments over the short time frame. In addition, future development is foreseen to be dependent on changes in climate (Box 4.1.3).

Box 4.1.3 Effects of climate change on eutrophication

Adaptation to climate change is a central issue for the planning and implementation of measures to reduce nutrient inputs, as well as for adjusting the level of nutrient input reductions to ensure protection of the Baltic Sea marine environment in a changing climate. For example, the maximum allowable inputs are calculated under the assumption that Baltic Sea environmental conditions are in a biogeochemical and physical steady-state. This assumes that the environment will reach a new biogeochemical steady state under the currently prevailing physical steady state, after some time when the internal sinks and sources have adapted to the new input levels. Within a changing climate this assumption will not hold, as the physical environment is also changing and will feedback upon the biogeochemical cycling, for example by enhancing growth and mineralization rates. Simulations also indicate that climate change may call for additional nutrient input reductions to reach the targets for good environmental status of the Baltic Sea Action Plan (Meier *et al*. 2012). Effects from climate change and input reductions will both take substantial time, and a deepened understanding of the development is needed to support management.

4.2 HAZARDOUS SUBSTANCES

Man-made chemicals and heavy metals enter the Baltic Sea via waste water treatment plants, leaching from house-hold materials, waste deposits, through atmospheric deposition from industrial plant emissions, and many other sources. Once in the Baltic they can cause various types of damage to the ecosystem. Some are highly visible in the form of oil-spills, for example. Many contaminants degrade slowly and their impacts can magnify as they accumulate in the aquatic food web. The current contamination status is elevated in all parts of the Baltic Sea, mainly driven by polybrominated flame retardants and mercury. Most indicators show stable status since the last assessment.

Thousands of environmentally hazardous substances have been identified as potentially occurring in the Baltic Sea. The most environmentally hazardous substances are those that are persistent, toxic and accumulate in biota. Some hundreds of substances are regularly monitored. Out of these, concentrations of twelve hazardous substance groups are included in the core indicators used in the integrated contamination status assessment.

Indicators used in the assessment

The core indicators cover substances of specific concern to the Baltic Sea as described in the HELCOM Baltic Sea Action Plan and are based on data from the HELCOM monitoring programme (Core indicator reports: HELCOM 2017l-s).

The core indicators have regionally agreed threshold values that are set based on knowledge of the eco-toxicity of the substances, meaning that when the threshold is achieved, the concentration of the substance is so low that it is not expected to cause harm to the marine environment (Box 4.2.1). However, a risk can never be fully excluded even when the threshold is achieved, especially for persistent or bio-accumulating substances, and the long-term goal is to reach zero concentrations for man-made chemicals. The environmental quality standards (EQS) defined in the EU Environmental Quality Standards Directive (EC 2008) linked to the EU Water Framework Directive (EC 2000) are agreed to be used as indicator threshold values.

If several threshold values are available, priority is given in HELCOM to environmental quality standard values for biota, rather than in water or sediment. For many substances, most data is available for biota and this estimate reflects the accumulation of contaminants in the living environment.

Core indicators have also been developed to monitor effects on a top-predator, the white-tailed eagle, as well as to detect trends in oil-spills. Since the previous holistic assessment, HELCOM has further developed the assessment system for hazardous substances, and taken steps towards applying regionally harmonised methods.

The integrated assessment of hazardous substances was done using the CHASE tool which aggregates the indicator results into a quantitative estimate of overall eutrophication status (Supplementary report: HELCOM 2017C).

Box 4.2.1 Threshold values for assessing hazardous substances

Environmental quality standard values in the field of water policy are set in directive 2008/105/EC of the European commission, amended in 2013 (EC 2008, 2013b). These values are referred to as 'EQS values', and are set for priority substances with respect to concentrations in water, and for some substances also with respect to concentrations in biota (fish or shellfish). Values for sediments are not published there, but can be found in the EQS substance dossiers. The environmental quality standard values are used by EU Member States for the classification of chemical status of water bodies under the Water Framework Directive, and relate to an expected 'safe' level of exposure. Below this level, it is assumed that no harm will be caused to the freshwater or marine environment.

Environmental quality standard values for water are used as threshold values in the core indicators for some substances. In these cases, the value relating to an annual average concentration is used. Monitoring in water can be challenging as the concentrations can be several orders of magnitude below the analytical detection limit.

When measurements in biota are used, different trophic levels of the foodweb are analysed depending on the substance (for example, mussels or predatory fish are used), and different parts of the fish (for example fish muscle or measurements on the whole fish). Hence, the measured concentrations often need to be converted in order to conform to the environmental quality standard biota-value, which may introduce uncertainties. In this derivation, four principal matrices and protection goals are considered on the basis of toxicity tests with representative organisms; the pelagic community ('QSwater'), benthic habitats ('QSsediment'), top predators ('QSbiota – secondary poisoning'), and human health through food consumption ('QSbiota – human health'). A QS value can be used for the assessment provided that it corresponds to at least the same level of protection as the environmental quality standard. The value for the most sensitive of these matrices and protection goals is used.

Background assessment criteria have been developed by OSPAR and ICES to define the background concentrations of naturally occurring substances, and close to zero concentrations for man-made substances. The defined values do not take ecotoxicological aspects into consideration. Hence, the approach is different to the derivation of the environmental quality standard values, which aims to relate to risks for adverse effects. If a background assessment criterion is used as a threshold value, this can be considered a more cautious assessment compared an environmental quality standard. Values based on background assessment criteria are currently not available for the HELCOM region, but could be calculated in future work.

Foodstuff threshold values stem from legislation of the European Union (EC 2006). They are derived taking into consideration information beyond the environmental parameters, such as dietary standards of the concerned human population, typical levels of contaminants in different foodstuff, and trade. The aim is to identify and prevent contaminated foodstuff from being placed on the market. Thus, the foodstuff threshold values do not cover all combinations of matrices and contaminants relevant for an environmental assessment of the marine environment. Because of this, a full equivalence between foodstuff threshold values and EQS-values should not be expected, although the values can in some cases be very similar or even the same.

Integrated status assessment

The pressure on the marine environment from concentration of contaminants is high in all parts of the Baltic Sea (Figure 4.2.1). This is mainly due to a group of brominated flame retardants and mercury, both measured in fish (Figures 4.2.5, 4.2.10).

The polybrominated diphenyl ethers have mainly been used as flame retardants in plastic materials and polyurethane foams, and enter the Baltic Sea through waste water treatment plants and diffuse sources. The main source of heavy metals, such as mercury, is burning of fossil fuels, which enter the Baltic Sea through atmospheric deposition. Mercury is currently legally used in low energy light sources. It is phased out from several previous uses including amalgams in dentistry, electrodes in paper bleaching, and thermometers, for example.

The highest contaminant concentrations, compared to the threshold value, generally occurred for measurements in biota, rather than in sediments or water, except for some areas in the southern Baltic Sea where the highest contaminant concentration were seen in tributyltin[17] in sediment (Table 4.2.1).

The four most contaminated areas in the integrated assessment, using the available core indicator results, were the Arkona Basin, the Eastern Gotland Basin, the northwestern coastal areas of the Bothnian Sea and the Kiel Bay, which all had the highest contamination scores in biota. Results showing differences in contamination status between adjacent coastal and open sea assessment units are probably influenced by differences in data availability, as reflected in the confidence (Figure 4.2.1). If an assessment unit with a low confidence has a low contamination score, this may indicate that the status could be worsened if more data were available.

The overall contamination status has not changed markedly during the six years that have passed since the previous holistic assessment (HELCOM 2010), showing that contamination from hazardous substances still gives cause for concern throughout the Baltic Sea area, but also that the situation is not deteriorating. This is also reflected in the more frequent downward than upward trends for concentrations of hazardous substances. A total of 433 time series at stations were assessed for trends. An upward trend (deteriorating condition) was detected in 11 instances, and downward trends (improving condition) were detected in 62 instances, across the studied substances (Figure 4.2.3).

[17] The threshold value is tested in this assessment, but is not adopted yet.

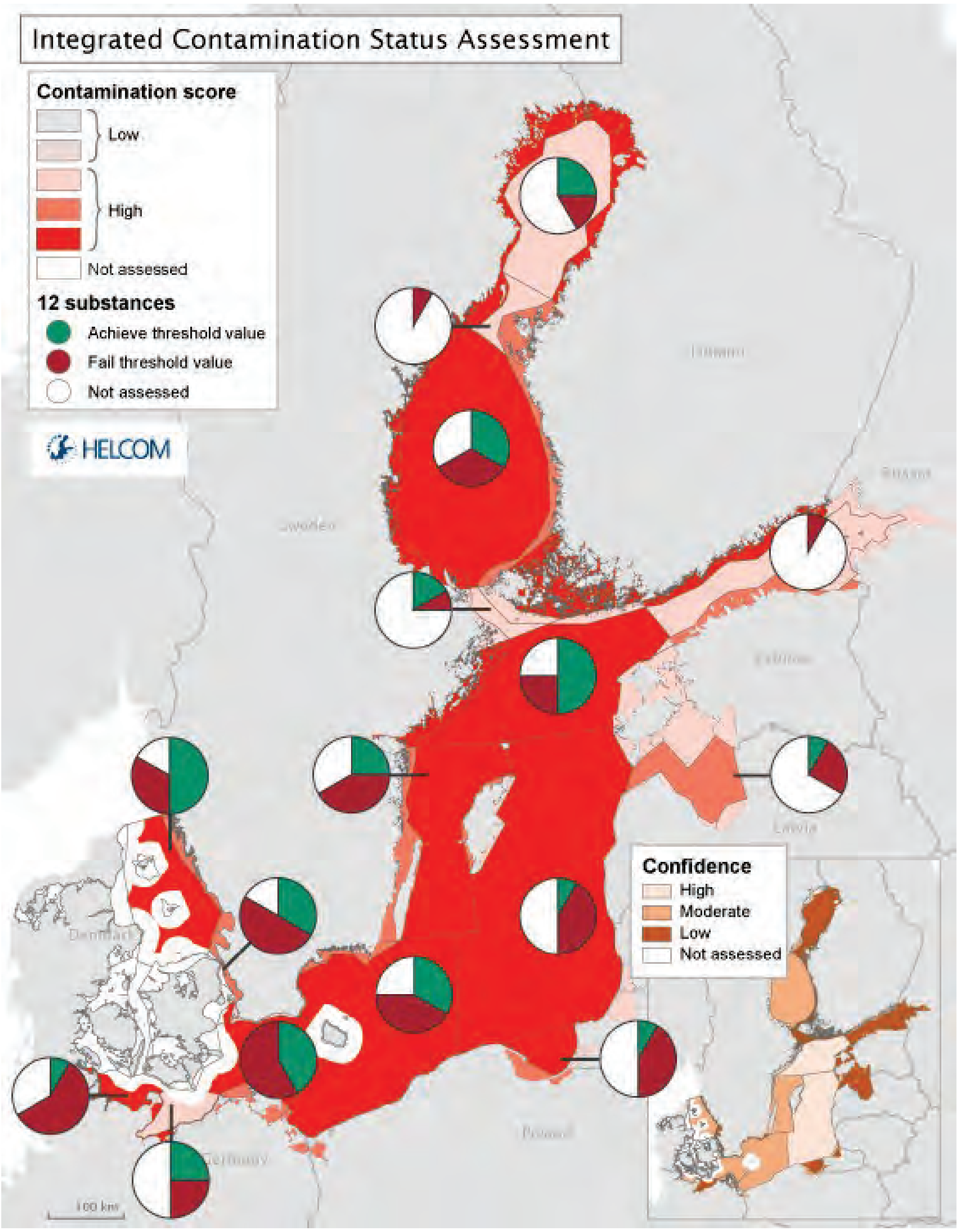


Figure 4.2.1. The integrated contamination status of the Baltic Sea assessed using the CHASE tool. The assessment shows that hazardous substances give cause for concern in all sub-areas. The integration is based on seven core indicators covering concentrations of twelve hazardous substances, using both the full data and 'initial status assessment' data. The pie charts show how many out of the twelve substance groups achieved or failed the threshold value in each assessment unit. Assessment units with lower confidence (as indicated in the map in the lower right corner) typically also have slightly better contamination status, indicating that these results may be worsened if more data were available. The status assessment of hazardous substances in Danish coastal and territorial waters has been done in accordance with the Water Framework Directive and can be found in the Danish national River Basin Management Plans.

Confidence in the assessment

The integrated results for the geographical areas are regionally comparable, however the variation in confidence needs to be considered. The confidence in the result is lowered if monitoring does not cover all key substances. Assessment units with lower confidence generally showed better status than those with high confidence (Figure 4.2.1). For example, polybrominated diphenyl ethers and mercury were highly influential in areas being assessed as not achieving good status in all areas where they were monitored.

To improve the geographical coverage, the integrated assessment also includes stations covered by data for only one or two years labelled as 'initial status assessment' data (Figure 4.2.2, Table 4.2.1). The statistical confidence for these stations is lower than for the stations with longer data series and thus lowers the confidence for the assessment unit. However, concentration between the two types of stations are generally similar and reaching as good a geographical coverage as possible is considered important.

An improvement of the data coverage, both regarding geographical coverage and substances assessed, is anticipated for the updated version of the report to be completed by 2018.

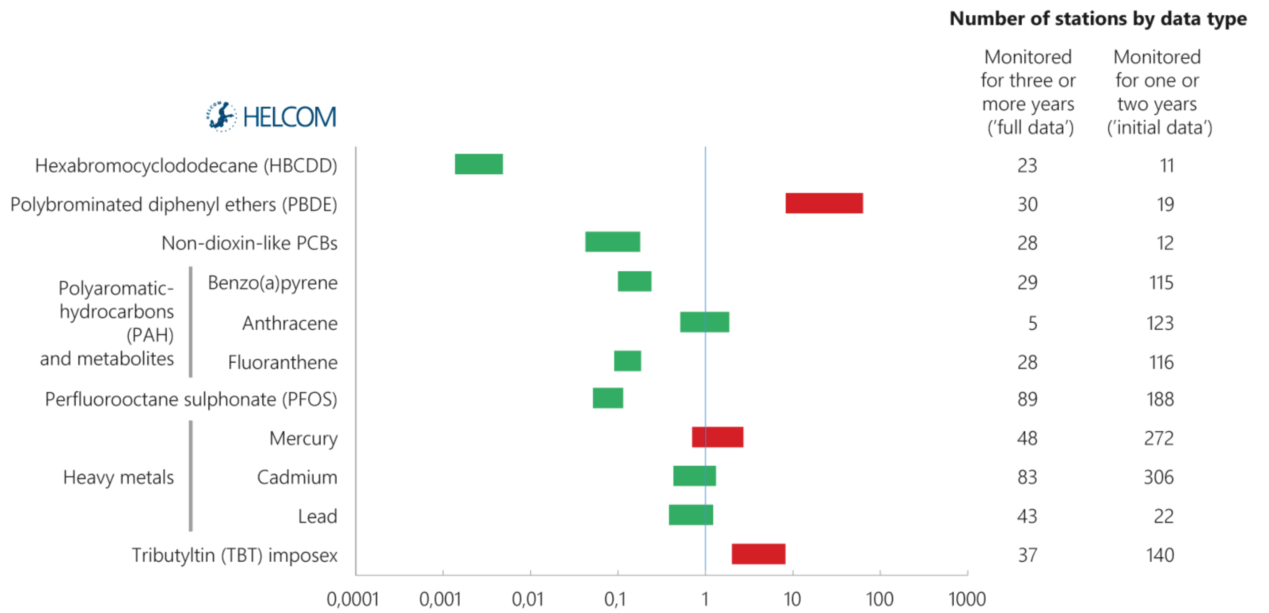


Figure 4.2.2. Contamination ratios (measurement/f) of the evaluated hazardous substances, based on coastal and open sea data used in the integrated assessment. The horizontal bars show the range of contamination score values from the twentieth to the seventy-fifth percentile for each substance on a log-transformed scale. Red bars indicate that the median value fails the threshold value for good status, as identified by the blue line. The assessment included data from long term monitoring ('full data') as well as from stations monitored for only one or two years ('initial data'). The right panel shows the number of stations in each of these groups, per substance. Corresponding information is not available for cesium at this time.

Table 4.2.1. Detailed results for the hazardous substances assessment in the open sea, by core indicators and substances. Cases were the substance fails the threshold value are highlighted by red cells and green cells denote that the substance achieves the threshold value. White cells denote cases not assessed due to lack of data. The core indicators have primary and secondary substances and threshold values. Primary substances and the matrix in which the primary threshold is set are shown in bold. Secondary substances and threshold values are in italics. The table also identifies the type of data that was used in the integrated assessment using the CHASE tool. 'F' denotes that data allowed for a full indicator assessment and 'i' denotes initial status assessment data. In these cases, only one or two years of monitoring data are available. Data can also be included in this category if many measurements are below the limit of detection. Full data was assigned a high confidence and initial data a low confidence in the integration. Abbreviations used: HBCDD = hexabromocyclododecane, PBDE = polybrominated diphenyl ethers, PCB = polychlorinated biphenyls, Non-DL PCB = non-dioxine-like PCBs, PFOS = perfluorooctane sulphonate. * Threshold values for tributyltin in sediment and imposex (marked with *) are included as test threshold values.

CORE INDICATOR	HBCDD	PBDE	PCB, dioxin and furan		Polyaromatic-hydrocarbons and metabolites			PFOS	Heavy metals							Tributyltin and imposex			Radioactive substances	
SUBSTANCE			Non-DL PCB	Dioxin	Benzo(a) pyrene	*Anthra-cene*	*Fluor-anthene*		Mercury	Cadmium			Lead			Imposex	Tributyltin		Cesium-137	
MATRIX / OPEN SEA SUB-BASIN	Biota	Biota	Biota	Biota	Biota	*Sediment*	*Biota*	Biota	Biota	*Biota*	*Sediment*	Water	*Biota*	*Sediment*	Water	Biota*	Sediment*	*Water*	Biota	Water
Bothnian Bay									i		i		i	i						
The Quark																				
Bothnian Sea	F	F						F	F + i		i		F + i	i						
Åland Sea											i			i						
Northern Baltic Proper	F	F	F		F		F	F	F				F							
Gulf of Finland																				
Western Gotland Basin	F	F						F	F		i		F	i						
Eastern Gotland Basin	F	F							F	F			F							
Gulf of Riga									i		i			i						
Gdansk Basin					i		i		i		i	i	i	i	i					
Bornholm Basin	F	F						F	F		F + i	i	F	F + i	i					
Arkona Basin	F	F + i	F		F + i	i	F + i	F	F + i	F + i	F + i	i	F + i	F + i	i		i			
Bay of Mecklenburg					i		i		i	i	F		i	F						
Kiel Bay		F				i			F		F		F	F			i			
Great Belt						i					i			i		F	i			
The Sound					F + i	i	F + i		i	i	i		i	i		F	i			
Kattegat	F	F				i		F	F		i			i		F	i			

Core indicator results

The core indicators have been evaluated against the commonly agreed threshold values. All threshold values and technical specifications are listed in the supplementary report (HELCOM 2017C).

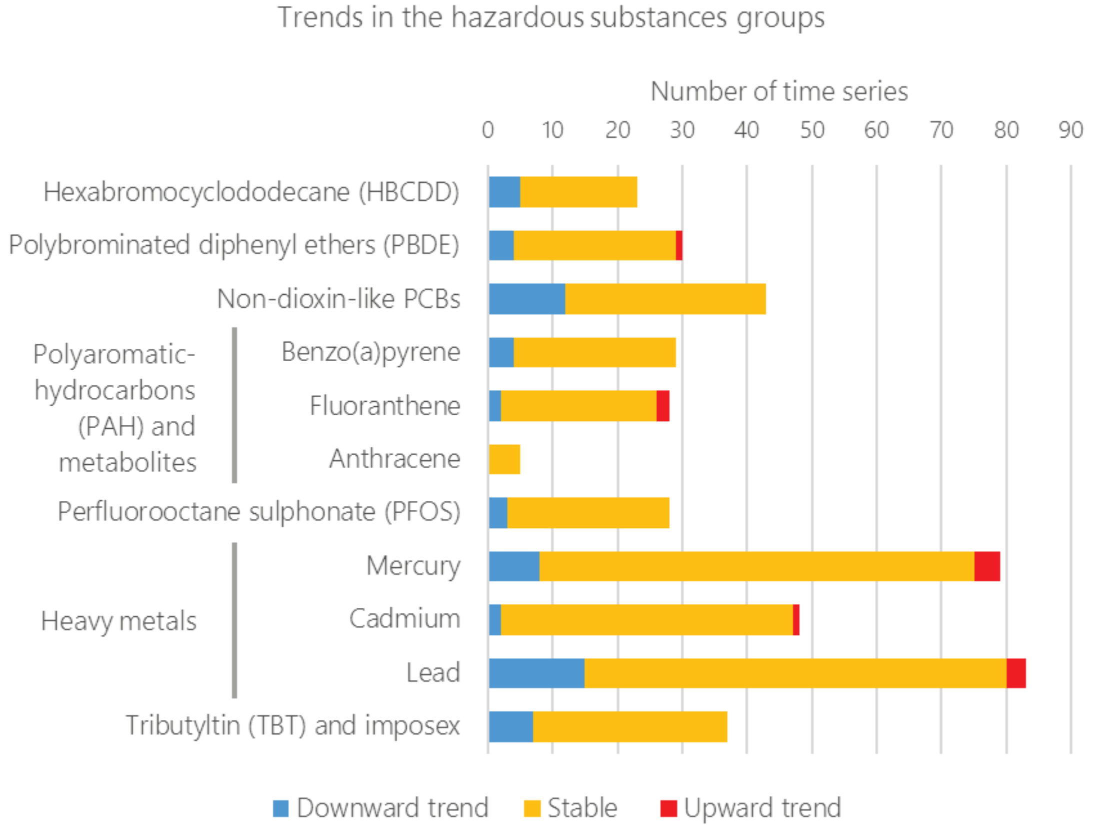


Figure 4.2.3. Trends in the hazardous substances groups, shown as counts of time series assessed at the monitoring stations. The available data for which the trends are calculated differ between substances and stations, covering roughly the following years for each substance; polybrominated diphenyl ethers (PBDE): 1999–2015; mercury: 1979–2015; cadmium: 1985–2015; lead: 1979–2015; hexabromocyclododecane (HBCDD): 1999–2015; perfluorooctane sulphonate (PFOS): 2005–2015; benzo(a)pyrene: 1997–2015; anthracene: 1990–2015; non-dioxine-like polychlorinated biphenyls (PCB): 1978–2015; fluoranthene: 1997–2015, and for the indicator 'Tributyltin (TBT) and imposex'[18]: 1998–2015. Corresponding data for cesium is not available at this time.

[18] Threshold values for sediment and imposex are included as test threshold values.

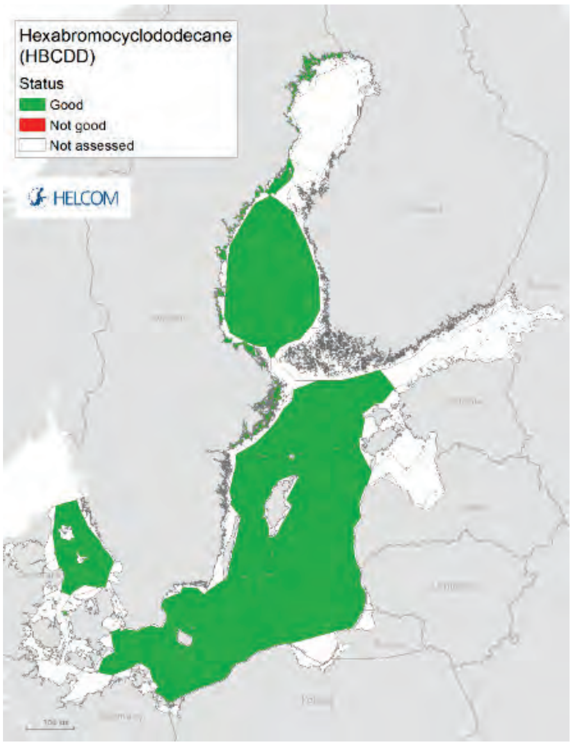


Figure 4.2.4. Assessment result for hexabromocyclododecane.

Hexabromocyclododecane

Hexabromocyclododecane (HBCDD) is a persistent, bioaccumulating and toxic compound with possible impacts on the reproductive and developmental system. It is a brominated flame retardant which is used as an insulation material in the building industry, or as coating of textiles to improve the fire resistance of the materials. As an example of its concentrations in the area, levels of hexabromocyclododecane in herring were below the threshold value, which is set to protect the marine ecosystem and humans consuming fish from adverse effects (Figure 4.2.4, Core indicator report: HELCOM 2017l). The monitoring of hexabromocyclododecane concentrations shows stable and downward trends.

In addition, several other man-made brominated substances have been found in the environment, but little is yet known on their effects on the environment and human health. To keep up with the developments and the emerging risks from such novel substances, there is a need to continue and develop further collaborative monitoring and mapping of their occurrence and use in the Baltic Sea region (Kemikalieinspektionen 2017a).

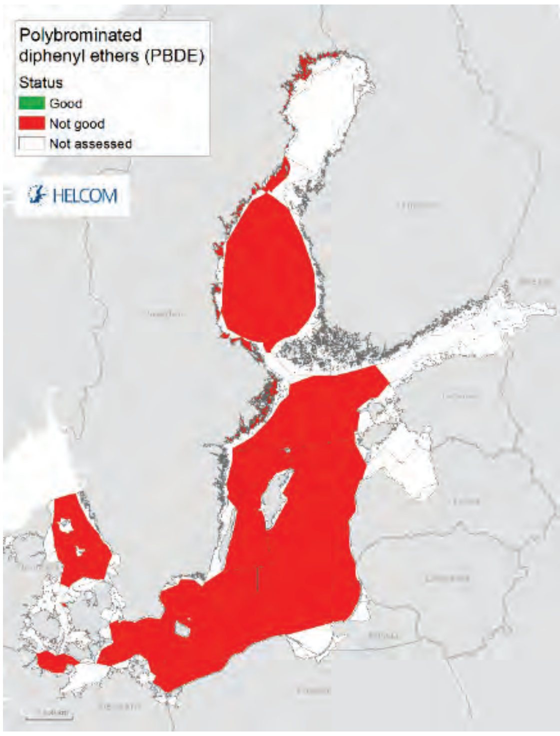


Figure 4.2.5. Assessment result for polybrominated diphenyl ethers.

Polybrominated diphenyl ethers

Polybrominated diphenyl ethers (PBDE) are toxic and persistent substances that bioaccumulate in the marine foodweb.

The threshold value is an environmental quality standard set to protect both the marine ecosystem and humans consuming fish from adverse effects. Polybrominated diphenyl ethers fail the threshold value in all areas where they are monitored (Figure 4.2.5, Core indicator report: HELCOM 2017m).

The use of polybrominated diphenyl ethers as a flame retardant has been banned in most products in Europe since 2004. Therefore, decreasing concentrations are expected in the future. Out of the thirty stations where trends were assessed, downward trends were identified in four stations, and one station showed an upward trend (Figure 4.2.3).

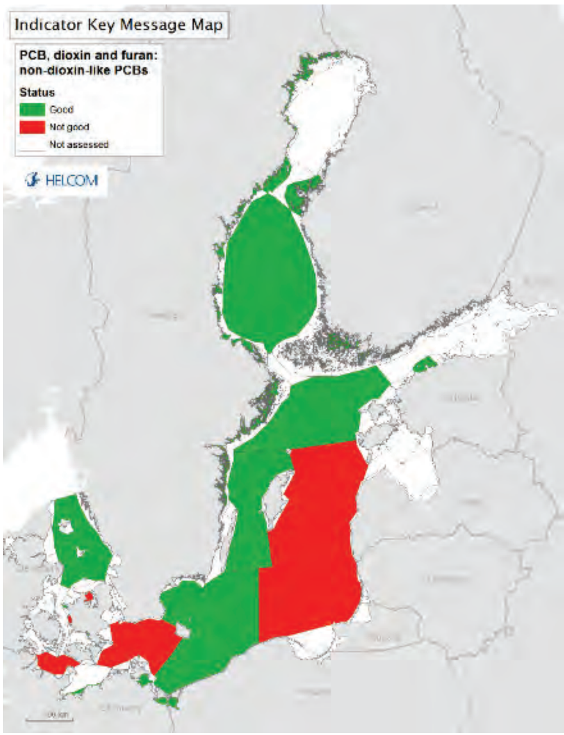


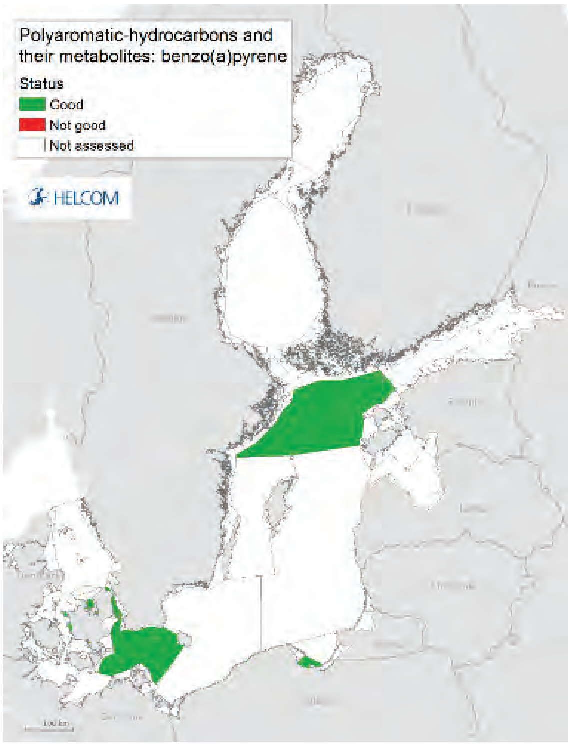
Figure 4.2.6. Assessment result for non-dioxin-like PCBs. Dioxins and dioxin-like compounds were only available as 'initial status assessment' data and are not part of the core indicator "PCB, dioxin and furan" main result.

PCB, dioxin and furan

Polychlorinated biphenyls (PCBs) are persistent, toxic substances and bio-accumulate in the marine foodweb. The substances have been used in a wide variety of applications and manufacturing processes, especially as plasticizers, insulators and flame-retardants. Polychlorinated biphenyls enter the marine environment due to inappropriate handling of waste material or leakage from transformers, condensers and hydraulic systems.

HELCOM has recommended bans and restrictions on transport, trade, handling, use and disposal of polychlorinated biphenyls. The HELCOM Ministerial Declaration of 1998, and the 1995 'Declaration of the Fourth international conference of the protection of the North Sea' called for measures against persistent, bioaccumulating toxic substances like PCBs by the year 2020. The Stockholm Convention on Persistent Organic Pollutants is ratified by the Baltic Sea countries to protect human health and environment.

Non-dioxin-like PCBs were assessed in relation to a threshold value that is based on food safety, showing values above the threshold in some areas (Figure 4.2.6, Core indicator report: HELCOM 2017n). Trends over time were stable or downward (Figure 4.2.3). No full assessment was possible for dioxins, due to data reporting issues.



Polyaromatic-hydrocarbons and their metabolites

Polyaromatic hydrocarbon (PAH) compounds with low-molecular-weight, such as anthracene, are acutely toxic to many marine organisms. High-molecular-weight PAH compounds, such as benzo(a)pyrene, are less toxic but have greater carcinogenic potential. Polyaromatic hydrocarbon compounds enter the marine environment via the release of crude oil products and all types of incomplete combustion of fossil fuels – coal, oil and gas or wood and waste incineration. They are represented in the core indicator by concentration of the substance benzo(a)pyrene in shellfish.

Figure 4.2.7. Assessment result for polyaromatic hydrocarbons (PAH) and their metabolites, reflecting the status of benzo(a)pyrene, the primary substance for the core indicator.

Benzo(a)pyrene concentrations are below the threshold value in all areas where it is measured, indicating that they will not cause adverse effects to the ecosystem or humans consuming shellfish (Figure 4.2.7, Core indicator report: HELCOM 2017o). Trends over time are relatively stable.

When measurements of benzo(a)pyrene are not available, the secondary substances fluoranthene and anthracene can be considered. Initial status assessments show that anthracene concentrations fail the threshold value in the southwestern Baltic Sea.

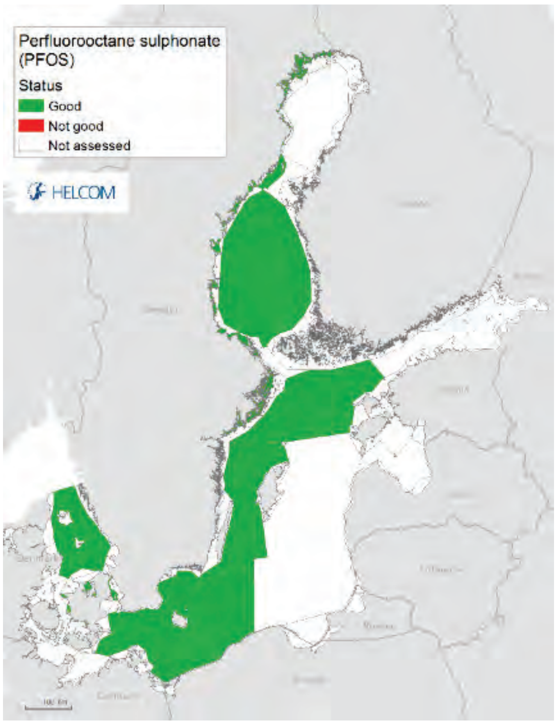


Figure 4.2.8. Assessment result for perfluorooctane sulphonate.

Perfluorooctane sulphonate (PFOS)

Perfluorooctane sulphonate (PFOS) is considered a global environmental contaminant, and is a persistent, bioaccumulating and toxic compound with possible effects on the immune, reproductive and developmental systems as well as lipid metabolism in organisms. The substance has been produced since the 1950s and used in the production of fluoropolymers. It is used commercially to provide grease, oil and water resistance to materials such as textiles, carpets, paper and coatings in general. Perfluorooctane sulphonate has also been widely used in firefighting foams.

Concentrations of PFOS are below the threshold values in all the monitored areas (Figure 4.2.8, Core indicator report: HELCOM 2017p). The concentrations in biota, (measured for example in herring) are at a low level. The concentrations are generally stable over time, with a few down ward trends.

The use of perfluorooctane sulphonate has been banned in the EU since 2008 but it has been replaced with other substances, so called per- and polyfluoroalkyl substances (PFAS) which have widespread use. The PFAS substances are often highly persistent and bio-accumulating and are also a cause of concern. Some PFAS substances are listed on the EU candidate list on 'Substances of very high concern' under the REACH regulation (ECHA 2017). Inclusion of additional PFAS substances as core indicators should therefore be considered in the future, to keep track of their use and occurrence in the Baltic Sea region (Kemikalieinspektionen 2017b).

Heavy metals

Heavy metals are toxic, and some of them, such as cadmium and mercury also bio-accumulate in the marine foodweb. One current source of heavy metals is burning of fossil fuels, leading to atmospheric deposition. Legislations are in place to decrease inputs of mercury, cadmium and lead to the Baltic Sea. The atmospheric deposition of cadmium and mercury to the Baltic Sea has decreased since the 1990s (Figure 4.2.9)

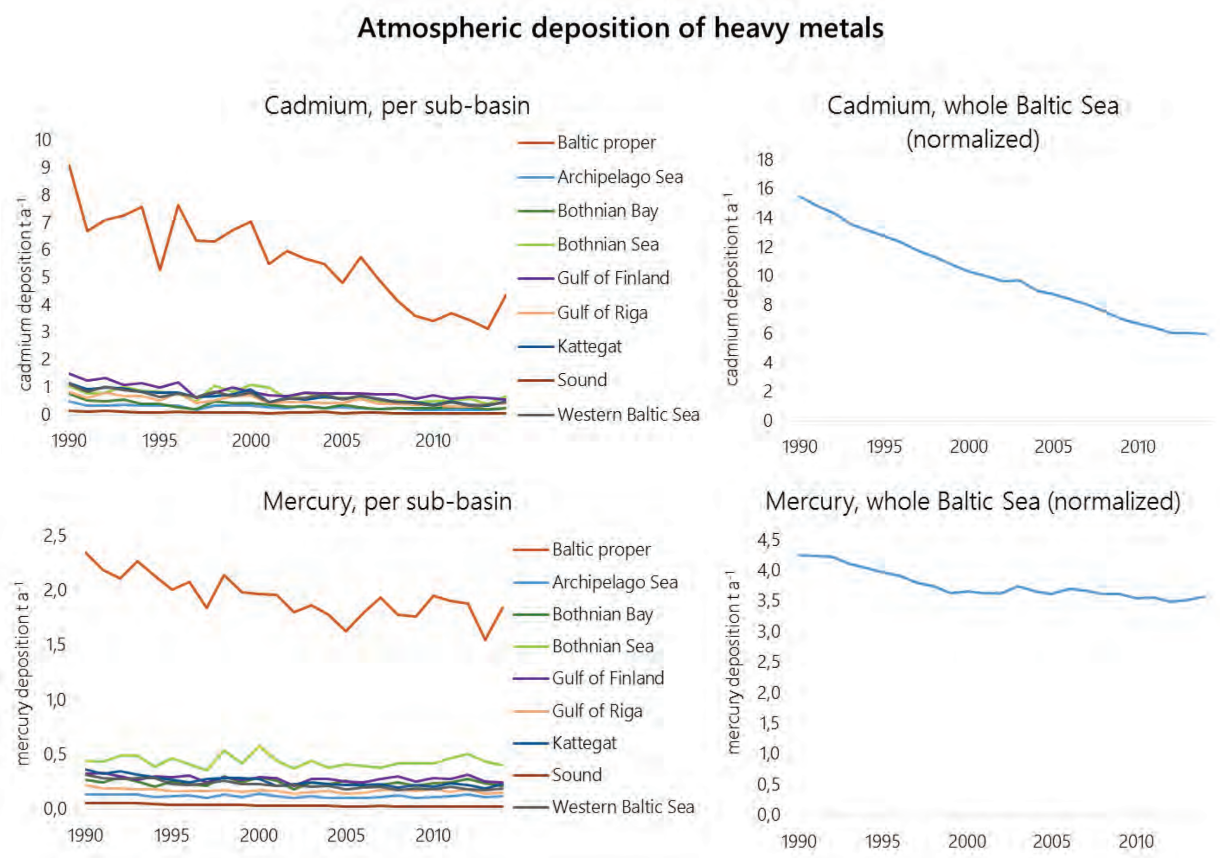


Figure 4.2.9. Temporal development in the total annual atmospheric deposition of the heavy metals cadmium and mercury to the Baltic Sea sub-basins. The right hand figures show values for the whole Baltic Sea. These are given as normalised atmospheric deposition to reflect the deposition independently of variability between years in weather conditions. Note different scales.

Mercury fails the threshold value in nearly all areas, except in some coastal areas. In areas where the threshold value is failed, the concentration in herring, for example, is at levels where top predators such as seals are at risk of suffering from secondary poisoning (Figure 4.2.10). Cadmium concentrations in both biota and sediment fail the threshold value in many areas and concentrations are clearly elevated from natural background concentrations. Lead concentrations achieve the threshold value in some areas (Figure 4.2.10), and show downward trends in its concentration in biota and sediment at fifteen stations (Figure 4.2.3). All three heavy metals mostly showed stable trends (Figure 4.2.3, Core indicator report: HELCOM 2017q).

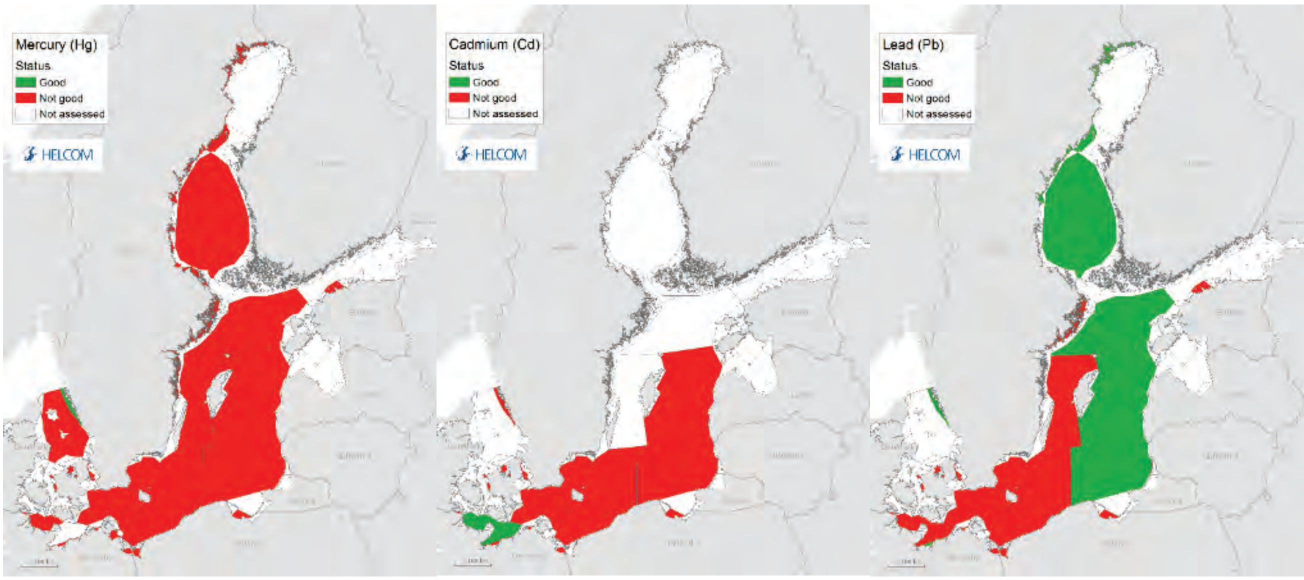


Figure 4.2.10. Assessment result for the heavy metals mercury, cadmium and lead.

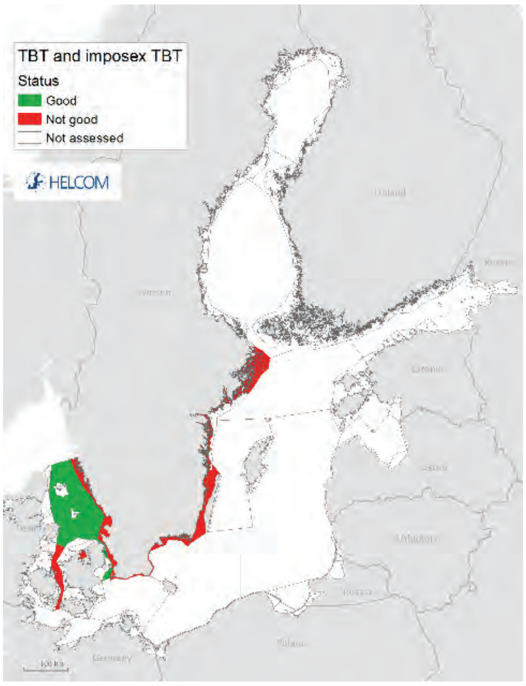


Figure 4.2.11. Assessment result for the indicator 'TBT concentration and imposex'. The results are shown for the imposex assessment. Only initial status assessment data was available for tributyltin (TBT) in sediment.

Tributyltin and imposex[19]

Tributyltin (TBT) is a toxic substance known to affect the hormonal function in marine organisms, for example causing imposex in marine snails. Tributyltin has previously been used in paint to prevent biofouling on ships. Its use in such antifouling paints has been banned on a global level by the 2001 International convention on the control of harmful anti-fouling systems on ships (the AFS convention), which entered fully into force in 2008. Most Baltic Sea countries have ratified the AFS Convention. From 1 January 2008, ships bearing an active tributyltin coating on their hulls are no longer allowed in Community ports (EC 2003c).

Indicated by deformed sexual organs in marine snails, concentrations of tributyltin fails the threshold value along coastal areas in the Baltic Proper, The Sound and the Kattegat, but is achieved in the open sea of the Kattegat. Sediment concentrations fails the threshold value in the southwestern Baltic Sea (Figure 4.2.11; Core indicator report: HELCOM 2017r). However, only data from the southwestern Baltic Sea, which represents only a small number of the available monitoring stations for tributyltin in sediments, have been included in this evaluation due to technical data reporting issues.

[19] The threshold values for sediment and imposex are being tested in this assessment, but are not yet adopted.

An updated evaluation with a wider spatial extent, especially in the southern parts of the Baltic Sea, will be presented for the updated version of the report in one years' time.

Radionuclides

Cesium (137Cs) is the greatest contributor of artificial radionuclides to the Baltic Sea. It emits ionizing radiation, which can have effects at the cellular level and lead to internal damage of organisms. 137Cs was deposited in the Baltic Sea after the accident at the Chernobyl nuclear power plant in 1986. Since then it has bio-accumulated in marine flora and fauna and deposited in marine sediments. The concentrations in herring have decreased from the high values in the 1990s in all sub-basins (Figure 4.2.12, Core indicator report: HELCOM 2017s).

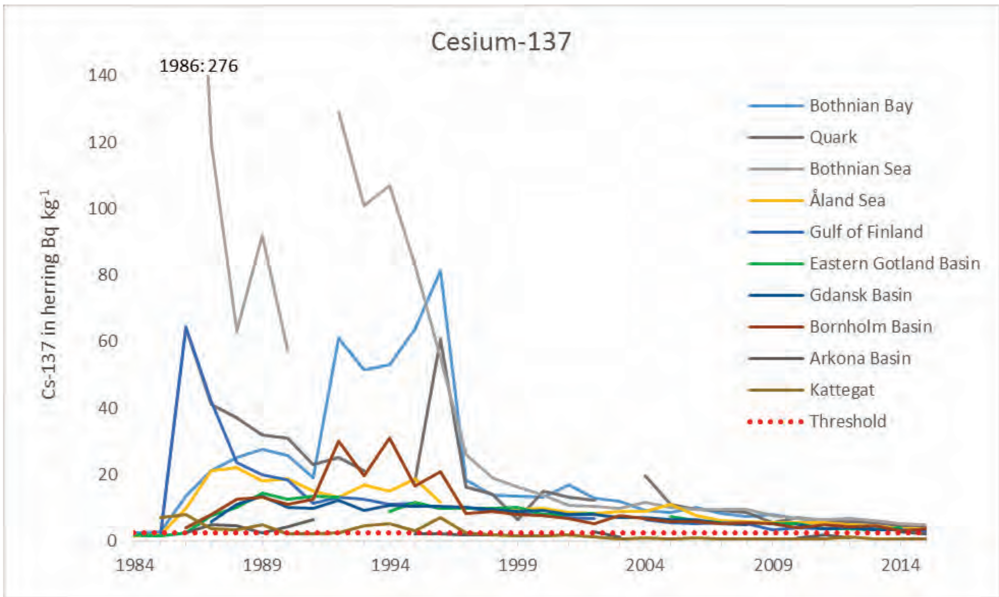


Figure 4.2.12. Temporal development of in the concentration of ^{137}Cesium in herring (measured without head and entrails or in filets, by sub-basin). Concentrations are given as Becquerels per kilogram, calculated per wet weight.

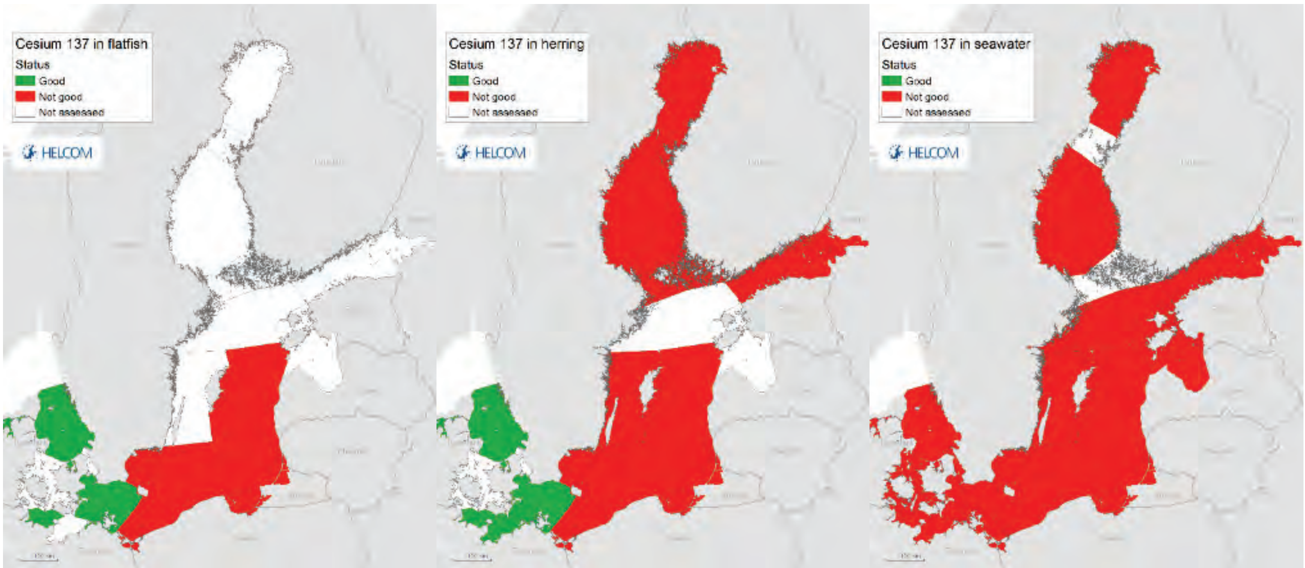


Figure 4.2.13. Assessment result for radioactive substances.

The concentrations of radionuclides are below the threshold value when measured in fish in the Arkona Basin, Bay of Mecklenburg and the Kattegat, indicating good status, but they are above the threshold value in all basins when measured in water. Due to the steady half-life of radioactive decay it is expected that concentrations below the threshold value in biota and water may be achieved in all of the Baltic Sea by 2020.

White-tailed eagle core indicator

White-tailed eagles are top predators of the food web, which makes them highly vulnerable to hazardous substances that accumulate and magnify through the food web. The white-tailed eagle has suffered for decades from the effects of persistent chemicals in the Baltic Sea environment. Impacts were already apparent in the 1950's and identified to be mainly due to at that time widely used insecticides (DDTs) and possibly polychlorinated biphenyls (PCBs). Bans on the use of these substances have already been in place for decades and positive development has occurred since the 1980s.

Negative effects of well-known long-standing environmental contaminants, as well as emerging new contaminants can become apparent in white-tailed eagles before they are visible in other species. Parameters describing the number of hatchlings in nests and the proportion of nests producing young (thus the overall productivity) signal effects from contaminants rapidly and forms the basis for the core indicator. While changes in the abundance of adult birds might only occur over a period of several years, an increased mortality of eggs and thus a lowered productivity is an early warning signal of contamination.

The assessment shows that the core indicator 'White-tailed eagle productivity' reached the threshold value in most coastal areas of the Baltic Sea. In the Archipelago Sea, the breeding success remained slightly below the threshold, and in the Swedish coast of the Bothnian Sea and the German coast the nestling parameter did not reach the threshold value (Core indicator report: HELCOM 2017t).

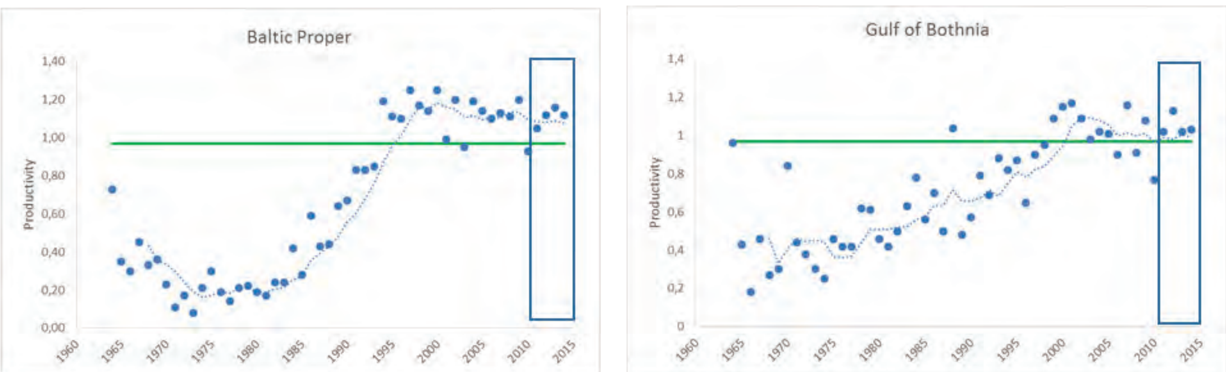


Figure 4.2.14. Mean annual productivity of white tailed eagle, estimated as the number of nestlings per occupied territory in coastal sub-populations of the Baltic Proper and Gulf of Bothnia (based on data from Sweden). The green line illustrates the threshold value of the core indicator. The blue box identifies the assessment period 2011–2015.

Acute pollution events core indicator

Oil is the main fuel in the majority of the ships in the Baltic Sea region, and large amounts of oil are transported across the Baltic Sea. Oil and other petroleum products are released into the sea intentionally or due to negligence, often as oil in bilge water or via dumping of waste oil. Oil may also be released in ship accidents. Most oil spills are detected along the main shipping routes. Oil spills are a serious threat to the marine environment, causing toxic effects and death of marine animals. Even small amounts of oil on the sea surface can harm waterbirds by contaminating their plumage, which reduces their buoyancy and thermal insulation.

Illegal oil spills have been monitored using aerial surveillance since 1988 in the Baltic Sea area. The aerial surveys today are conducted by all HELCOM Contracting Parties with standardised methods, and cover nearly the whole Baltic Sea area. The effort is focused on the busiest shipping routes. The information collated through the aerial surveillance is used in the core indicator on operational oil-spills from ships.

The core indicator evaluation shows that oil spills failed the threshold value in the Bothnian Bay, the Quark, Bothnian Sea, Åland Sea, Eastern Gotland Basin, Kiel Bay and the Great Belt during the assessment period 2011–2015. The threshold values are set based on the volumes of oil spills into each sub-basin during a modern baseline status defined by the reference period 2008–2013, when the estimated volume of oil spills was at a historically low level. The long-term goal in HELCOM is to reach a level of zero oil spills.

Both the number of observed illegal oil spills and the estimated volume of detected oil have decreased in all sub-basins during recent decades. The size of single spills has also shown a decreasing trend, with a significant decrease in spills larger than $10m^3$. This decrease in oils spills has been achieved although no concomitant decrease in maritime traffic has occurred, indicating that measures conducted to decrease oil spills to the environment have been successful (Core indicator report: HELCOM 2017u).

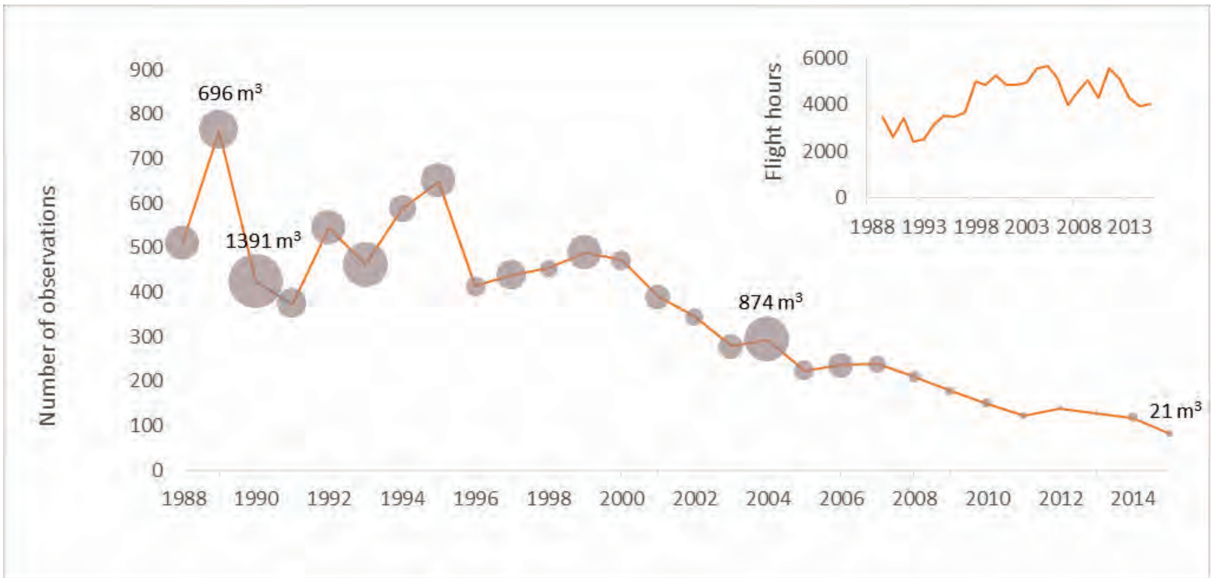


Figure 4.2.15. The number of oil-spills detected in aerial surveillance by the Baltic Sea countries between 1988 and 2015. The number of flight hours are shown in the inserted figure. The size of the circles indicates the amount of spilled oil in cubic meters. The peaks in the amount of spilled oil detected in 1990 and 2004 were likely caused by single events. In 1990 an accidental spill due to a collision between the Soviet tanker Volgonef 1263 and the West German dry cargo ship Betty at the south coast of Sweden is the main cause, whereas the underlying cause for the high estimated amount of oil in 2004 is undocumented. The peak values highlight that single oil spills may introduce large amounts of oil to the environment, and underline the importance of estimating the volume of introduced oil when evaluating whether the pressure is at a level allowing the environment to reach good status.

Box 4.2.2. Pharmaceuticals

The main source of pharmaceuticals to the Baltic Sea come from humans and animals, via urine and faeces, as well as the inappropriate disposal of unused medical products into sewers. Municipal wastewater treatment plants are considered a major pathway for introduction to the aquatic environment, with an estimated release of about 1.8 thousand tons of pharmaceuticals to the Baltic Sea. The fate and impacts of those pharmaceuticals in the environment is still largely unknown.

During the period 2002 to 2013, pharmaceuticals were detected in about 14 % of the water, sediment and biota samples in the Baltic Sea (HELCOM 2016c). The most frequently detected substances belong to the therapeutic groups of anti-inflammatory and analgesics, cardiovascular and central nervous system agents. In biota, the largest number of different pharmaceutical substances and the highest concentrations were found in blue mussels.

A number of pharmaceuticals considered to be of special concern to the aquatic environment have been included on a 'watch list' under the EU Directive regarding priority substances in the field of water policy, and maximum acceptable detection limits have been proposed (European Commission 2013). Of the listed substances diclofenac was detected in 25 % of the samples in the Baltic Sea, and failed the proposed maximum acceptable detection limit in 2 % of the samples. The antibiotic claritromycin was detected in two out of 126 water samples and on one occasion in biota. Out of 228 water, sediment and biota samples, the hormones estradiol and 17a-ethinylestradiol were detected in three water samples. However, in many cases the analytical level of detection of the methods were not sensitive enough to give a result.

HELCOM aims to develop core indicators for diclofenac concentration and estrogenic-like chemicals and effects.

4.3 MARINE LITTER

Marine litter is a clearly visible problem along the Baltic Sea coastline, but it also accumulates out at sea and occurs in many different types and size classes. The smallest microlitter particles are invisible to the human eye, but reach the marine food web when animals ingest them. Larger pieces of marine litter deteriorate habitat quality and can cause direct harm to animals when they become entangled or ingest the litter. Plastic materials are a special concern due to their risks to the environment and very low degradation below the photic zone in the water column, resulting in high persistence of plastic litter especially at the seafloor. Around 70 % of the litter items recorded in the Baltic Sea are derived from human usage of plastic materials. The regional goal agreed in HELCOM is to reduce the amount of marine litter significantly by 2025 and prevent harm from litter in the coastal and marine environment.

Litter in the sea can affect human activities and have socio-economic impacts, due to the cost of removal, or negative effects on tourism and recreation, for example. It may also damage fishing gear or present a risk to navigational safety. Marine litter also has various effects on marine life, either directly or by affecting the quality of the habitat by effects on physical structure or local biogeochemistry.

Artificial, polymer materials, more commonly known as plastics, are of special concern due to their longevity, and because they may provide a pathway for the transport of harmful chemicals into the food web. Litter has been observed to cause harm to animals, via ingestion clogging the digestive tract or causing contamination. Additionally, marine litter is known to damage, alter or degrade habitats and to be a possible vector for the transfer of alien species, leading to effects on biodiversity. The risks associated with microlitter for marine animals is presently under extensive study, including evaluation of potential effects on nutrition and food webs.

During the last few years HELCOM has worked and made progress on the development of core indicators for assessing marine litter. These indicators are not yet operational, although an assessment approach is underway for beach litter, litter on the seafloor and microlitter in the water column (HELCOM 2016a–c).

Marine litter on the beach

Marine litter is often left by people on beaches, or it may end up at the shoreline after transportation from other points of discharge. Updated data for the Baltic Sea region is currently available covering the time period either 2012 to 2016 or 2014 to 2016 for eight countries, and gives an indication of the spatial distribution of marine beach litter along the Baltic Sea coastlines (Figure 4.3.1).

Plastic is clearly the most common litter material, followed by paper, processed wood, metal and ceramics (Figure 4.3.2). The amount of litter items on the beach are highest during spring for most types of litter materials for the Baltic Sea, although there are differences between countries. Most of the litter items are found in the western Baltic Sea and in the Northern Baltic Proper, whilst wooden litter items are recorded mostly in the central and northern parts of the Baltic Sea. The spatial differences are influenced by local human activities but also by the level of beach cleaning in between monitoring events. In addition, the shape of the coastline and the direction of water currents appear to play an important role in determining where litter accumulates.

The available data is not yet sufficient to evaluate the trend in beach litter over time for all basins. It is anticipated that the longest available data series will be used for further analysis and baseline determination.

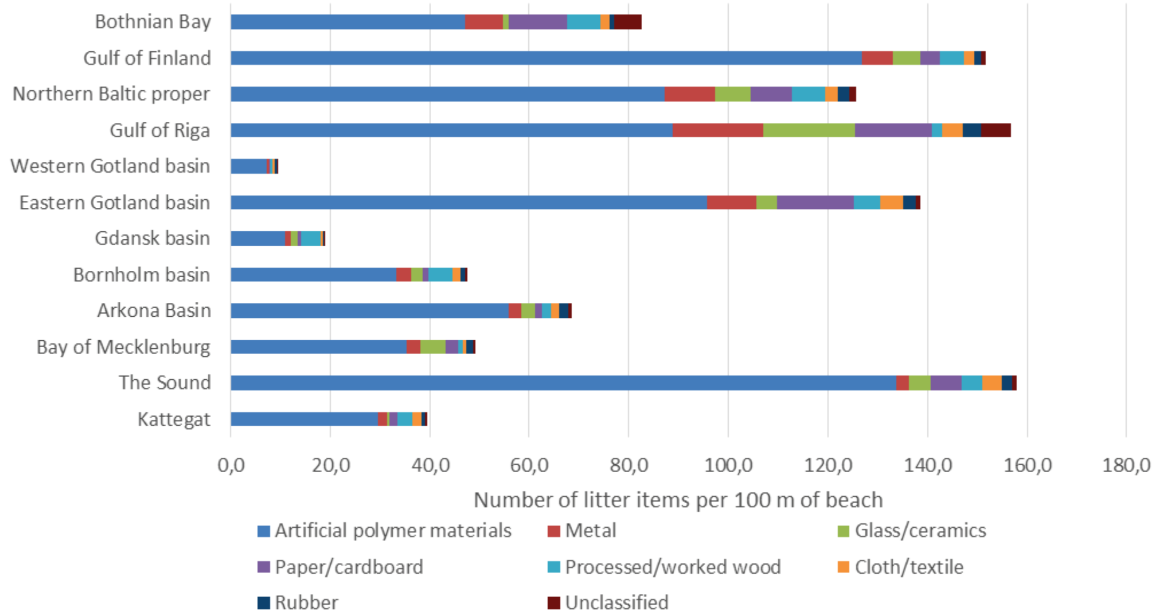


Figure 4.3.1. Indication of the distribution of marine litter items on the beach in different basins of the Baltic Sea, using available data from Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden for the years 2012 to 2016. The spatial differences are influenced by local human activities but also by the level of beach cleaning, the shape of the coastline and water currents. Because the period for litter monitoring and the number of the monitoring sites varies between countries, all data have been recalculated and presented as the average number of litter items per 100 m of the beach. The litter is divided into eight regionally agreed litter categories.

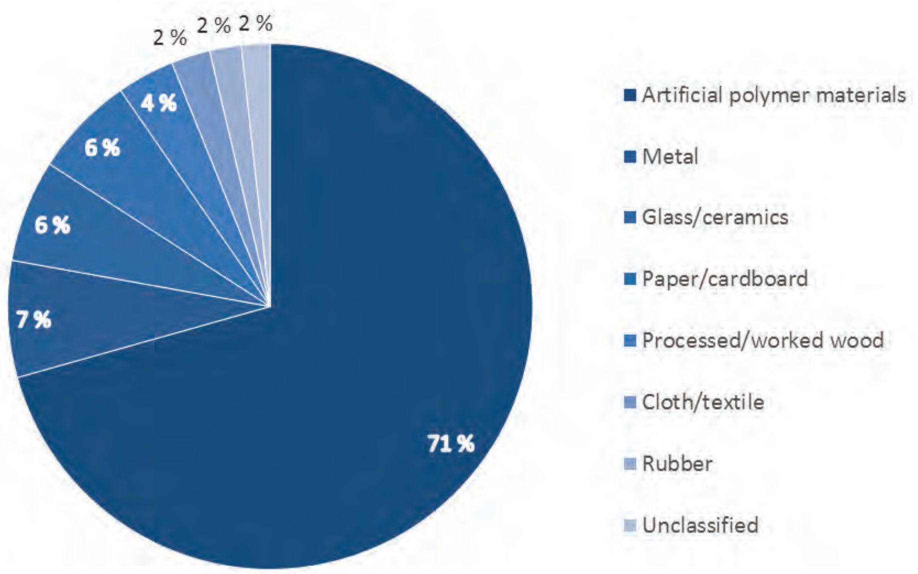


Figure 4.3.2. Proportions of litter items in the eight regionally agreed litter categories, based on the average number of litter items per 100 meter beach in the Baltic Sea for the years 2012 to 2016.

Litter on the seafloor

Litter that has entered the marine environment can be transported long distances by water currents, and can accumulate on the seafloor far away from its original source. Hence, all types of sources can contribute to seafloor litter, but items associated with maritime activities, such as lost and discarded fishing gear are a major component of seafloor litter. Abandoned, lost, or discarded, fishing gear is termed 'ghost nets' and pose a threat to marine life since they continue fishing not only fish, but also birds and marine mammals and can be considered as posing an especially large risk to marine life. Experiments have shown that the catching efficiency of lost gillnets amounts to approximately 20 % of the initial catch rates after three months, and around 6 % after 27 months (WWF Poland 2011).

Seafloor litter can be monitored alongside fish, using trawling surveys. The Baltic International Trawl Survey (BITS), coordinated by the international council for exploration of the sea (ICES), has been going on for several years but data on litter on the seafloor has been collected systematically only since 2015. The trawl survey covers areas from the Northern Baltic proper and south, but there is no Baltic-wide trawl survey and shallow water areas are not covered.

Figure 4.3.3 Ghost nets are lost fishing gear that continue fishing on the sea floor, catching fish as well as other species.

Microlitter

The term microlitter is used for litter particles smaller than 5 mm, but they can also be much smaller (GESAMP 2015). Some studies have focussed on particle sizes as low as 20 or even 10 µm. It includes both synthetic and non-synthetic particles (such as plastic, cellulose, cotton, wool, rubber, metal, glass, combustion particles). The particles can be from primary sources, or derived from the breakdown of larger litter items (so called secondary particles). Microlitter may be found in all parts of the environment; on the water surface, within the water column, on the sea floor and shore, as well as inside marine organisms. Also particles with low density (such as many common plastic types) can reach the sea floor by being incorporated in marine snow, attached to detritus falling from the surface to the deeper water.

Most of the environmental harm of microlitter has been associated with microplastics. Ingestion of microplastics by a variety of animals has been shown in laboratory and field studies.

Although the proportion of microlitter of different materials has not been assessed in the Baltic Sea, it is likely that plastic polymers form the majority of microlitter particles, like they do for larger marine litter, but other components may also be important (Magnusson *et al.* 2016). Information on impacts of microlitter and microplastics on marine food webs is constantly growing.

Impacts and recovery

Many marine litter items, and their negative impacts, accumulate in the environment due to the slow degradation time. Additionally, the degradation process will make the nature of the problem change over time from macro to microlitter. Global estimates have indicated that 275 million metric tons of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million metric tons entering the ocean (Jambeck *et al*. 2015), and the world annual plastic production is increasing. Most plastics are used in packaging or in the building industry and are discarded within a year of their production.

Political will and a robust regulatory framework are key factors in reducing marine litter. With increasing awareness, efforts are also increasing to change production and consumption patterns with the aim of stopping waste becoming litter. In addition, regulatory frameworks and actions to improve waste and wastewater management are important. A large number of measures have been undertaken by HELCOM over recent years, which directly or indirectly can be expected to have resulted in reducing amounts of marine litter. Among them, the 2013 HELCOM Ministerial Declaration (HELCOM 2013a) made a commitment to achieve a significant quantitative reduction of marine litter by 2025 (compared to 2015) and to prevent harm to the coastal and marine environment. Such an aim is intended to be achieved via the implementation of land-based measures, sea-based measures and educational and outreach actions defined as part of the HELCOM Action Plan on Marine Litter (HELCOM 2015b).

4.4 UNDERWATER SOUND

Sound is continuously present in the underwater environment, and is produced naturally by wind, waves, ice, and thunder, as well as by animals. Human activities cause additional sounds which may have a polluting effect. These are typically by-products of marine activities and infrastructure, such as shipping, bridges, or underwater construction work, but are also spread deliberately by the use of eco-sounders, sonars and seismic airguns, for example. HELCOM has developed monitoring of underwater sound, and agreed that 'underwater sound should not have negative impact on marine life in the Baltic Sea'.

Sound waves propagate over long ranges in water and their impact may occur far from the sources, across national boundaries. Two categories of sound are identified: continuous and impulsive. Continuous sound from a source can be constant, fluctuating, or slowly varying over a long time interval.

Various human activities may generate continuous sound. Examples of such activities are among others bridges, offshore wind turbines, shipping and boating which also influence on the local sound environment. One concern is that human generated continuous sound may mask animals' communication and signals used for orientation.

Impulsive sound is characterised by short duration and a fast pulse rise time. The sound associated with piling, underwater explosions or airgun signals used in seismic surveying are examples of impulsive sound. This type of sound can displace animals, as they are scared away from the area, and can also cause temporary or permanent hearing loss if no mitigation measures are applied.

A good environmental status with respect to underwater sound requires that the level and distribution of both continuous and impulsive sounds should not cause negative impacts on marine life (HELCOM 2013a). At this time, such levels have not been defined for sound sensitive species in the Baltic Sea.

Continuous low frequency anthropogenic sound

Continuous sound levels in the Baltic Sea were measured in a comprehensive study using automated hydrophone loggers in 2014 by the project Baltic Sea Information on the Acoustic Soundscape (BIAS). The data were used to develop modelled soundscape maps (Figure 4.4.1), which show the spatial and temporal distribution of continuous sound in different frequency bands across the Baltic Sea (1/3 octave bands of 63, 125 and 2000 Hz). The lower frequency bands are typical of ship induced sound, and the higher frequency bands are measured due to their ecological relevance.

The maps identify areas with different levels of continuous sound and at the same time they show the statistically calculated temporal distribution of sound levels at these areas. Continued monitoring is carried out by several countries on a temporary basis, and a regional programme for monitoring continuous underwater sound is under development.

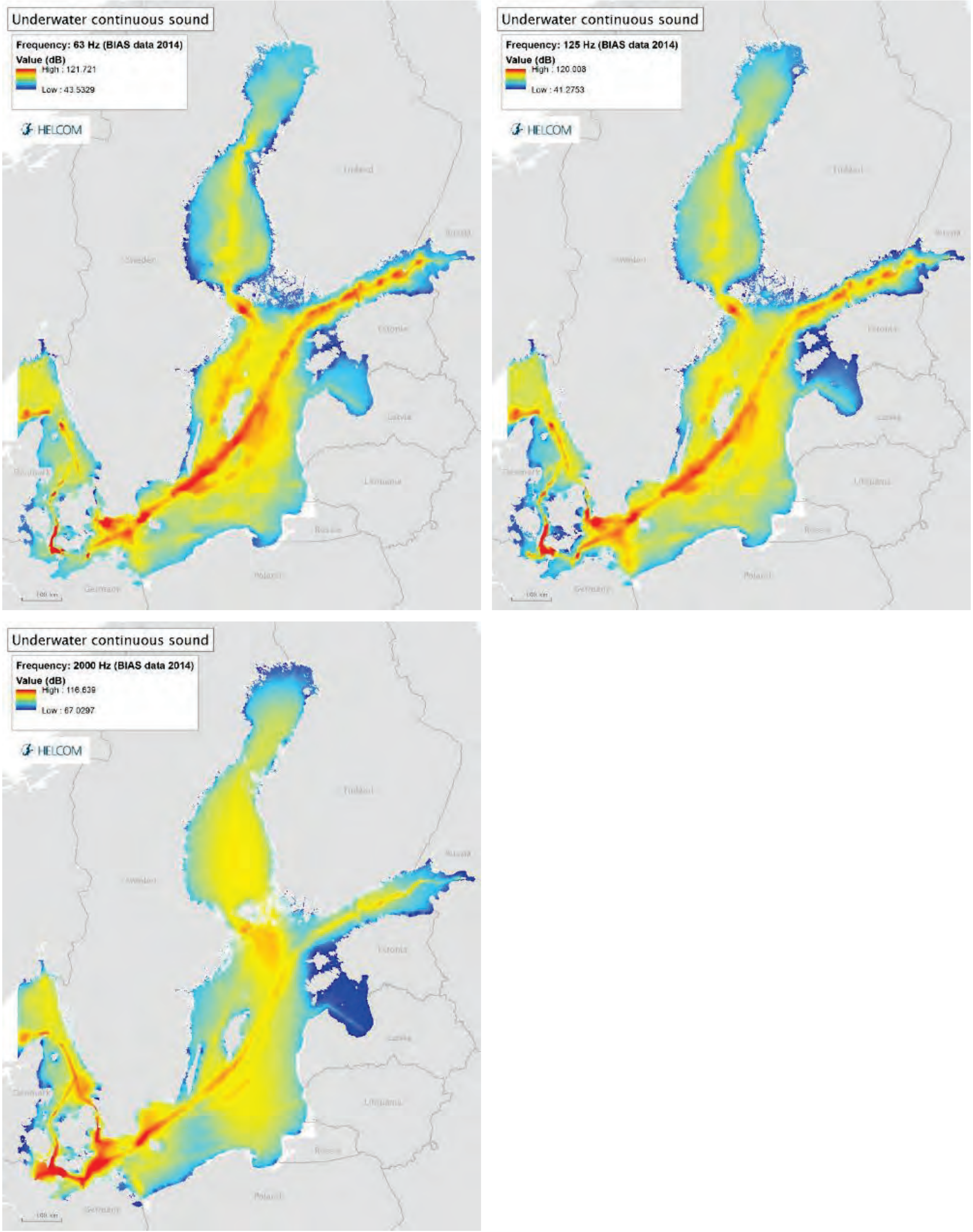


Figure 4.4.1. Soundscape maps in the Baltic Sea, showing underwater continuous sound at 1/3 octave frequency bands of 63 Hz, 125 Hz and 2000 Hz. Areas with high sound level overlap clearly with the location of major shipping routes. The sound produced from shipping is within a frequency interval that overlaps with the hearing range of several species. The results have been extracted with help of the soundscape planning tool of BIAS (2016).

Impulsive sound

Impulsive sounds may cause large scale displacement as well as physical damage to marine animals. In some cases mitigation measures may help to lower the damage.

The occurrence of activities associated with loud impulsive sounds, such as sonar events, airguns and underwater explosions and pile driving, can (since 2015) be logged in a regional registry established by HELCOM and OSPAR and hosted by ICES. Countries have agreed to register these activities, and reports on sound-generating activities have so far been supplied by five countries during the period 2013–2016[20]. Denmark has delivered data on pile driving for 2015 (12 events). Sweden has reported sonar events (90), airguns (31) and underwater explosions (35) in 2015 and Germany pile driving events in 2013 (95) and 2014 (67). Germany had no registered impulsive events in 2015 to be reported according to the reporting guidance (JRC 2014). Lithuania has reported explosions in 2013 (8) and 2016 (12). In the future the registry will provide a quantitative view of activities that generate impulsive sound and their distribution in the Baltic Sea to support future status assessments.

Information from the registry will also support evaluation of possible impacts on species and decisions on mitigation strategies to be applied when conducting impulsive sound generating activities.

Impacts

Across the Baltic Sea there is strong temporal and spatial variability in sound levels, but as yet it is not clear how much marine species are impacted.

Harbour porpoise and seals are species that are likely to be especially affected by human generated sound. They have very good underwater hearing abilities and rely on sound for their orientation, communication and foraging. Harbour porpoise also uses echolocation to find prey. Many Baltic fish species hear and produce sound at low frequencies (Figure 4.4.2). For example cod uses sound to communicate and to perceive their environment. For most species, including fish, diving birds and the majority of Baltic invertebrates, little is known about what role sound plays, even though it is likely that it is essential in at least some part of their life cycle and that they could be affected by high sound levels.

For the first time in the HELCOM assessment, spatial information of the sound distribution in the Baltic Sea (Figure 4.4.1) has been compared with maps of key areas for sound-sensitive species. The overlap (Figure 4.4.3) gives indication of the risks from sound generating activities to different species. Spawning areas for cod and recruitment and foraging areas for harbour porpoise are examples of areas with elevated risk of impact.

[20] Poland reports data as soon as reporting transect data will be fixed

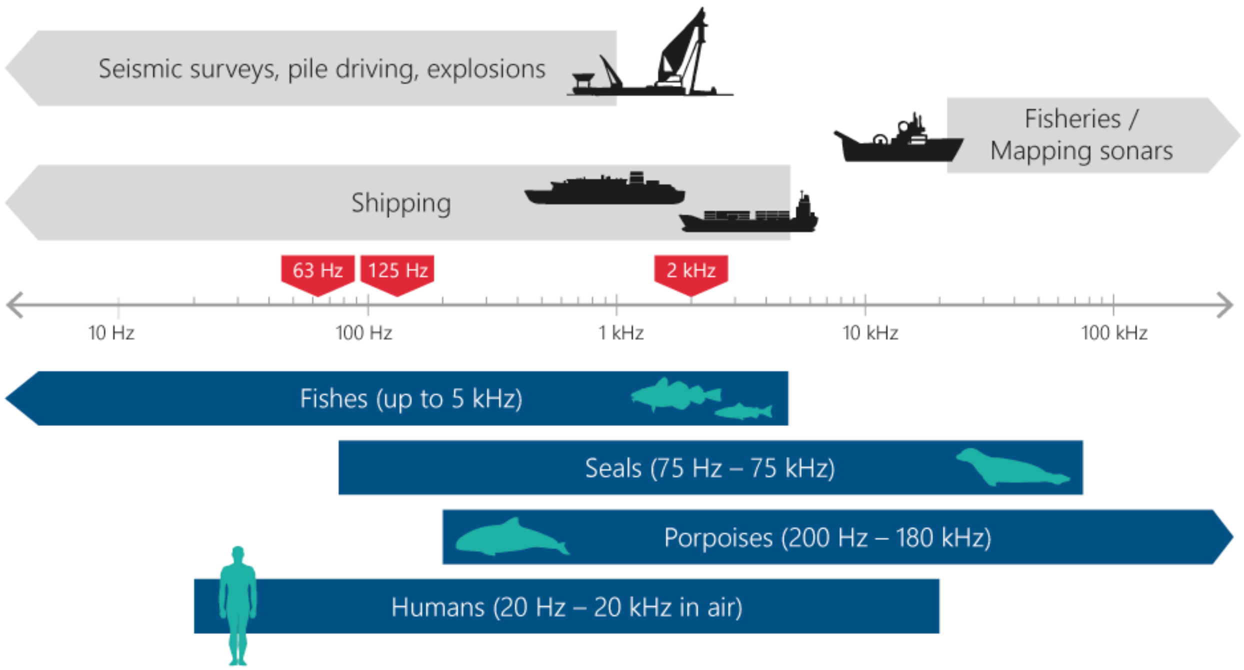


Figure 4.4.2. Auditory range of some marine species present in the Baltic Sea and sound frequencies generated by human activities. Human hearing is provided as a reference. After Scholik-Schlomer (2015) adjusted to Baltic Sea conditions. The red fields indicate the monitored frequency bands within BIAS. Source: BIAS 2017.

A changing sound environment

There is no data to show how sound levels have changed over time in the Baltic Sea. Looking ahead, at least some of the human activities which may generate underwater sound, such as off-shore construction work, energy installations and shipping, as well as dredging and leisure boating are likely to increase. Depending on these developments as well as technical improvements, it is likely that both the level of sound and its character will change over time. Pre-emptive mitigation measures and the implementation of sound reduction solutions are foreseen to play an important role in counteracting and reducing the impact of sound in areas where elevated sound levels are found to impose a risk to sound-sensitive species. Further, maritime spatial planning can help to minimize risks.

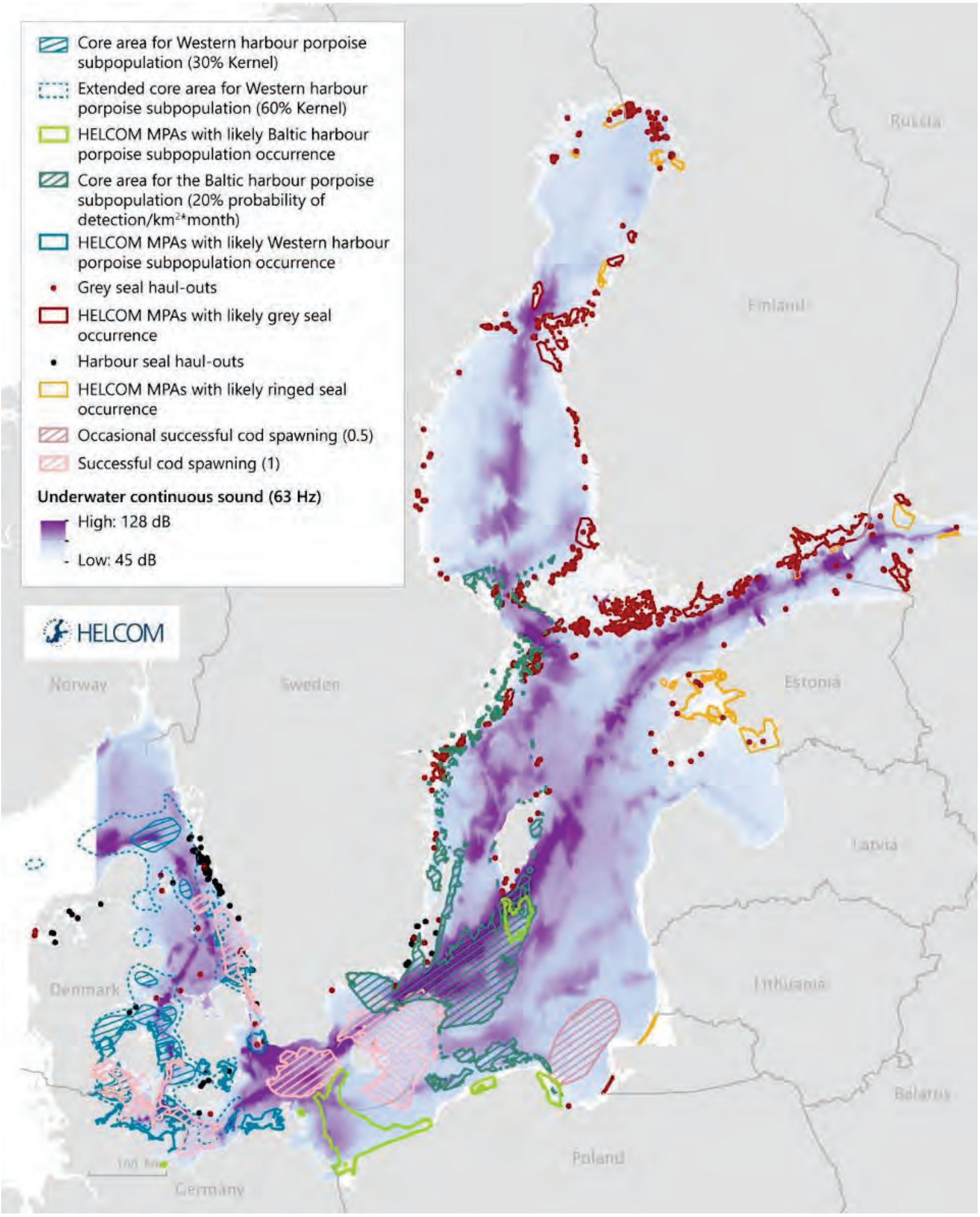


Figure 4.4.3[21]. Overlap of spatial information of the sound distribution in the Baltic Sea with sound sensitive areas derived from biological data on sound sensitive species so far identified. Based on Schack *et al.* (2016, see HELCOM 2016g).

[21] Figure subject to change according to the revision of the document for HELCOM guidelines for establishing environmental targets for underwater noise (HOD52 doc 3.6).

4.5 NON-INDIGENOUS SPECIES

Non-indigenous species have not dispersed naturally into their current environment, but have been transferred there as a result of either intentional or unintentional human activities. Shipping and boating are important vectors for the introduction and spread of non-indigenous species, since the species are easily transported in ballast water tanks or on ship hulls. Up to this date, around 140 non-indigenous species or species with unknown means of arrival (cryptogenic species) have been recorded in the Baltic Sea. Of these, 14 were new introductions for the Baltic Sea in the period 2011–2015.

Harbours and ports are hot spots for the introduction of non-indigenous species, as they may easily find suitable places to settle in shallow water or modified habitats (Lehtiniemi *et al.* 2015). The non-indigenous species are not dispersed by natural means to the new area, but follow some human-mediated means of transport, so called vectors. The most probable vectors for non-indigenous species into the Baltic Sea are aquaculture and shipping (Galil *et al.* 2014). The species may attach to the ships hulls, by fouling, or be transported in the ballast water and then be released when the water is exchanged. In addition the opening of connections to different river systems created by canals are probably vectors for dispersal, and many Ponto-Caspian species have found new routes to the Baltic Sea in this way. Salinity levels and temperature may in some cases limit the spread and establishment of non-indigenous species within the Baltic Sea (Holopainen *et al.* 2016).

After their first introduction to a new sea non-indigenous species may spread further within the new sea area. For instance, the round goby (*Neogobius melanostomus*), a bottom-dwelling invasive fish, was observed for the first time in the Baltic Sea in 1990. After a few years with low abundance it suddenly increased dramatically, and it is now a dominant species in many areas of the Baltic Sea, with a capacity to change interactions in the benthic food webs (Kotta *et al*. 2016). This pattern of establishment and consecutive spread is characteristic of invasive species. However, not all non-indigenous species are invasive, and may not spread widely nor become abundant. Established non-indigenous species may influence biodiversity and the ecosystem in a negative or a positive way, or they may have no effect. Even though it is difficult to foresee their effect, a risk assessment could guide the management of non-indigenous species and help to implicate measures at an early stage (Katsanevakis *et al.* 2014).

The HELCOM core indicator assess the number of new introductions (primary introductions) to the Baltic Sea region. The threshold value is set in relation to the objective that there should be no primary introductions of non-indigenous species due to human activities during a six year assessment period. Thus, the core indicator evaluates the successfulness of management to prevent introductions (Olenin *et al.* 2016).

Assessment result

Fourteen species have arrived as new non-indigenous species in the Baltic Sea since the year 2011. Hence, the core indicator fails the threshold value (zero new introductions) for good status. The animal species were represented by five small crustaceans, three worms (Annelida), and four species belonging to other animal groups. Two algae were also observed; one diatom and one red alga (Table 4.5.1). The estimate may be seen as a minimum count, as it is difficult to ascertain the absence of a new introduction. The given geographic position for first occurrence may also be influenced by variation in monitoring intensity among sub-basins (Core indicator report: HELCOM 2017v).

During the assessment period an unknown number of previously arrived non-indigenous species have expanded their distribution range to new sub-basins in the Baltic Sea. Since it is often difficult to ascertain if this secondary spread is due to human activities or not, these species are not included in the evaluation of the core indicator. For example, the mud crab (*Rhithropanopeus harrisii*) was observed as a new species to the Swedish Western Gotland basin in 2014, but given that it was previously observed in Poland, Denmark, Germany and the Russian Kaliningrad coast in the 1950s it is not counted as a new arrival.

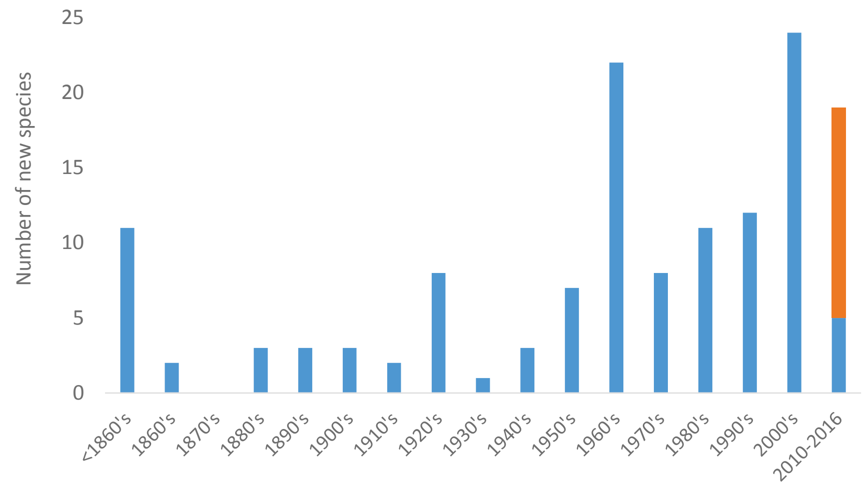
Table 4.5.1. Non-indigenous species with primary introductions in the Baltic Sea during 2011–2015. The reporting of observations during 2016 is not yet complete, and additional species for this year will be included in an update in 2018.

Species	**Taxonomic group (phylum or division)**	**First reported from**	**Year**
Caulleriella killariensis	Annelida	Kattegat	2012
Beroe ovata	Ctenophora	Great Belt	2011
Chaetoceros concavicornis	Ochrophyta[22]	Great Belt	2011
Sinelobus c.f.vanhaareni	Crustacea	Arkona Basin	2012
Grandidierella japonica	Crustacea	Bay of Mecklenburg	2015
Haminoea solitaria	Mollusca	Bay of Mecklenburg	2016
Antithamnionella ternifolia	Rhodophyta	Kiel Bay	2014
Diadumene lineata	Cnidaria	Kiel Bay	2011
Hemigrapsus takanoi	Crustacea	Kiel Bay	2014
Tubificoides heterochaetus	Annelida	Gdansk Basin	2013
Echinogammarus trichiatus	Crustacea	Bornholm Basin	2014
Garveia franciscana	Cnidaria	Kiel Bay	2014
Proasellus coxalis	Crustacea	Bornholm Basin	2011
Laonome sp.	Annelida	Gulf of Riga	2013

Human mediated introductions of species to the Baltic Sea has also occurred in the past. A reconstruction of previous events suggest that the rate of introduction of non-indigenous species has increased in recent decades (Ojaveer *et al*. 2016). Introduction rates during the first and second decade of the 2000s seem to be of the same order of magnitude

[22] Class Diatomea.

(Figure 4.5.1). Importantly, the likelihood of observing new introductions is dependent on the monitoring effort, and increases with increasing monitoring effort.



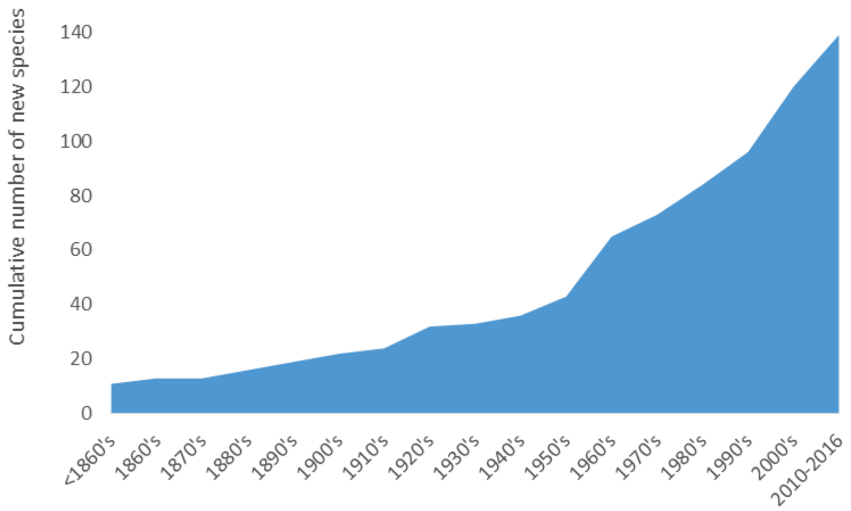


Figure 4.5.1. Number of new non-indigenous species in the Baltic Sea. Upper graph: Estimated number of new observed non-indigenous species in Baltic Sea per decade. The bars indicate the number of invasions per time period. The orange part of the last bar denotes observations from 2011 onwards. Lower graph: The same data set shown as cumulative numbers since the 1900s. Based on data from the data based 'AquaNIS', as used in Ojaveer *et al.* (2016).

Impacts

Non-indigenous species pose a threat to the marine environment as they may induce changes in the structure and dynamics of the ecosystem. The impacts are complex and may be hard to distinguish from impacts of other pressures. Economic impacts may occur due to loss of fishing possibilities, expenses incurred by industries to clean intake or outflow pipes, and biofouling. Public health impacts can arise from the introduction of pathogens or toxic algae (Zaiko *et al.* 2011). In general, however, the impacts of non-indigenous species in marine ecosystems are poorly documented (Ojaveer *et al.* 2016).

Once a non-indigenous species has become established and spread to a wide area then eradication is not a viable management option. Hence, management should primarily aim to prevent further introductions, along with minimizing the negative effects of the already introduced non-indigenous species.

The entry into force of the Ballast water management convention of the International Maritime Organization in September 2017 and its further ratifications can be expected to decrease the pressure and risk of new introductions of non-indigenous species and other harmful organisms to the Baltic Sea. To date the HELCOM countries Germany, Russia, Denmark, Sweden and Finland have all ratified the convention.

4.6 SPECIES REMOVAL BY FISHING AND HUNTING

Fishing and hunting are traditional sources of livelihood in all Baltic Sea countries. Hunting has a minor role today, but fishing is still an important source of food and income. Stock assessments show that three out of eight internationally assessed fish stocks achieve good status with respect to both biomass and fishing mortality rates. However, fourteen stocks are not yet evaluated. Recreational fishing may contribute considerably to the total mortality, especially in coastal areas, but estimates on its magnitude are uncertain. A current challenge being met by the fishing sector is to ensure resource utilization in line with the ecosystem approach.

Commercially exploited fish

The Baltic Sea fisheries targets both marine and freshwater species, but the most important species for the commercial fisheries are marine. Cod, herring and sprat represent about 95 % of the total catch in biomass terms. The catches are used for human consumption or industrial use as oil, fish meal or animal fodder, depending on the market conditions.

Other important commercial species are plaice, flounder, dab, brill, turbot, along with the migratory species salmon, and sea trout. Common commercial species with freshwater origin include pike, perch, pikeperch, vendace, and whitefish. The Baltic Sea fisheries also catch eel, classified as a widely distributed species with a population that extend over several marine regions but which has declined considerably (see also Box 5.4.1 in Chapter 5.4). Recreational fishing mainly targets the same stocks as commercial fisheries.

The overall objective of the Baltic Sea fisheries is to ensure economically, environmentally and socially sustainable use of fisheries resources in alignment with the ecosystem approach. Long term management plans for the internationally managed fish stocks aim to ensure that these are capable of producing a maximum sustainable yield (MSY), as mainly being regulated by the exploitation rate (EC 2016). Advice based on analytical assessment are provided by the International Council for the Exploration of the Sea (ICES).

Results are reported here with respect to fishing mortality and spawning stock biomass in relation to the reference points for maximum sustainable yield, including data as available by ICES (2016a).

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 to evaluate the status in relation to management targets for more species and stocks in the future.

Commercial species in coastal and transitional waters are assessed nationally and are not covered here.

Assessment result

The currently presented assessment result is based on the average results for the years 2011 to 2015, based on data from ICES (2016b).

For each stock, the level of fishing mortality was assessed by comparison with the reference value 'F_{MSY}', which is the level of fishing mortality estimated to deliver a long term maximum sustainable yield. The spawning stock biomass was assessed in relation to the associated reference value 'MSY B-trigger'. Reference values from 2015 were used (ICES 2016a). 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.

Three of the eight assessed stocks had too high a fishing mortality on average during 2011–2015, whereas five stocks were fished at a 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.

Fourteen of the internationally managed stocks currently lack reference points and could therefore not be assessed. (Figure 4.6.1). Furthermore, there is no assessment available for the age and size distribution.

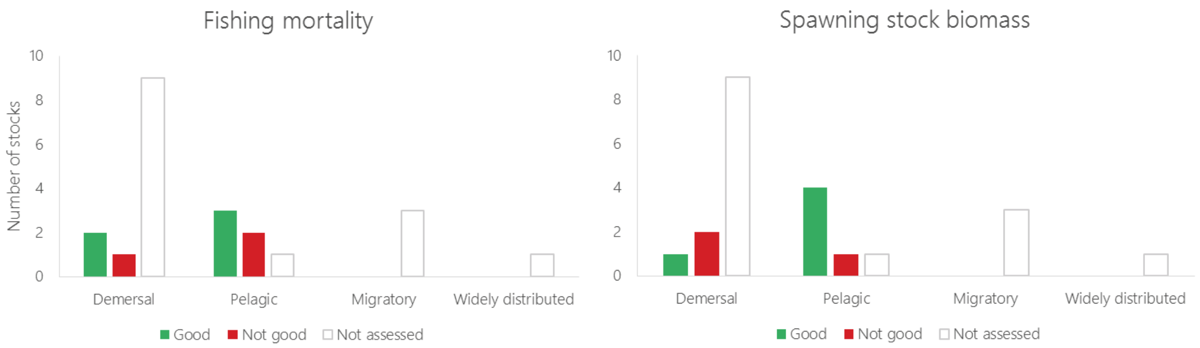


Figure 4.6.1. Number of Baltic Sea internationally managed fish stocks in good and not good status, by species groups. Currently non-assessed stocks are given in white. Left: Fishing mortality, Right: Spawning stock biomass.

Table 4.6.1. 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 F_{MSY} and the MSY B-trigger, respectively. Cases where 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 (2016a).

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			

Among the most widely distributed pelagic stocks, the fishing mortality of sprat during 2011–2015 was above the long term average, whereas that of herring in the central Baltic Sea was slightly below the long term average (Figure 4.6.2). The fishing mortality of Western Baltic cod was also lower than the long term average, but still high above the reference point[23].

[23] No data available for Eastern Baltic cod.

In addition to commercial fishing, substantial removals by recreational fisheries are documented for Western Baltic cod and salmon, and these catches are included in the assessment.

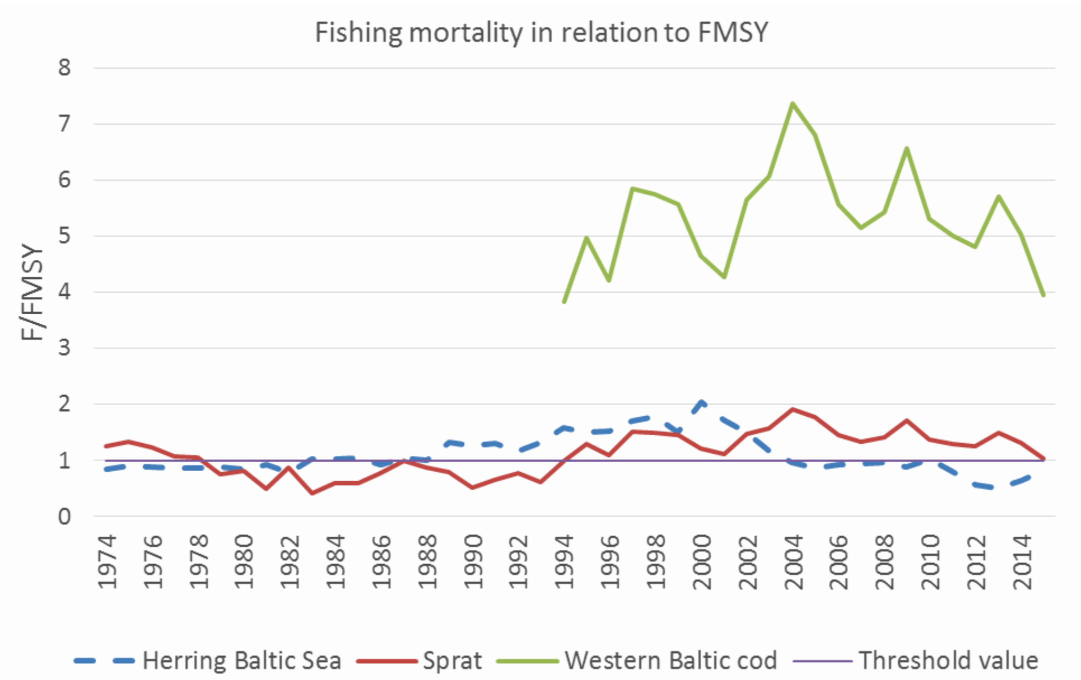


Figure 4.6.2. Temporal development of fishing mortality relative to F_{MSY} in the pelagic fish stocks herring in the central Baltic Sea, the sprat stock, and the Western Baltic cod stock. F/F_{MSY} was calculated based on the 2015 assessment data (ICES 2016a). 'Herring Baltic Sea' is the stock of ICES subdivisions 25–29 and 32, 'Sprat' covers ICES subdivisions 22–32, and Western Baltic cod covers ICES subdivisions 22–24.

Box 4.6.1. Methods used in the commercial fishery

Cod is mainly fished by demersal trawls reaching the seabed. It is also fished with gillnets, often with a by-catch of flatfish, which is also utilised.

Pelagic commercial species are almost exclusively sprat and herring, and are mainly fished by pelagic trawls, in the water column.

Salmon is caught by long lines during its feeding stage in the sea, or by trap nets or gill nets during their spawning run, and salmon fishing is also sometimes allowed in river mouths. Drift nets have been fully banned in the Baltic Sea since 2008.

The coastal fisheries use mainly gill nets, pound nets, trap nets, and in some areas Danish seines. A variety of species are targeted, depending on season and availability, including herring, cod and flounder and coastal freshwater species. Demersal trawling occurs in some coastal areas, but is forbidden in the coastal zone in many of the Baltic countries.

Impacts and recovery from fishing

Impacts of overfishing include depleted fish stocks and reduced biomass. Since fisheries are typically focused on specific species and larger fish, they may also cause structural changes to populations and the food web. Such changes in overall species composition, and a decreased size and age structure of populations, have been seen both in the Baltic and adjacent areas (Cardinale *et al.* 2009, Eero *et al.* 2008; Svedäng and Hornborg 2014, see also Chapter 5.4). Overfishing, and the associated changes at population and ecosystem level, affect long term fishing opportunities and food provision, since the changes in population or food web structure make the depleted stocks less productive and more vulnerable to environmental pressures (Berkeley *et al.* 2004, Stige *et al.* 2017).

Fisheries activities in Baltic Sea countries are regulated by the EU Common Fisheries Policy (CFP). In 2009, the European community and the Government of the Russian Federation agreed to cooperate over fisheries and conservation of living marine resources in the Baltic Sea. The current revision of the common fisheries policy was adopted in 2013 and aims to promote environmentally, economically and socially sustainable fishing, including measures to end overfishing and reduce fish discards, for example. Currently, multiannual plans are in place for the main part of the internationally managed fish stocks, and adjustments to fishing gear have taken place to mitigate negative impacts on the ecosystem and fish stocks (EU 2016c).

In addition to the targeted species and size classes of fish, unselective fishing imposes mortality on smaller sized fish and non-target species of fish, but also on birds and mammals (see Boxes 5.4.2 and 5.5.1), which are caught as incidental by-catch. The unwanted catch of fish has been mostly discarded in the past, and has been monitored and included in stock assessments for cod and some flatfishes. Since 2017, there is a discard ban in place for cod, sprat, herring and salmon. In coming years, the effects of these measures are to be evaluated.

Hunting of seals

Seals have been hunted historically for skin, fur, meat and fat, and they were an important source of income for people, particularly in the Northern Baltic Sea. Seals were also considered a nuisance due to their competition with fisheries, and hunting was encouraged. During the 1900s, bounties were even paid for hunting seals. A combination of hunting and environmental factors led to a dramatic decline in seal populations.

In the 1970s and 1980s, seals were protected by all countries in the Baltic Sea region. The number of seals has increased, and today conflicts with human fishing activities have re-emerged in an increasing number of areas. As a result, controlled hunting is allowed for grey seals in Denmark, Estonia, Finland and Sweden, ringed seals in Finland and Sweden, and harbour seals in Denmark and Sweden. The highest permissible annual quota among these countries is around 2 000 grey seals, 230 ringed seals and 235 harbour seals combining information from all countries. The reported hunting is often below the quotas (Table 4.6.2).

Incidental by-catch of seals in fishing gear is an additional source of human induced mortality for seals that is not included here (Box 5.4.2), and the levels of illegal hunting are not known.

The Baltic Sea regional recommendation on management principles for the conservation of seals states that there should be no hunting of seal populations below the safe biological level (the so called limit reference level, see Chapter 5.5), and that hunting of populations above this level is only allowed if the growth rate is positive. These principles are adhered to in the Baltic Sea region at this time[24]

Table 4.6.2. Numbers of hunted seals per year and the shares of highest permissible annual quota (%) in Finland and Sweden. The data is for 2011–2015 (min–max) for Finland and for 2016 for Sweden. Hunting of grey seals is also allowed in Estonia. In Denmark, licenced fishermen may apply for permission to shoot a limited number of grey seals or harbour seals within close proximity of their fishing gear. Ringed seals are only hunted in Finland and Sweden.

Species	**Finland**	**Sweden**
Grey seal	224–307 (15–20 % of quota)	201 (41 % of quota)
Harbour seal		180 (62 % of quota)
Ringed seals	87 (87 % of quota)	81 (77 % of quota)

Hunting of waterbirds

The legislation for bird hunting is highly variable among countries. Waterbirds are hunted in some countries, although the timing is regulated, with hunting prohibited during the spring migration and breeding season[25] (EC 2009). For example, in Denmark there is no hunting of waterbirds allowed between 1 February and 31 August. Southern Baltic Sea countries have a more extensive protection of bird species. For example all sea ducks in Poland are protected, and bird hunting is not permitted within a 3 000 meter strip between the coast and the sea or for 5 000 meters onto land (Polish hunting Law 2004). In effect, ducks (mallard, common teal, common pochard and tufted duck) which can be hunted on inland waters are protected at the coast. A similar legislation is in place in many other countries (Table 4.6.2).

Where hunting is permitted, common game species include common eider, long-tailed duck, common goldeneye, mallard, common teal, Eurasian wigeon and common scoter (Table 4.6.3). The velvet scoter is hunted in Denmark (Asferg 2016) and protected in Sweden. Species hunted only in some countries include goosander, tufted duck, and red-breasted merganser as well as garganey, pintail, shoveler and gadwall. In addition, waterbird populations are hunted elsewhere along their flyways.

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[24] According to follow-up by the HELCOM SEAL Expert Group of the implementation of the Recommendation.
[25] Hunting in spring is permitted on the Åland islands.

In addition to game hunting, the great cormorant (*Phalacrocorax carbo*), which is considered to cause damages to fish stocks and fisheries, is hunted as part of predator control in some countries. Reports show on average 2 100 shot cormorants per year in Denmark (Asferg 2015), 400–800 per year in Finland (Åland) and around 3 500[26] in Sweden (HaBiDeS 2017). Some countries have an eradication programme for cormorants, where eggs are sprayed with a substance to prevent them from hatching. Birds are also decimated by other human induced pressures, such as oil spills and incidental by-catch, with unknown total level.

Among the hunted water bird species, common eider, long tailed duck, mallard, goosander and red-breasted merganser are included in the HELCOM core indicators, showing below baseline values during the assessment period. The common goldeneye, tufted duck and cormorant are included in the core indicators showing values higher than the baseline years.

The numbers of long-tailed duck have decreased strongly and the wintering population is categorised as endangered on the HELCOM red list (HELCOM 2013b), and the same status applies to common eider, common scoter and velvet scoter.

Table 4.6.3. Reports on hunted water birds in Baltic Sea coastal areas, estimated numbers per year during 2011–2016. Hunting of these species does not occur in in coastal and marine areas of Germany, Lithuania and Poland, but some of the species are hunted at adjacent inland waters. An 'X' denotes that the species is hunted, but that the number of hunted birds in the Baltic Sea area is not known.

Species	**Denmark 2014/15**	**Estonia 2012/16**	**Finland**	**Sweden**
common eider *(Somateria mollissima)*	43 000	0	1 000–7 000	2 000
long-tailed duck (*Clangula hyemalis*)	1 400	7	8 000–19 000	40
common goldeneye (*Bucephala clangula*)	8 400	79	x	x
common teal (*Anas crecca*)	100 500	1771	x	x
mallard *(Anas platyrhynchos)*	483 500	3783	x	x
common scoter *(Melanitta nigra)*	7 100	1	x	90
velvet scoter (*Melanitta fusca*)	2 700	0	x	0
goosander *(Mergus merganser)*	0	0	x	x
tufted duck *(Aythya fuligula)*	5 300	25	x	x
Eurasian wigeon *(Anas penelope)*	41 000	1019	x	x
red-breasted merganser *(Mergus serrator)*	0	0	x	x

[26] Based on the years 2011-2015. Estimates are for the whole country, not only marine areas.

4.7 SEABED LOSS AND DISTURBANCE

Loss and disturbance to the seabed is caused by human activities that inflict permanent changes or temporary disruptions to the physical habitat. Examples of such activities include extraction of seabed sand and gravel modification of the seabed for installations, maintenance of open waterways by dredging, and bottom trawling. Based on the data available for the assessment and current knowledge, less than 1 % of the Baltic Sea seabed is potentially lost due to human activities while over 50 % of the seabed area is potentially disturbed during the assessment period (2011-2015). There is currently no regionally agreed method for assessing how loss and disturbance is causing adverse effects on the marine environment.

Several human activities may cause severe damage to benthic habitats and species, some by direct contact with the seabed and others through indirect effects caused by the increased turbidity or sedimentation, for example. Whether an activity leads to a permanent loss or a temporary disturbance of benthic habitats depends on many factors such as the duration and intensity of the activity, the technique used, and the sensitivity of the area affected. The loss of a natural habitat may give rise to a new artificial habitat, for example when a construction creates rocky bottoms on sand. This may also lead to ecological changes that are undesirable.

Many activities may contribute to both permanent loss and disturbance of the seabed (Figure 4.7.1). Estimating seabed loss and physical disturbance at a regional and sub-basin scale requires a generalised approach which links together different types of activities with potential loss and disturbance of the seabed and thereby simplifies the complex reality (Box 4.7.1).

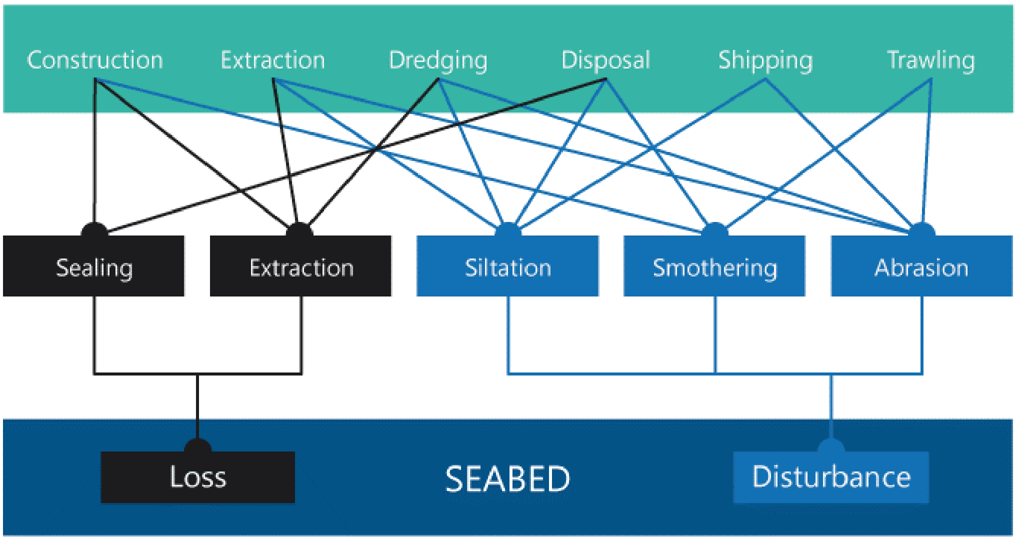

Figure 4.7.1. Generalised overview of human activity types and the physical pressures they may exert on the seabed. The pressures are further grouped into those causing loss and disturbance of the seabed. Black lines link to potential physical loss of seabed habitats, and blue lines link to potential physical disturbance. Smothering is linked to disturbance in the graph, but may in some cases also lead to loss, depending on tolerance of the impacted organisms and intensity of the pressure.

Human activities potentially attributed to seabed loss and disturbance

Construction and installations

Off-shore wind farms, harbours and underwater cables and pipelines are examples of constructions that cause a local but permanent loss of habitat. In addition, disturbance to the seabed may occur during the period of construction and installation. The pressures exerted during the construction phase are in some instances similar to those during sea-bed extraction or dredging into the seabed (see below).

Installation of off-shore construction may in some cases also encompass drilling or the relocation of substrate for use as scour protection. The area lost by scour protection around the foundation of a wind farm turbine has been estimated to be in the order of 20 meters from the wind turbine (OSPAR 2008). The scour protection will give rise to a new man-made habitat.

Cables and pipelines may be placed in a trench and then covered with sediment extracted elsewhere. Most often the sediment composition then differs from surrounding habitats (Schwarzer *et al.* 2014). On hard substrates, cables are often covered with a protective layer of steel or concrete casings. The loss of habitats by smothering and sealing from cables has been generalised to a 2 meters distance for the assessment purposes (OSPAR 2008).

Open systems of mariculture affect the seabed habitat through sedimentation of excrements under the fish and shellfish farms, as the accumulated material changes the seabed substrate. However, the extent of the effects in terms of loss and disturbance depends on the hydrological conditions and on the properties of the mariculture, and currently no information exists on the recovery rate when the pressure is removed.

Dredging

Dredging activities are usually divided into capital dredging, which is carried out when building new constructions, and maintenance dredging, which is done in order to maintain existing waterways.

Dredging causes different types of pressure on the sea bed; removal of substrate alters physical conditions through changes in the seabed topography, increased turbidity caused by re-suspended fine sediments, and smothering and siltation of nearby areas due to settling of suspended load. Loss of habitat occurs during capital dredging which usually is a pressure occurring once at a specific location. But loss of habitat also occurs during maintenance dredging which is performed repeatedly, often at regular intervals. The loss is limited to the dredging site, whilst disturbance through sedimentation may have a wider spatial extent.

Some studies have estimated that disturbance through sedimentation may affect animals and vegetation up to a couple of kilometres from the core activity (Lassalle *et al.* 1990, Boyd *et al.* 2003, Orviku *et al.* 2008). In addition, remobilisation of sediments with deposited substances may contribute to contamination and eutrophication effects.

Sand and gravel extraction

During sand and gravel extraction sediment is removed from the seabed, for use in construction, coastal protection, beach nourishment and land-fills, for example.

Sand and gravel extraction can be performed using either static dredging or trailer dredging. When using static dredging, the pressures exerted by sand and gravel extraction are comparable to those during dredging; potential physical loss of habitat (which may be partial or complete depending on how much sand or gravel is removed and which extraction technique is used), altered physical conditions through changes in seabed topography, increased turbidity caused by fine sediments that are mobilised into the water, or smothering or siltation on nearby areas. When performing trailer dredging the pressures exerted are more limited. In addition, in areas where the sediment mobility and dynamics are naturally high, the effects of sand and gravel extraction may be less significant.

Since the extracted material is sieved at sea to the wanted grain size, the unwanted matter is discharged and may result in a changed grain size of the local sediment on the seabed. Sedimentation levels are more restricted during sand and gravel extraction than during dredging, and may occur a few hundred metres from the core activity (Newell *et al*. 1998). There is more or less full mortality of benthic organisms at the site of sand and gravel extraction as they are removed together with their habitat (Boyd *et al.* 2000, 2003, Barrio Frojan *et al.* 2008), whereas the extent of the impact on adjacent areas is smaller (Vatanen *et al.* 2010).

Importantly, there are modern techniques and concepts which, if applied, can help to reduce the negative impact. Recolonization by sand- and gravel dwelling organisms is for example facilitated if the substrate is not completely removed. Precautionary measures are also recommended in HELCOM Recommendation 19/1 on 'Marine Sediment Extraction in the Baltic Sea Area'.

Disposal of dredged matter

Disposal of dredged matter may cause covering of the seabed, smothering of benthic organisms, and lead to loss of habitat if the sediment characteristics are changed. In addition, increased turbidity during the disposal cause increased siltation on the site itself and in the areas around it. Disposed material may contain higher concentrations of hazardous substances and nutrients than the disposal site and may cause accumulation of these pollutants at the disposal site and adjacent areas.

The impacts on the species depend mainly on the seabed habitat type, the type and amount of disposed material, and distance to the disposal site. Burial of benthic organisms may cause mortality, but some species have the ability to re-surface (Olenin 1992, Powilleit *et al.* 2009). The probability of survival is higher on soft bottoms, whereas vegetation and fauna on hard substrates die when covered by a few centimetres of sediment (Powilleit *et al.* 2009, Essink 1999). The spatial extent of the impacts is similar to that of dredging a couple of kilometres from the core zone of the activity (Syväranta and Leinikki 2015, Vatanen *et al.* 2015).

Shipping

Ship traffic can cause disturbance to the seabed in several ways; propeller induced currents may cause abrasion, resuspension and siltation of sediments, shipbow waves may cause stress to littoral habitats, and dragging of anchors may cause direct physical disturbance to the seabed.

Disturbances to the seabed from shipping mainly occur in shallow areas. The effects are often local, concentrated to shipping lanes and to the vicinity of harbours. For larger vessels, increased turbidity has been observed down to 30 m depth (Vatanen *et al*. 2010), and mid-sized ferry traffic has been estimated to increase turbidity by 55 % in small inlets (Eriksson *et al.* 2004). Erosion of the sea-floor can be substantial along heavy shipping lanes, and has been observed to cause up to 1 m of sediment loss due to abrasion (Rytkönen *et al.* 2001).

Bottom trawling

Bottom contacting fishing gear causes surface abrasion. During bottom trawling it may also reach deeper down into the sediment, causing subsurface abrasion to the seabed.

The substrate that is swept by bottom trawling is affected by temporary disturbance, and bottom dwelling species are removed from the habitat or relocated (Dayton *et al*. 1995). The impact is particularly strong on slow growing sessile species which may be eradicated. Since the same areas are typically swept repeatedly, and due to high density of trawling in some areas, the possibility to recover may also be low for more resilient organisms, and a change in species composition may be seen (Kaiser *et al*. 2006, Olsgaard *et al*. 2008).

In addition, the activity may mobilise sediments into the water, which may be transported to other areas and cause smothering on hard substrates, or may release hazardous substances that have been previously buried in the seabed (Jones 1992, Wikström *et al.* 2016).

The estimate of disturbance from fishing used in this evaluation is based on fishing intensity calculated by ICES (International council for exploration of the sea), based on data from the vessel monitoring system on the location of fishing vessels complemented with logbook information.

Box 4.7.1 Method to estimate loss and disturbance of the seabed

Physical loss is defined as a permanent change of seabed substrate or morphology, meaning that there has been change to the seabed which has lasted or is expected to last for a long period (more than twelve years (EC 2017a). The following activities were considered in the assessment as causing loss of seabed: construction at sea and on the shoreline (also including cables and pipelines, marinas and harbours, land claim, and mariculture), sand and gravel extraction, dredging, and disposal of dredged matter (Figure 4.7.1).

Physical disturbance is defined as a change to the seabed which can be reverted if the activity causing the disturbance ceases (EC 2017a). The same activities as in the assessment of physical loss were considered in the assessment as causing physical disturbance (acting via the pressures of siltation, smothering, and abrasion), and in addition shipping and trawling were included as potentially causing physical disturbance (Figure 4.7.1).

The potential extent of loss and disturbance to the seabed was estimated by identifying the spatial distribution of human activities exerting these pressures. The extent of pressures was estimated based on the information from the literature, and the data sets were aggregated into two layers representing physical loss and physical disturbance, respectively. Whether an activity in reality leads to loss of or disturbance of habitats depends on many factors, such as the duration and intensity of the activity, the technique used and the sensitivity of the area affected. The identification of which activities lead to loss and/or physical disturbance is still under development. The aggregated layers were also compared with information on the spatial distribution of broad benthic habitat types, in order to estimate the potentially lost and disturbed area of benthic habitats (Supplementary report: HELCOM 2017D)

The results are presented descriptively as an indication of the potential extent of the pressure. However, no threshold values are defined for physical loss and disturbance and thus no value judgement of status is placed on the results.

Confidence in the assessment has not been calculated because the data layers include only information on which potential pressures are present, while their absence according to the data may reflect a true absence or missing information. Therefore the potential loss and disturbance can be underestimated in some sub-basins due to lack of data of specific pressures. It is however possible to qualitatively evaluate gaps in the pressure layers based on knowledge of the national data sets that are underlying the Baltic wide layers. The data layers used in this assessment include all layers listed in the supplementary report (HELCOM 2017D). It has been agreed to further consider the application of e.g. the layer on bathing sites and leisure boating in the updated version of the report.

Estimation of physical loss

The level of long term physical loss of seabed in the Baltic Sea was estimated to be less than 1 % on the regional scale until the year 2015. Highest estimates of potential loss at the level of sub-basins were found in the more densely populated southern Baltic Sea and ranged between 1 and 5 % in the Sound, the Bay of Mecklenburg and the Great Belts. In the majority of the sub-basins, less than 1 % of the seabed area was estimated to be potentially lost (Figure 4.7.2).

The human activities mainly connected with seabed loss were sand extraction, dredging and disposal of dredged matter and to a lesser extent offshore and coastal installations, and mariculture. In terms of broad benthic habitat types, the highest proportion of area potentially lost was ‘infralittoral sand’, but the highest total area potentially lost was estimated for ‘infralittoral mixed’ substrate’ (Figure 4.7.3).

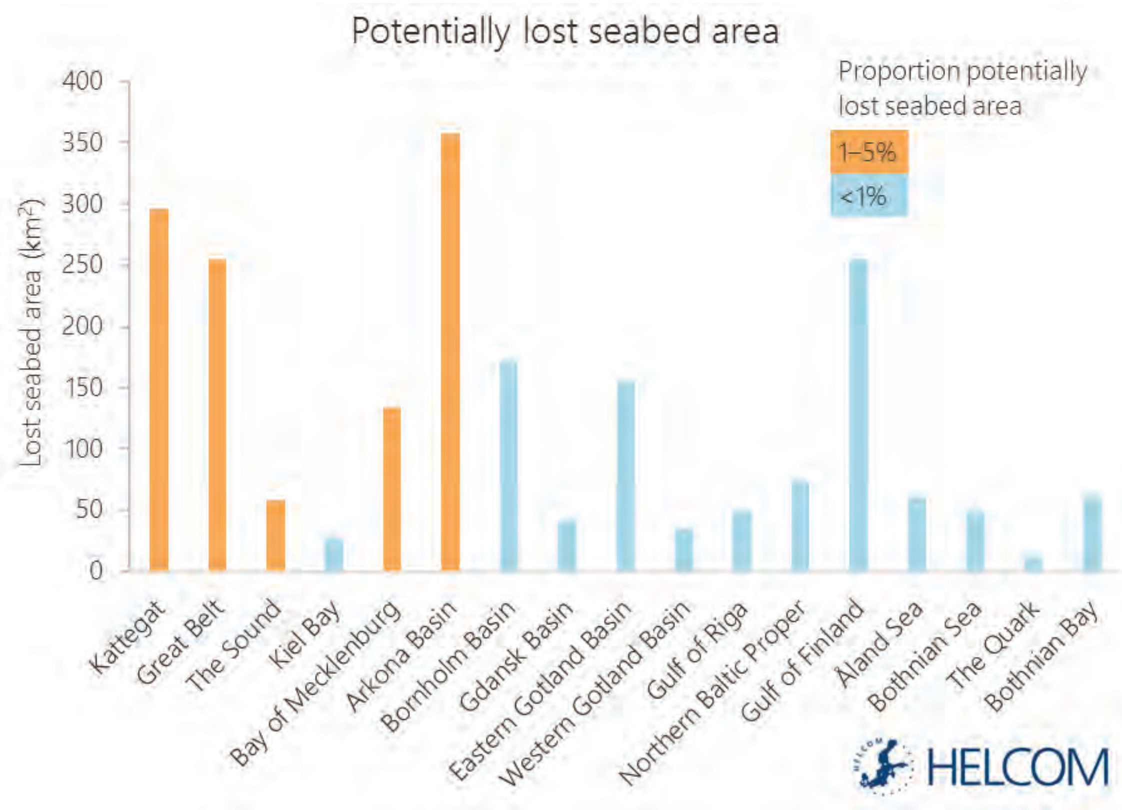

Figure 4.7.2. Estimate of seabed area (km^2) potentially lost due to human activities per Baltic Sea sub-basin. The estimation is calculated from spatial data of human activities causing physical loss, as listed in the text.

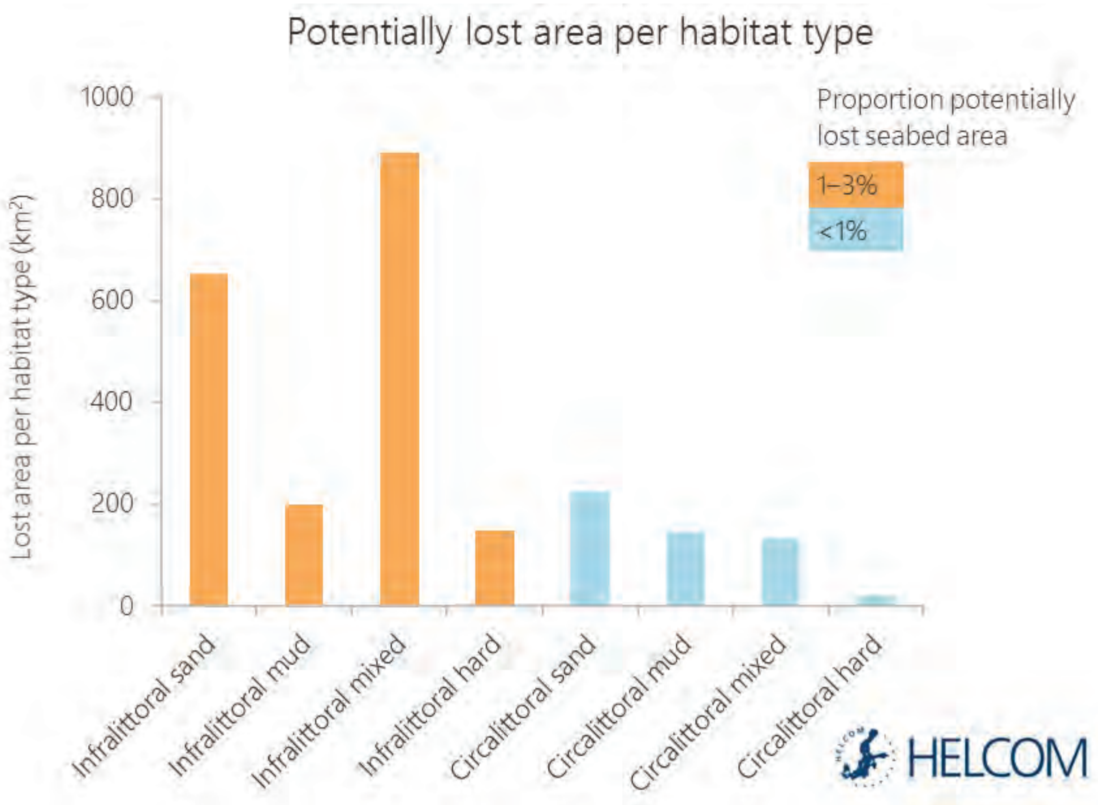

Figure 4.7.3. Estimate of area of broad benthic habitat types potentially lost due to human activities. 'Infralittoral' is the permanently submerged part of the seabed that is closest to the surface, typically with benthic habitats dominated by algae. 'Circalittoral' is the zone below the infralittoral, and is in the Baltic Sea typically dominated by benthic animals.

Estimated physical disturbance

Around half of the Baltic seabed was estimated to have been potentially disturbed (236 000 km^2) during 2011–2015. The spatial extent of potential physical disturbance to the seabed varied between 20 and almost 100 % per sub-basin (1 200 to 39 000 km^2; Figure 4.7.4). However, the estimation does not reflect whether these areas are associated with adverse effects to the benthic habitats as the intensity of the disturbance is unknown. The intensity or severity of the disturbance is an important aspect which is intended to be covered in future indicator-based assessments.

The activities connected to the widest potential physical disturbance are bottom-trawling fishing, which is common in the southern parts of the Baltic Sea, and shipping. At a more local scale, however, more severe physical disturbance may be caused by dredging and the disposal of dredged material. The largest area of potentially disturbed seabed were estimated in the Eastern Gotland Basin and the Bornholm Basin, which are also both comparatively large sub-basins in the Baltic (Figures 4.7.4 and 4.7.5). The sub-basins with highest proportion of potential disturbed seabed were found in the southern Baltic Sea, between the Kattegat and the Arkona Basin.

Importantly, these estimates are based on best available data on the extent of the activities concerned. In some cases, areas licensed for an activity, such as dredging, disposal of dredged matter and extraction of sand and gravel, do not necessarily reflect the extent of the exerted pressure, as the activity may be undertaken only in parts of the licensed area. These limitations in data add to the uncertainties of the estimate.

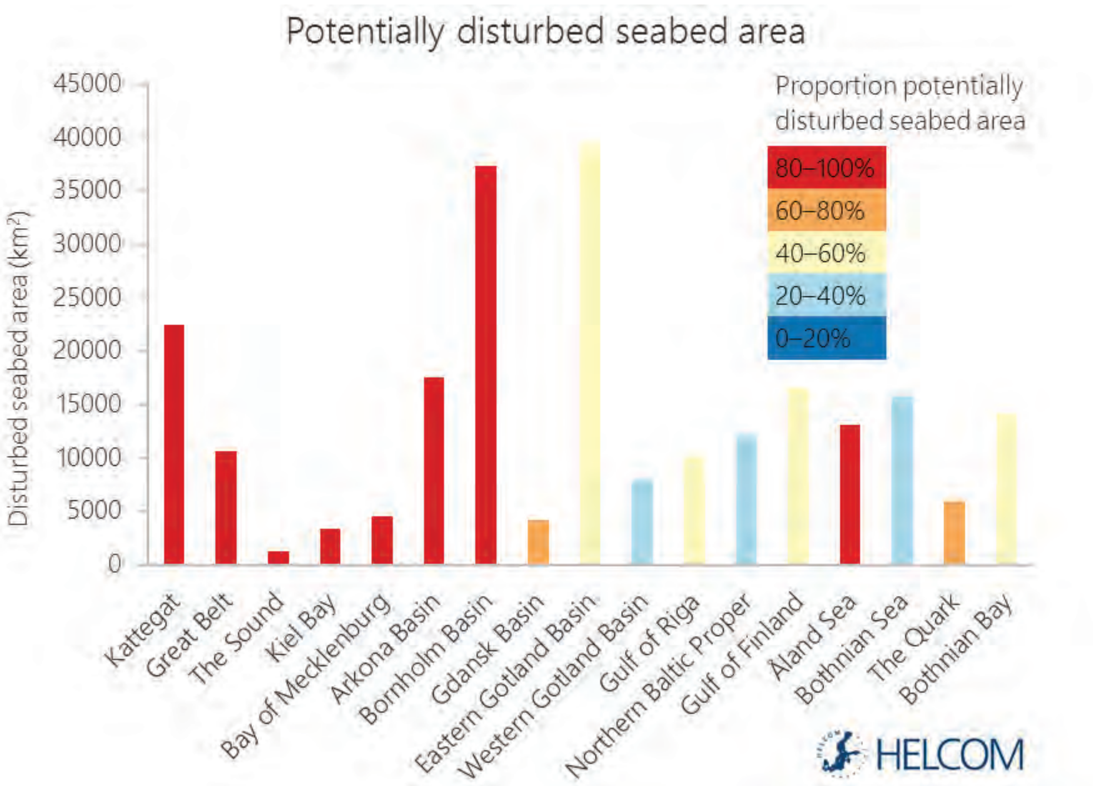

Figure 4.7.4. Estimate of seabed area (km2) potentially disturbed in the Baltic Sea sub-basins. The color of the bars indicate the proportion of potentially disturbed seabed area per sub-basin. The area is estimated based on spatial information of the distribution of human activities connected to the pressures, as explained further in the text. The estimate is based on any presence of a human activity connected to the pressure, and does not consider the level or severity of the disturbance.

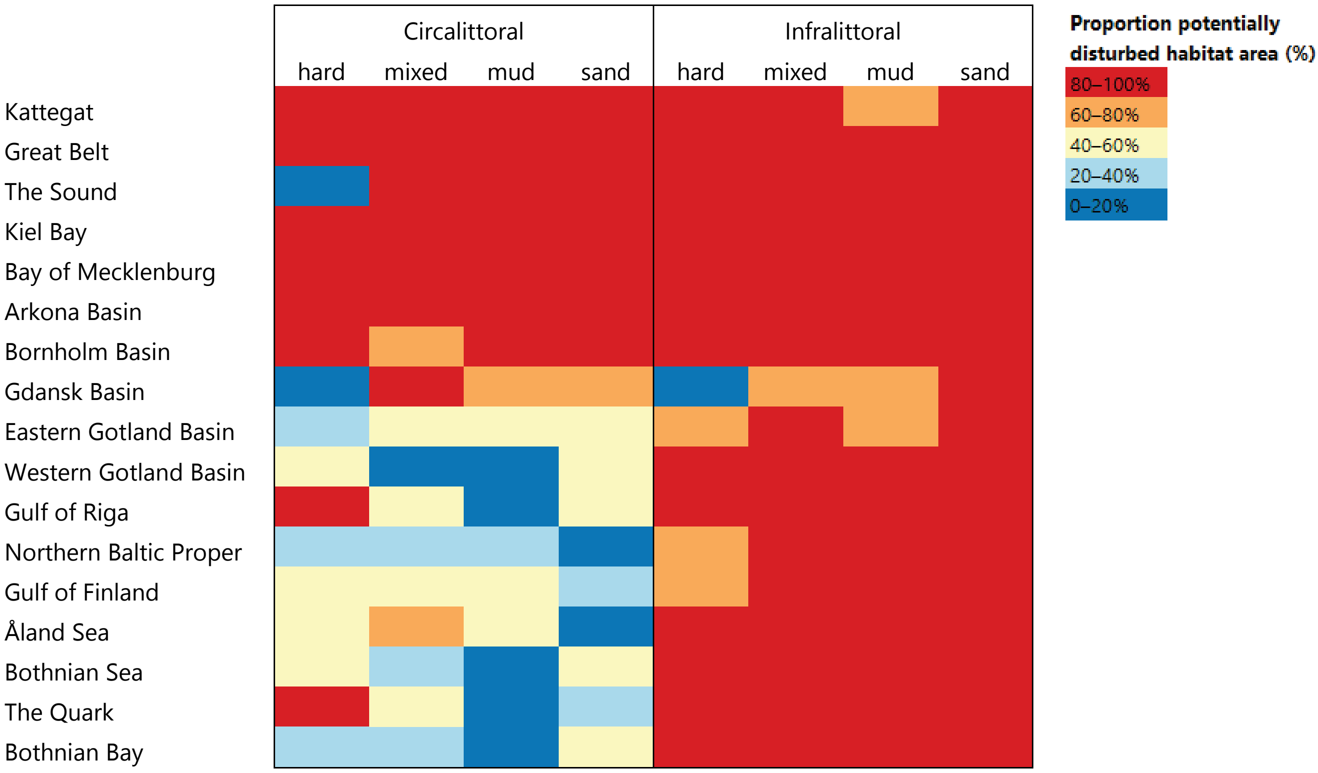

Figure 4.7.5. Estimate of the proportion (%, given in ranges) of the different broad benthic habitat types potentially disturbed due to human activities per sub-basin. The estimate is based on the total number of human activities linked to potentially causing this pressure, and does not reflect the actual level of impact.

Chapter 5. Biodiversity

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 (described in Chapter 4) 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.

The Baltic Sea is home to about 2 700 macroscopic species and innumerable smaller microscopic species (HELCOM 2012, 2013b). Around 1 700 macroscopic species are found in the most marine sub-basin ofthe 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 5.0.1, see also Figure 1.2).

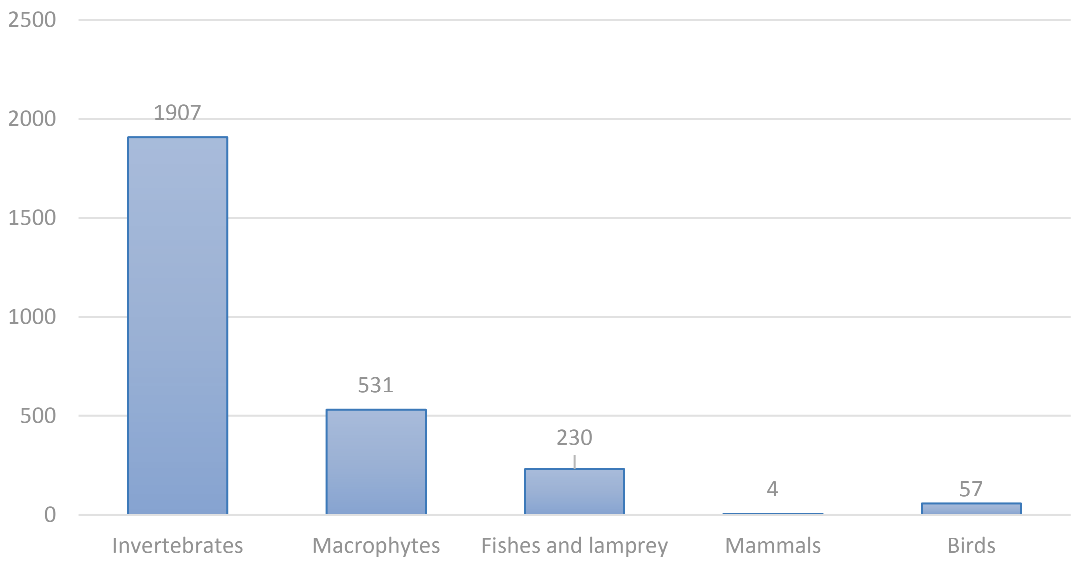

Figure 5.0.1. Number of macroscopic taxa in the Baltic Sea within different species groups. Based on HELCOM (2012).

The goal of the Baltic Sea Action Plan is to reach a favourable conservation status of Baltic Sea biodiversity. HELCOM Recommendations are important regional agreements for achieving this goal. For example, HELCOM countries have agreed to take measures to improve the status of species that are threatened according to the 2013 HELCOM red list (HELCOM 2013b) with the aim of achieving a favourable conservation status for all species by 2021 (HELCOM 2016h). Marine Protected Areas (MPAs) are important tools to conserve both species and habitats in the Baltic Sea, expressed through a HELCOM Recommendation to establish an ecologically coherent and effectively managed network of HELCOM MPAs (HELCOM 2014b).

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 2013c). Hitherto, ten regionally agreed biodiversity core indicators have been made operational and are included in this assessment, and additionally three are agreed to be included as test. The assessment is a milestone in this continuous development, with the long term aim of HELCOM countries being to incrementally improve the regional assessment by including more aspects of biodiversity.

While the biodiversity assessment has been considerably strengthened since the initial holistic assessment (HELCOM 2010a) 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.

Assessment overview

This chapter presents core indicator results for biodiversity components representing functional groups from secondary producers up to apex predators. The indicators assess all key taxonomic groups occurring in the Baltic Sea (Figure 5.0.2), based on available data.

The integrated biodiversity assessment has been carried out using the integrated biodiversity assessment tool (BEAT) for the level of five ecosystem components; benthic habitats, pelagic habitats, fish, mammals, and water birds (Supplementary report: HELCOM 2017E). In the integrated assessment, the biodiversity core indicators have been supplemented with additional indicators, with the aim of achieving a regionally representative assessment that is as comprehensive as possible. Selected core indicators of eutrophication have been added to the biodiversity assessment in cases where no directly corresponding biodiversity indicators are yet available. 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; see also Chapter 4.6).

Descriptions of the core indicators are found in the core indicator reports (HELCOM 2017k, w-ag; see also HELCOM 2017g-j), and a method description for the integrated assessment of biodiversity is found in the supplementary report (HELCOM 2017E).

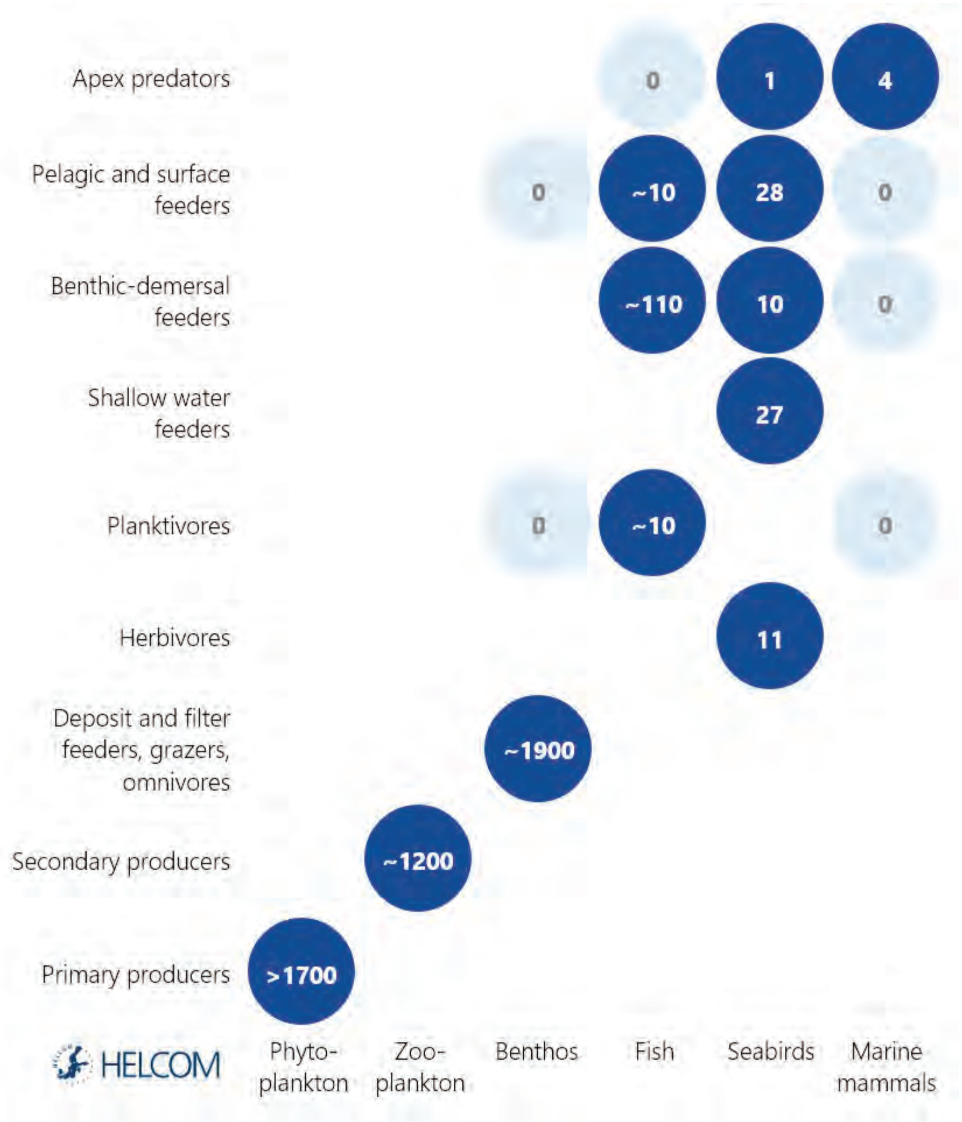

Figure 5.0.2 Estimated numbers of species in the Baltic Sea. The numbers are shown in relation to functional groups on the vertical axis and taxonomic groups on the horizontal axis. Light blue fields represent species groups typical to marine waters which are not represented in the Baltic Sea. Data sources: for numbers of phytoplankton and zooplankton: Ojaveer *et al.* (2010); benthic fauna: HELCOM (2013b); 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 (2016c). 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.

5.1 BENTHIC HABITATS

The seabed of the Baltic Sea encompasses several types of habitat, from species-rich seagrass meadows and macroalgae in shallow areas, to soft bottom fauna which can also thrive deeper down. Due to the lack of tides, all species live continuously submerged. Habitat loss and disturbance affect benthic habitats and, in the Baltic Sea, many benthic communities are also negatively affected by eutrophication. A special concern is the large area with low oxygen or no oxygen at all in the deep basins of the central Baltic Sea, which limits the distribution of benthic fauna with implications for overall food web productivity.

The conspicuous salinity gradient is reflected in the composition of the Baltic Sea benthic communities, and species diversity decreases with decreasing salinity towards the inner areas (Gogina *et al*. 2016). The southern Baltic Sea areas are dominated by marine species, such as polychaete worms and molluscs, including the bivalves *Arctica islandica* and *Astarte borealis.* The benthic vegetation on hard substrates is dominated by brown and red seaweeds, and eel grass *(Zostera marina)* is an important species on shallow sandy bottoms. Typical species further in, along the salinity gradient, include amphipods (mainly *Monoporeia affinis*), the isopod *Saduria entomon*, and the Baltic clam (*Macoma balthica*). Among the benthic vegetation, the importance of marine macroalgae decreases with decreasing salinity.

Many freshwater plants and animals also thrive in this brackish water. In all areas, crustaceans, worms, snails and mussels are an important food sources for water birds and many fish species.

Indicators for assessing benthic habitats

The assessment of benthic habitats in the open sea was based on the core indicator 'State of the soft-bottom macrofauna community'[27] which assesses changes in the species composition and also considers how sensitive different species are to disturbance (Figure 5.1.4, Core indicator report: HELCOM 2017k). In addition, the eutrophication core indicator 'Oxygen debt'[28] was used, in order to give information on living conditions for macrofauna in deeper areas. The indicators are not yet operational in all sub-areas (Figure 5.1.1, Core indicator reports: HELCOM 2017j-k).

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 (see also figure 5.1.5). The use of national indicators makes results not directly comparable between coastal areas of different countries, 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

[27] 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.
[28] The core indicator 'Oxygen debt' is not applicable in all sub-basins, see Figure 5.1.1.

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 (Chapter 4.7). 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.

Integrated status assessment of 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[29]) and in all assessment units where the core indicator 'Oxygen debt' was included (Figure 5.1.1). Long term data show that the oxygen debt below the halocline has increased over the past century in the Baltic Proper (see Chapter 4.1), and also in the Bornholm Basin (HELCOM 2013d). The indicator 'State of the soft-bottom macrofauna community' achieved the threshold value in most assessed areas, indicating good status in these cases (Figure 5.1.1, associated table). 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 (Figures 5.1.1 to 5.1. 3). 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 5.1.2). The confidence in the assessment varied between low and moderate in both coastal and open sea areas.

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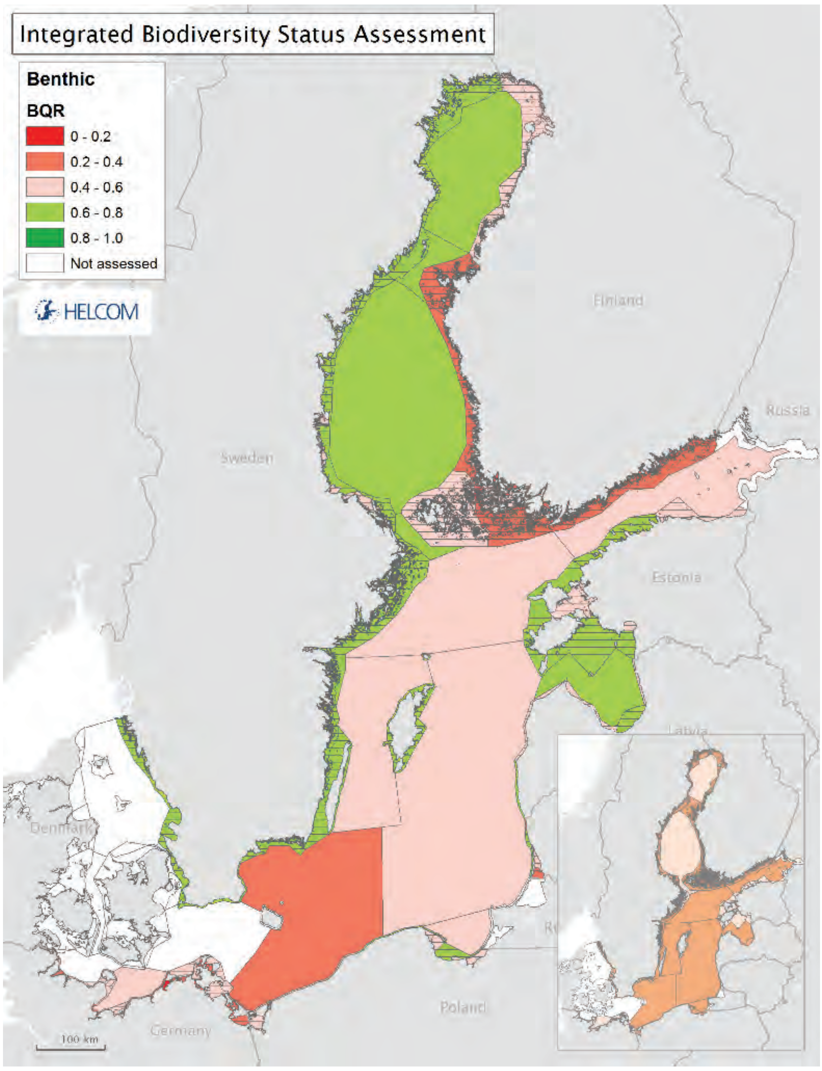
[29] Included as a test indicator.



	Soft bottom macrofauna community	Oxygen debt
Kattegat		
Great Belt		
The Sound		
Kiel Bay[30]		
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 5.1.1. Integrated biodiversity status assessment for benthic habitats using the BEAT tool[31]. 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'[32] 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[33]. 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 (see also supplementary report: HELCOM 2017E).

[30] Data foreseen by end of 2017.
[31] Results for coastal waters in Estonia may be subject to change.
[32] Included as a test indicator.
[33] 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'.

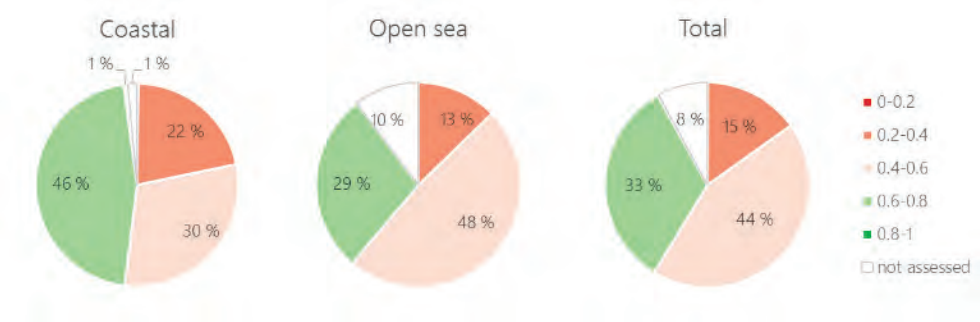


Figure 5.1.2. Summary of the integrated assessment result for benthic habitats, showing the proportion of the Baltic Sea area within five categories, based on km^2. The categories are based on the obtained biological quality ratios (BQR scores) as shown in the legend. Scores above 0.6 correspond to good 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.

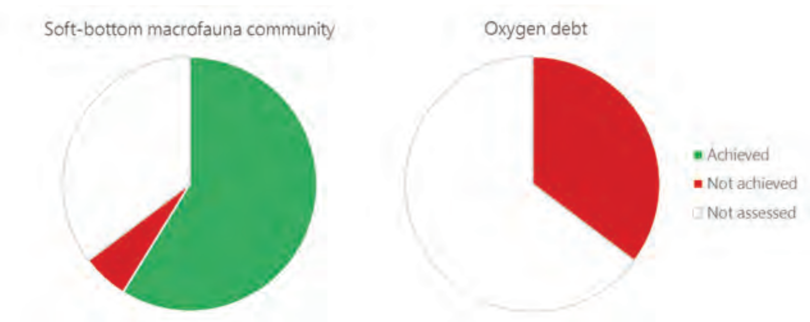


Figure 5.1.3: Summary of core indicator results in the open sea areas, showing the proportion of assessment units achieving the threshold value for good status. The white sector represents areas not assessed due to lack of threshold values for the indicator 'State of the soft-bottom macrofauna community', due to lack of commonly agreed indicator methodology for 'Oxygen debt', or where the indicator 'Oxygen debt' is not applicable[34]).

[34] Not applicable from the Kattegat to the Arkona Basin, in the Gulf of Riga or the Quark.

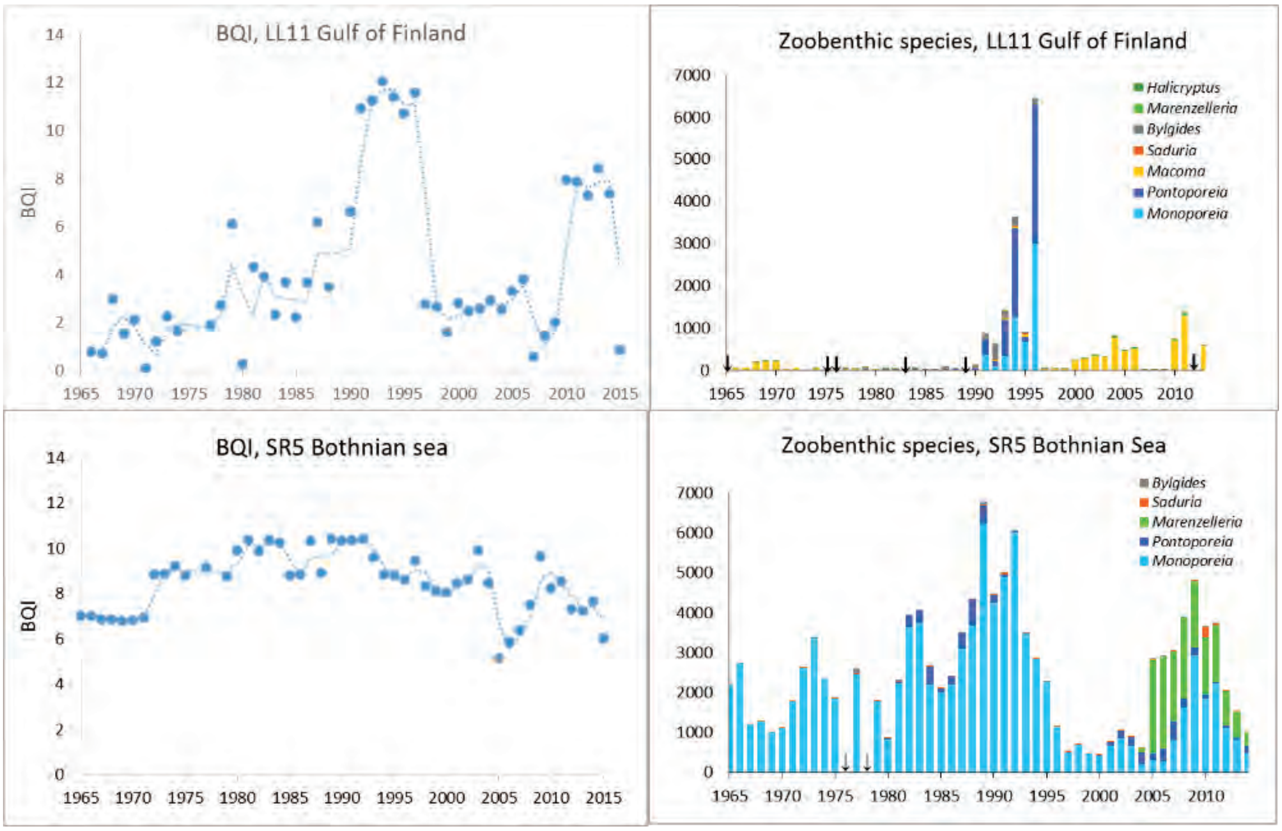


Figure 5.1.4. The core indicator 'State of the soft-bottom macrofauna community' is measured at assessment unit level by the Benthic Quality index (BQI), which addresses the abundance and species composition of benthic animals. The figures show examples of trends in the index measured at station level: 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.

Red-listed benthic species and habitats

The core indicator based assessment of benthic habitats is made at the community level by the core indicator 'State of the soft-bottom macrofauna community'. At the species level, the HELCOM red list gives additional information on the status of benthic species. The red list includes nineteen species of macrofauna categorised as threatened (HELCOM 2013b). A majority of these occur in the Kattegat or the westernmost part of the Baltic Sea, some of them at the border of their distribution area with respect to salinity.

Altogether 51 species were red-listed, but not all species occurring in the area were evaluated. Out of 317 assessed macrophytes, three species were categorised as endangered, four as vulnerable, and four as near threatened.

A HELCOM threat assessment has also been made for characteristic living environments for species, so called biotopes and biotopes complexes (HELCOM 2013e). Seventeen biotopes were evaluated as threatened. The biotope 'aphotic muddy bottoms dominated by the ocean quahog (*Arctia islandica*)', which occurs above a salinity of 15 [psu], was categorised as critically endangered. Data availability is relatively poor for many biotopes in the Baltic Sea and the confidence in the red list assessment of biotopes is therefore relatively low.

Ten biotope complexes, which are comparable to 'habitats' as defined in Annex 1 of the EU Habitats Directive (EC 1992), were also assessed, and eight of these were categorised as threatened in the Baltic Sea, for example estuaries and coastal lagoons (HELCOM 2013e). All habitats listed under the Habitats Directive require protection and the designation of marine protected areas. For example sandbanks (1110) and reefs (1170) were assessed as unfavourable by all countries reporting in the Baltic Sea region except Estonia and Lithuania in the reporting period 2007–2012 of the Habitats Directive.

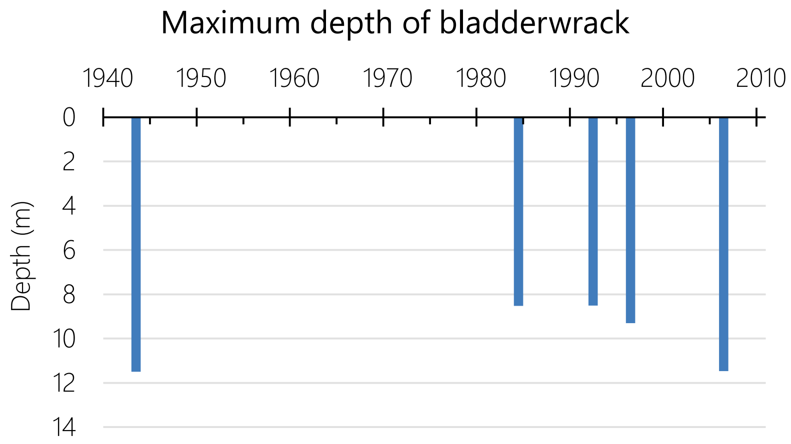


Figure 5.1.5. Shallow hard-bottom habitats are affected by various environmental factors, including eutrophication and changes in turbidity. As a result, the distribution and density of macroalgae is diminished in many Baltic Sea coastal areas. The figure shows example of how the depth distribution of the habitat-forming macroalga Fucus vesiculosus has changed over time in the Singö Archipelago, Åland Sea. Coastal areas are widely monitored around the Baltic Sea but currently there is no common core indicator for macrophytes. Based on monitoring data from Stockholm and Uppsala University, Sweden.

Functions of the benthic habitat

Plants and animals in the benthic habitats are essential for several functions in the marine ecosystem and the loss of these habitats may also have profound impacts on other ecosystem components.

Benthic animals living in the sediment, mainly bristleworms, mussels and amphipod crustaceans, influence local oxygen conditions via their digging and burrowing activities, and this activity can also mobilise substances to the water column (Norkko *et al*. 2015, Josefson *et al*. 2012). Benthic animals also have important roles as deposit feeders, decomposing organic matter that sinks to the seafloor, and as grazers in shallow areas (Törnroos and Bonsdorff 2012). Further, many benthic species are a fundamental food source for fish and birds, or are important because they form shelter or breeding areas for mobile species. As an example, seaweeds and plants in the coastal area provide important environments for many fish species, which depend on these habitats for their reproduction (Seitz *et al*. 2014).

Many benthic habitats are impacted by several pressures from human activities at the same time, including pollution and alterations of the physical habitat (Villnäs *et al*. 2013, Sundblad *et al*. 2014). In the open sea, the large distribution of areas with poor oxygen conditions is a key area of concern for the future status of benthic habitats (Casini *et al*. 2016, Villnäs *et al*. 2012, see also Figure 1.9 in Chapter 1).

5.2 PELAGIC HABITATS

The open water column is the key setting for productivity in the Baltic Sea. Microscopic primary producers support the growth of zooplankton, which all fish species depend upon during at least some part of their life. The status of pelagic habitats is affected by human induced pressures such as eutrophication and hazardous substances, as well as by natural and human-induced changes in climate. Primary producers generally show not good status in the Baltic Sea region, except in the Kattegat. Zooplankton were only assessed north of the Gotland Basin, indicating good status in the Gulf of Bothnia but not in the other assessed areas.

Phytoplankton form the base of the pelagic food web and support the growth of zooplankton, either directly as food, or by a more complex route including the microbial loop. Phytoplankton blooms are a natural phenomenon in the Baltic Sea ecosystem, with blooms in late summer dominated by nitrogen-fixing cyanobacteria. Due to eutrophication, however, the phytoplankton blooms have become more frequent and extensive (Vahtera *et al*. 2007).

Zooplankton consist of small crustaceans and several other animal groups. Cladocerans and copepods are the dominating groups of crustaceans, and a key food base for pelagic fish. Since larger zooplankton are often more nutritious, and a strong production of zooplankton is important for the productivity of higher trophic levels, the biomass and size distribution of the zooplankton community is a useful measure of the status of the pelagic food web (Gorokhova *et al.* 2016).

Indicators for assessing pelagic habitats

The status of the pelagic habitats in the open sea was assessed using the core indicator 'Zooplankton mean size and total stock'[35] in the northern part of the Baltic Sea (Gulf of Bothnia, Gulf of Finland and the Northern Baltic Proper (Core indicator report: HELCOM 2017w), and the two eutrophication indicators 'Cyanobacterial bloom index'[36] and 'Chlorophyll-a' in order to represent changes in primary producers (Core indicator reports: HELCOM 2017g, i). 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. However, particularly in coastal waters, the results of the biodiversity assessment may differ from the results of the eutrophication assessment in coastal areas (Chapter 5.1), which uses a different set of indicators. Further work to develop indicators representing the pelagic habitat is foreseen to strengthen the reliability of the assessment. The use of national indicators varied among geographical areas and

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[35] Included as a test indicator.
[36] Included as a test indicator.

hence, the results for coastal areas are not directly comparable between countries but provide an indication on the status of the coastal micropelagic system at Baltic regional scale.

The status of higher trophic levels (fish, birds and marine mammals) are assessed in the subsequent sub-chapters (5.3–5.5).

Integrated status assessment of pelagic habitats

Good status was not achieved in any open sea sub-basin, with the exception of Kattegat (Figure 5.2.1). The integrated results reflect a deteriorated status according to all assessed core indicators in most cases (Figure 5.2.3).

The indicator 'Cyanobacterial bloom index'[37] 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[38]. In the Northern Baltic Proper, both the mean size and the biomass of zooplankton have decreased from the 1970s to the present (see also Figure 5.2.4). 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 5.2.2). The confidence in the assessment was between moderate and high in the open sea and low in coastal areas.

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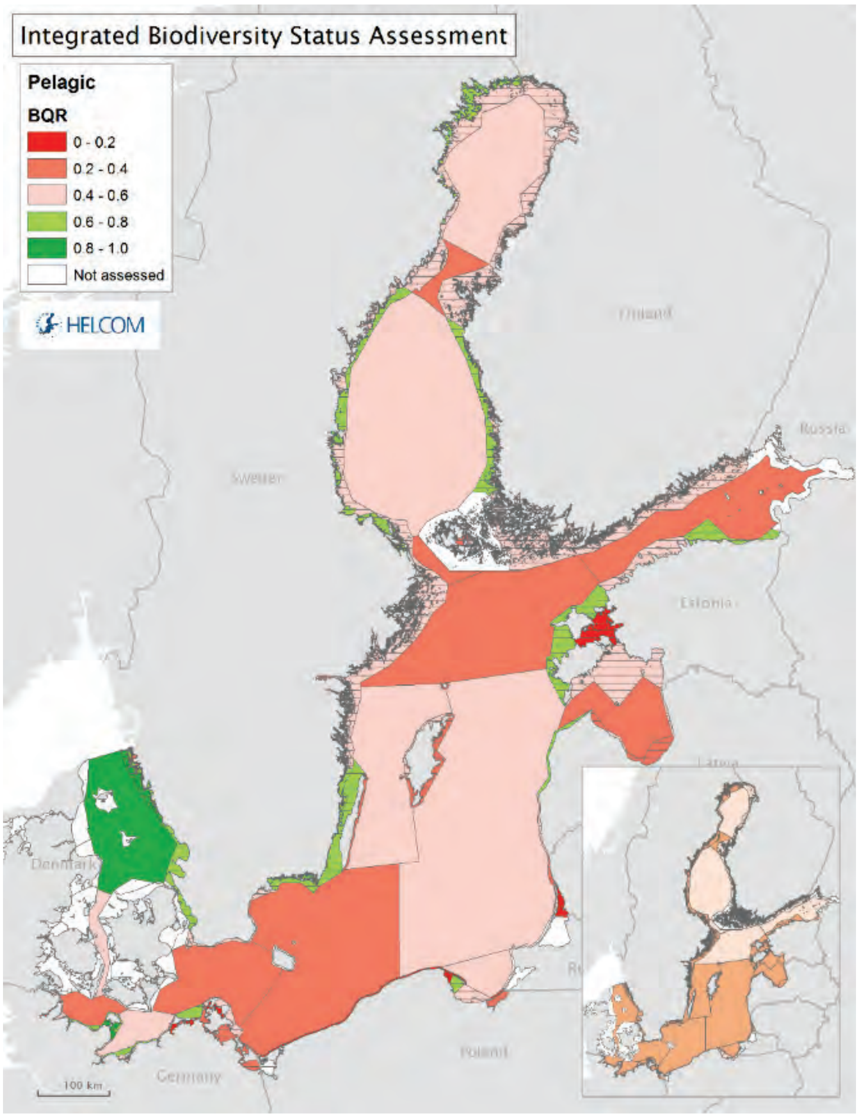
[37] Included as a test indicator.

[38] 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 5.2.1 Integrated biodiversity status assessment for pelagic habitats[39]. 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'[40], and on 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[41]. 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 (see also supplementary report: HELCOM 2017E).

[39] Results for coastal waters may be subject to change.
[40] Included as a test indicator.
[41] 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'.

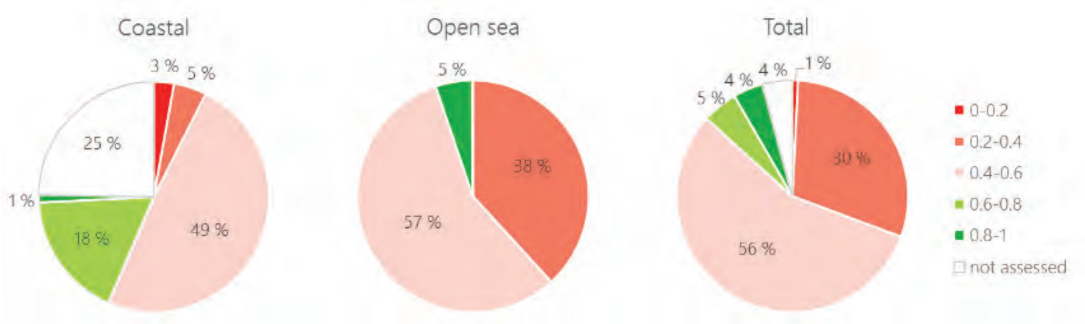


Figure 5.2.2. Summary of the integrated assessment result for pelagic habitats, showing the proportion of the Baltic Sea area within five categories, based on km^2. The categories are based on the obtained biological quality ratios (BQR scores) as explained in the legend. Scores above 0.6 correspond 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.

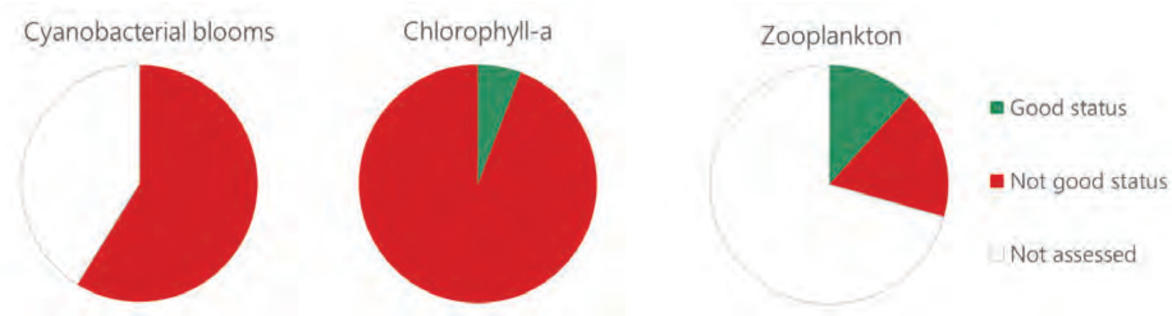


Figure 5.2.3. Summary of core indicator results in the open sea areas, showing the proportion of assessment units achieving good status. White represents areas not assessed as the indicator is not relevant or applicable (Cyanobacterial blooms) or due to lack of threshold values (Zooplankton mean size and total stock).

Changes in the species and size structure

The function of the pelagic food web is not only dependent upon levels of productivity, but also upon changes in the relative abundance of different species and species groups. Diatoms and dinoflagellates are the dominating groups of phytoplankton during the spring bloom, and both are important food for higher trophic levels. Shifts in the relative abundance of diatoms and dinoflagellates occurred primarily in the late 1980s when a series of mild winters occurred (Wasmund *et al*. 2013). These fluctuations may affect the nutrition of zooplankton and lead to subsequent changes in other parts of the food web. For example, diatoms produced in the pelagic habitat are also important for the benthos as they sink quickly after the bloom, whereas dinoflagellates stay longer in the water column.

In the Eastern Gotland Basin an indicator based on the ratio of diatoms to dinoflagellates has been tested, showing that good status was not achieved in the assessment period (Wasmund *et al.* 2017, Figure 5.2.5)[42].

In zooplankton, changes among taxa and species groups varied among the sub-basins. In the Gulf of Finland, changes observed in the core indicator were largely attributed to a decline in the groups of cladocerans over time,

[42] Data approval still pending from some countries.

whereas the decline in total zooplankton biomass in the Northern Baltic Proper and the Bornholm Basin was mostly attributed to a decline in copepods (see also Figure 5.2.4). Regardless of this variability, an increase in the proportion of small-sized taxa and groups was observed in all basins that did not achieve the threshold value.

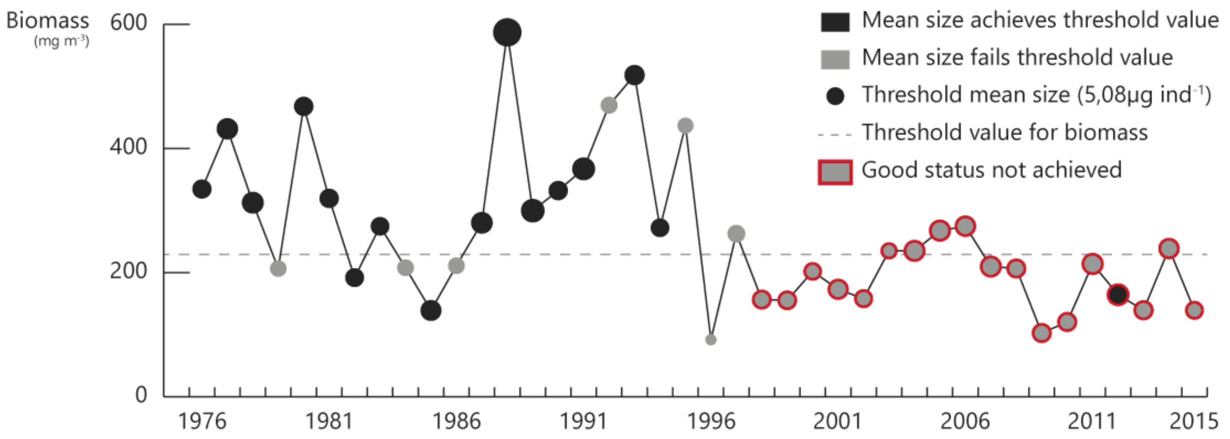


Figure 5.2.4. The assessment of the core indicator 'Zooplankton mean size and total stock' requires that a minimum level of both the total biomass and the mean size of the zooplankton community is reached. The figure shows the long term trend in the core indicator in the Northern Baltic Proper, as an example. The size of the circles corresponds to mean size of the zooplankton community, which ranged from 2 to 13 micrograms per individual. 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 (Core indicator report: HELCOM 2017w).

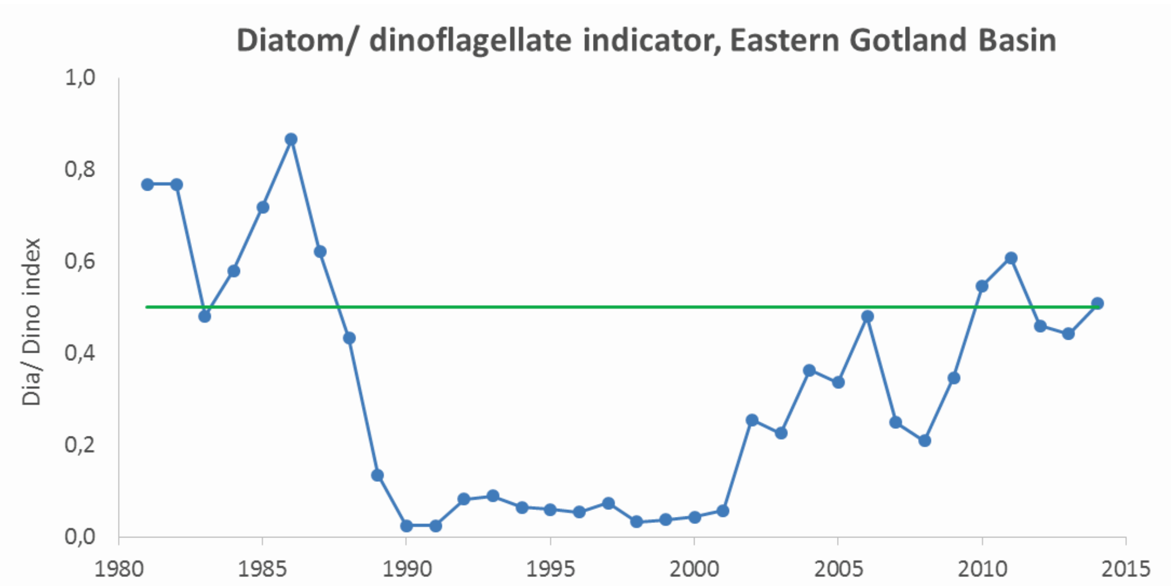


Figure 5.2.5. Trend over time in the 'Diatom/Dinoflagellate index'[43] in the Eastern Gotland Basin. The green line shows the minimum threshold value, which is set at 0.5 in this basin (Pre-core indicator report: HELCOM 2017ah).

[43] Included as a test indicator.

Impacts and recovery

The status of pelagic food-webs is highly dependent on nutrient levels. Surplus nutrients elevate phytoplankton growth, but the pelagic phytoplankton and zooplankton are also highly influenced by other factors in their environment, such as temperature and acidity (pH). These factors affect both the productivity and species composition of the pelagic community.

The abundance, but also the species composition of pelagic primary producers and zooplankton, is important for their quality as food for higher trophic levels. Blooms of cyanobacteria can include species that are toxic and induce alterations in the species composition of the grazing zooplankton. An increase in small-sized zooplankton with simultaneous decrease in total zooplankton biomass is likely to result in poorer food quality for pelagic feeding fish, such as herring, sprat and juvenile cod (Rönkkönen *et al.* 2004, Gorokhova *et al.* 2016).

The decreased size structure may also lower the level of grazing by zooplankton on phytoplankton, potentially affecting their abundances. Surplus primary productivity also decreases the recreational value of the sea, and enhances oxygen consumption and the extension of hypoxic conditions in benthic habitats (Vahtera *et al.* 2007).

The improvement of the status of the pelagic habitat in the Baltic Sea depends to a large degree on the success in reducing eutrophication but also on maintaining the structural integrity of the Baltic Sea food web. Both primary producers and zooplankton are also directly affected by changes in temperature and seasonality, leaving the pelagic system responsive to changes in climate (Dippner *et al*. 2001, Möllman *et al*. 2005).

5.3 FISH

Many fish species are a human food source, but fish are also prey for marine mammals and sea birds. Fish themselves feed on benthic species, zooplankton, and smaller fish, and are thereby a link between different parts of the food web. When migrating, they also have an ecological role in connecting different areas of the sea. The assessment of fish from a biodiversity perspective indicates good status for coastal fish in about half of the assessed areas. The migrating species salmon and sea trout show overall not good status. In the open sea, three out of eight currently assessed commercial stocks show good status.

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 southwest and in open sea areas. Coastal areas are key habitats for freshwater species, such as perch and cyprinids, as well as providing spawning and feeding areas for many marine species, such as cod, flounder, and herring. Most of the migrating species, including salmon, sea trout, sea lamprey and some populations of whitefish, are born and spawn in rivers but spend most of their growth phase in the Baltic Sea. The eel of the Baltic Sea is a highly migrant species and belongs to the same population as all other European eels (Box 5.3.1).

Indicators included in the assessment

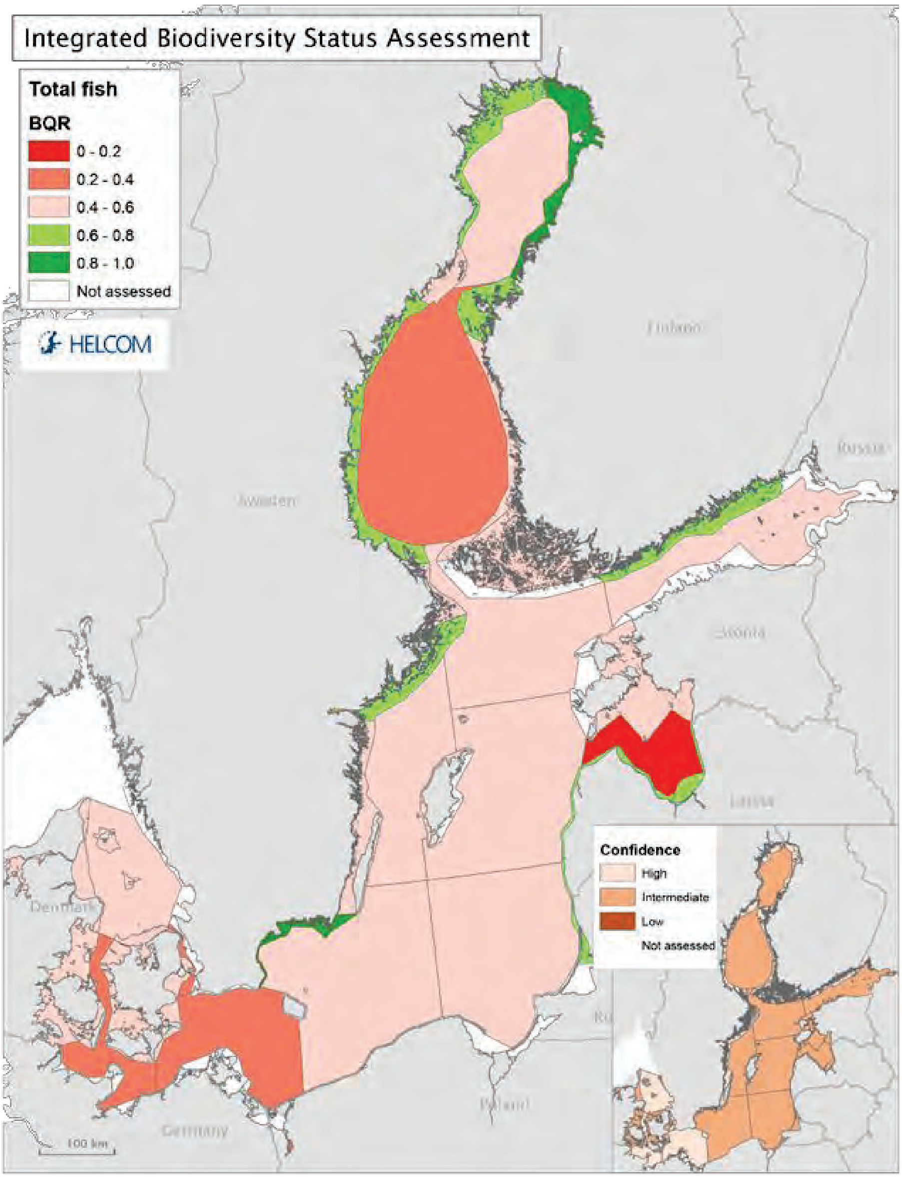
The integrated assessment of coastal areas includes core indicators representing characteristic Baltic Sea coastal fish species, the 'Abundance of key coastal fish species' and 'Abundance of key coastal fish functional groups' (Core indicator reports: HELCOM 2017x-y).

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; see Chapter 4.6 for detailed assessment results for commercial fish).

The migrating species salmon and sea trout are assessed by core indicators (HELCOM 2015c, 2017z), but were not included in the integrated assessment at this time, due to inconsistencies in the input data. 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[44].

[44] 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.

Integrated status assessment of fish



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 5.3.1. 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 Chapter 4 (Table 4.6.1). The confidence assessment is shown in the smaller map, with darker shaded areas indicating areas with lower confidence[45].

[45] Confidence in the open sea east of the Bornholm Basin is reduced due to the absence of analytical assessment results for demersal fish species. In this area, only pelagic stocks are currently included. Additional results are foreseen to be included by the end of 2017.

The integrated status of coastal fish was good in about half of the twenty-one assessed coastal areas (Figure 5.3.1). Differences among the areas likely reflected the influence of local factors on reproduction, growth and mortality. 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 (Figure 5.3.1). Demersal fish were only included for the southern Baltic Sea. Separate results for each fish stock are given in Table 4.6.1, and are also described further below. Assessment results for additional stocks, including also demersal fish in the eastern parts of the Baltic Sea, are foreseen to be included by the end of 2017.

Indicator results

Coastal fish

The core indicator 'Abundance of key coastal fish species' 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 assessed in the eastern and northern coastal areas, and flounder in the southeast. Thirteen out of twenty-one assessed areas achieved the threshold value (Figure 5.3.2, Core indicator report: HELCOM 2017x).

The core indicator 'Abundance of key coastal fish functional groups' combines information on two aspects of the food web: the abundance of predatory fish and of fish feeding at lower trophic levels. The indicator is only assessed in the eastern and northern coastal areas.

Low values in the component on predatory fish indicates disturbed food webs. Fishing is one key pressure potentially influencing the indicator, but it may also be influenced by pressures affecting recruitment and growth, for example (HELCOM 2017z). This component achieved the threshold value in thirteen of sixteen assessed areas (Figure 5.3.2).

The lower trophic level component was most often measured as abundance of fish from the taxonomic family cyprinids, for which high values are associated with eutrophication. Cyprinids do not occur naturally in more saline areas, and in those cases total abundances of coastal lower trophic level fish species are used. This component achieved the threshold value in seven of sixteen assessed areas (Figure 5.3.2, Core indicator report: HELCOM 2017y).

Overall, a continuously deteriorating status has predominated during the past three decades according to trends in both cyprinids and coastal predatory fish, and a slight increase in the share of areas with improving status has only been seen during the years of the current assessment period (Bergström *et al*. 2016).

Migrating species: Salmon and sea trout

Salmon (*Salmo salar*) and sea trout (*Salmo trutta*) spend the first few years of their life cycle in the river as parr. After this, they become smolt and start their feeding migration to the sea. Many Baltic rivers have lost their original wild salmon populations due to damming of rivers for hydropower and dredging. The species are also affected by targeted fishing as well as by being incidental by-catch in fisheries targeting other species.

The core indicator 'Abundance of salmon spawners and smolt' was assessed for the Gulf of Bothnia, Gulf of Finland, Gulf or Riga, and the Gotland Basin, indicating not good status in all these areas except for the Northern Quark (Core indicator report: HELCOM 2017z). Assessment results are lacking for many assessment units (Figure 5.3.2).

The core indicator 'Abundance of sea trout spawners and parr' was last updated in 2014. At that time, the indicators showed not good status in most of the assessed area, except for the most western parts of the Baltic Sea (Core indicator report: HELCOM 2015c).

The restoration of river habitats and management of river fisheries to strengthen Baltic Sea salmon and sea trout is a BSAP regional commitment (HELCOM 2011, update of reporting is currently ongoing).

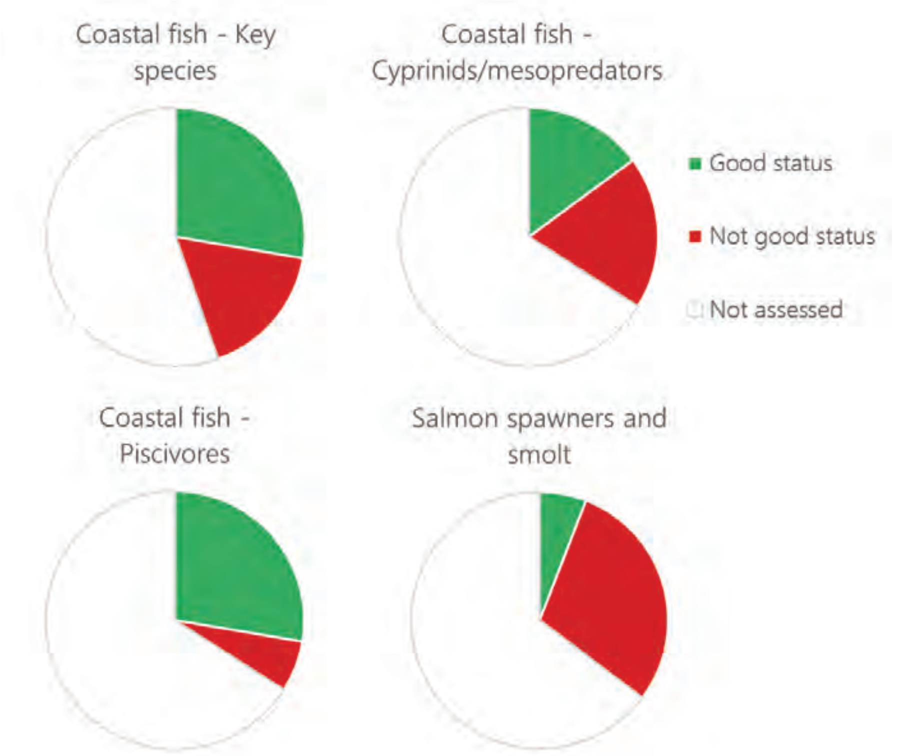


Figure 5.3.2. Core indicator results showing shares of assessment units that achieved the threshold value for good status for coastal fish, and for 'Abundance of salmon spawners and smolt'. White sectors represent assessment units that were not assessed due to lack of data.

Commercial fish species in the open sea

The internationally assessed commercial fish in the Baltic Sea encompass twenty-two fish stocks, representing twelve species. The stocks are assessed in relation to the objective of the fisheries management; that the spawning stock biomass and the fishing mortality should be kept at levels that are consistent with long term sustainability (see Chapter 4.6).

Out of the assessed stocks (assessed for the years 2011–2015) five were in not good status, three showed good status, and fourteen lacked assessment results (Figure 5.3.3). The demersal sole (*Solea solea*), Western Baltic cod (*Gadus morhua*), as well as herring spring spawners in the Western Baltic and Kattegat (*Clupea harengus*), did not achieve good status with respect to spawning stock biomass. The Gulf of Riga herring stock and sprat in the Baltic Sea failed good status with respect to fishing mortality (See also Table 4.6.1) [46].

Eastern Baltic cod was not assessed due to lack of quantitative biomass estimates and reference points in later years, but survey data indicate that its biomass has been reduced since a peak in 2010–2011 and has reached a stable lower level during the period from 2013 to 2016.

The long term development in spawning stock biomass of some of the main stocks in the Baltic Sea, sprat, central Baltic Sea herring and Western Baltic cod, are shown in figure 5.3.4.

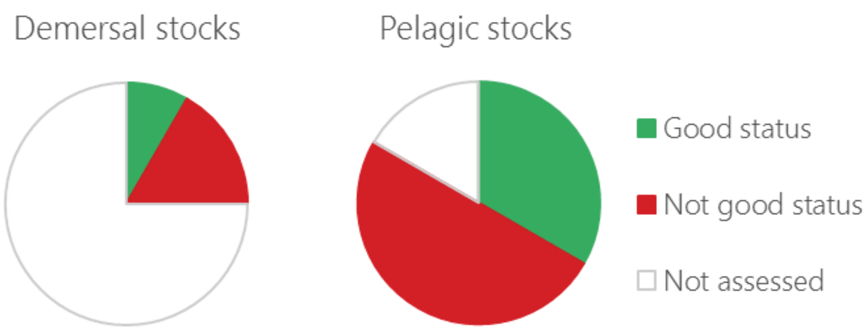
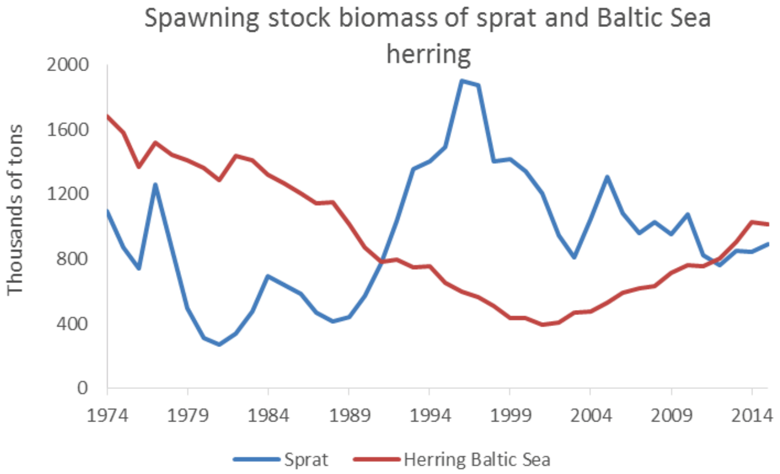


Figure 5.3.3. Results for internationally assessed commercial species showing the shares of demersal and pelagic stocks in good status (green), not good status (red) and not assessed (white). Assessment results for additional stocks are foreseen by the end of 2017.

[46] 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.



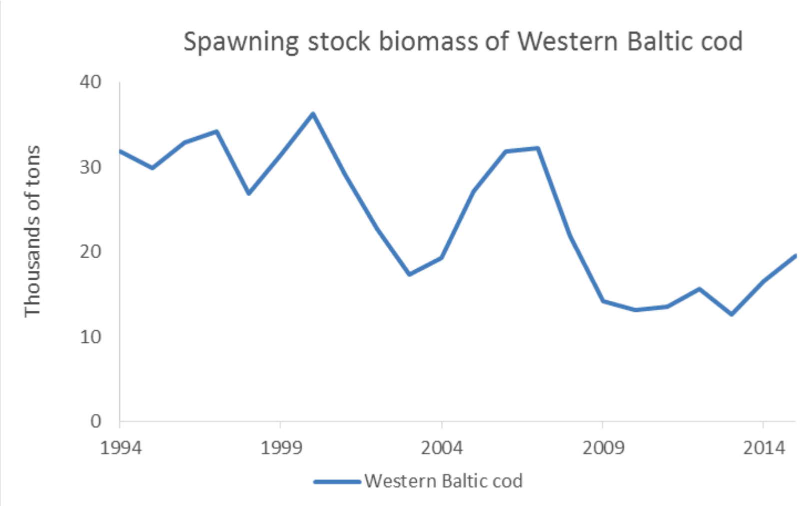


Figure 5.3.4. Temporal development in the spawning stock biomass of sprat and central Baltic Sea herring (1974–2015; upper graph) and of Western Baltic cod (1994–2015; lower graph), based on data from stock assessment models (ICES 2016a). Sprat covers ICES subdivisions 22-32, central Baltic Sea herring covers 25-29 and 32, while Western Baltic cod covers 22-24.

Size structure of fish

In addition to abundance and biomass, changes in individual size and condition of fish are important measures of the overall status of fish populations. The proportion of larger individuals of Eastern Baltic cod has declined sharply since 2013, and the condition factor of Eastern Baltic cod shows a declining trend (Figure 5.3.5).

There are many potential reasons for the decline, including changes in fishing patterns, natural mortality, and reduction in growth, for example, but so far no conclusive explanation has been identified. The declining condition of Eastern Baltic cod has also been related to changes in feeding opportunities and the spread of hypoxic areas in the Baltic Sea, and possibly other factors such as increased parasite infestation coupled to increased abundance of grey seals and fisheries selectivity (Eero *et al.* 2015, Casini *et al*. 2016).

For pelagic fish, the condition and mean weight declined substantially in the 1990s to a stable lower level (Casini *et al.* 2011).

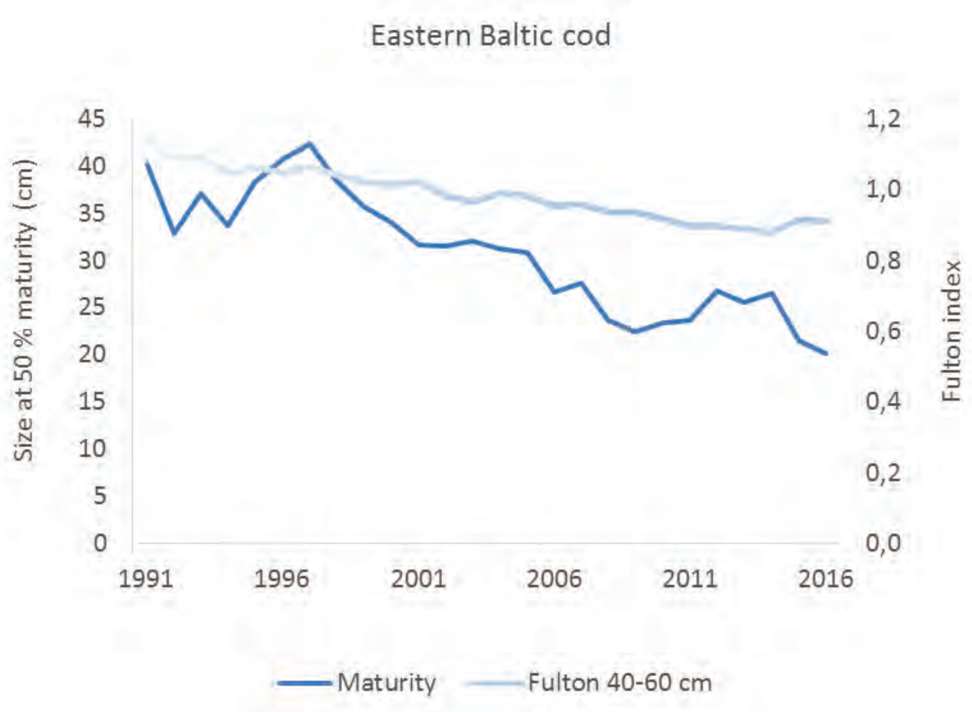


Figure 5.3.5. The condition of Eastern Baltic cod and the size at which it matures is decreasing. The dark blue line shows the development over time in the size at which 50 % of the population is mature. The light blue line shows condition calculated as Fulton's index for cod between 40 and 60 cm length. Based on data from the Baltic International Trawl Survey, Quarter 1.

Red-listed species of fish and lamprey

Fourteen species of fish and lampreys have been evaluated as threatened according to the HELCOM red list (HELCOM 2013b). The American Atlantic sturgeon (*Acipenser oxyrinchus*) which used to be common in the Kattegat and more rarely occurring in the Sound is considered regionally extinct.

The list of critically endangered species includes the European eel (Box 5.3.1), as well as grayling (*Thymallus thymallus*) in coastal areas of the Bothnian Sea. The sharks porbeagle (*Lamna nasus*) and spurdog (*Squalus acanthias*) in the Kattegat are also listed in this category, likely reflecting impacts of pressures occurring outside of the Baltic Sea region to a large extent, as the species are represented by populations that are widely distributed in the Northeast Atlantic.

The list has three further species listed as endangered and seven as vulnerable, including sea lamprey (*Petromyzon marinus*). Further, all shark and ray species in the Kattegat and western Baltic Sea are included in the red list. As they are at the border of their distribution in the Kattegat, the status of the shark and ray stock and their return to this area is also dependent on management outside of the HELCOM region.

Box 5.3.1. The red-listed eel

Historically, eel (*Anguilla anguilla*) has been a common species across the Baltic Sea, occurring even in the far north. With a common recruitment area in the Sargasso Sea all eel in Europe and the Mediterranean are part of the same (panmictic) population, occurring in scattered marine, coastal, river and lake ecosystems.

The main concern regarding eel is its sharply decreased recruitment since the 1980s (Moriarty and Dekker 1997, ICES 2016). A decreasing trend has probably been present even longer (Dekker and Beaulaton 2016). The cause of recent changes may be a combination of factors such as overfishing, inland habitat loss and degradation, mortality in hydropower turbines, contaminants, parasites and climatic changes in the spawning area (Moriarty and Dekker 1997, ICES 2016d).

In the Baltic Sea, there is a decreasing number of licensed fishermen targeting eel, and there have been efforts to ban recreational fishing and to decrease the number of licensed fishers (ICES 2016d). The status of the eel stock has been poorly documented until recently, with incomplete catch statistic being one issue.

Indications are that the eel in the Baltic Sea constitutes about a quarter of the total population of European eel today. Since the mid-1900s, fishing yield all over Europe has gradually diminished and is now below 10 % of the quantity caught in the past.

In 2007, the EU Eel Regulation implemented a Distributed Control System, setting a common restoration target at the international level, and obliging EU countries to implement the required protective measures, with the aim of ensuring 40 % of mature eels make it to the sea, in relation to estimated pristine conditions. The required minimum protection has not yet been achieved, and although eel management plans are being established on national level, no joint management and assessment actions have been achieved. Eel has recently been included in Appendix II of the Convention of Migratory Species, and are also conserved through the EU Habitats Directive.

Impacts and potential future changes

The status of fish is potentially affected by several pressures in the ecosystem. Where overfishing occurs, this is typically connected with reduced fish population sizes. Further, targeted fishing on certain species and size classes often leads to a shortage of large predatory fish, and an overrepresentation of smaller fish and fish of lower trophic levels (Pauly *et al.* 1998). Fish are also strongly affected by climate change, as well as many other factors, such as eutrophication, habitat loss and disturbance. Climate change affects fish directly, with effects on recruitment and growth. It also influences the distribution range of species, as well as prey availability and species interactions (MacKenzie *et al.* 2007).

In coastal areas and river mouths, a gradual but continued deterioration of essential recruitment habitats is a concern, as these often coincide with areas that are attractive for coastal development and construction, and habitat quality is also affected by eutrophication (Seitz *et al*. 2014). In the open sea, the most important spawning area for Eastern Baltic cod (currently), the Bornholm Basin, is only a fraction of its historical area due to increasing oxygen deficiency.

The Gdansk Basin and the Gotland Basin have had a very limited contribution to cod recruitment since the 1990s (Köster *et al.* 2017).

Climate change is likely to increase in importance over time, by affecting the physiology of fish and the availability of zooplankton, which fish depend on during their early life stages. A foreseen increased temperature and decreased salinity would also affect how fish species are distributed within the Baltic Sea, so that marine species will be disadvantaged and habitats of freshwater species will likely expand.

5.4 MARINE MAMMALS

Four marine mammal species are resident in the Baltic Sea: the grey seal, harbour seal, ringed seal and the harbour porpoise. These mobile top predators have an important role in regulating the food web, but are also sensitive to pressures in all their area of distribution, as well as to changes in the food web. Their exposure to accumulated pressures make marine mammals important indicators of the health of the ecosystem. Overall, the status of marine mammal species is assessed as unfavourable. However, at species level, grey seals and harbour seals show increasing population sizes. A particular concern is the local population of harbour porpoise in the Baltic Proper, with a population size recently estimated at around 500 animals. Also, the population of ringed seals in the Gulf of Finland is of concern, as the population (which is sensitive to climate change) is decreasing, currently only represented by around 100 animals.

Hunting has been a major pressure on marine mammals in the Baltic Sea historically. Populations of seal were severely reduced due to hunting at the beginning of the 1900s. Environmental contaminants in the 1960s and 1970s caused further decimation of the populations by severely reducing the fertility of ringed and grey seals (Helle 1980).

The harbour seal sub-populations in Kattegat and the Danish Straits have also experienced two cases of mass mortality in recent times, caused by the 'Phocine distemper virus', resulting in more than 50 % of the sub-population dying in 1988 and about 30 % in 2002 (Härkönen *et al.* 2006).

These events resulted in severe reduction of the abundance of mammals in the Baltic Sea, but today the situation has improved for several of the populations.

Indicators included in the assessment

The status of the seal species was assessed by core indicators reflecting population trends and abundance, as well as their distribution (Core indicator reports: HELCOM 2017aa-ab). Grey seals were also assessed using core indicators reflecting changes in nutritional status and reproductive status (Core indicator reports: HELCOM 2017ac-ad, Box 5.4.1). 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 threats on marine mammals from incidental by-catch, see Box 5.4.2, for hunting on seals, see Chapter 4.6.

Box 5.4.1. 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 (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 seals, and infections and ulcerations to the small intestine for grey seals.

More details on the core indicator concepts and how threshold values have been defined can be found in the core indicator report.

Integrated status assessment of 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 5.4.1). 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.

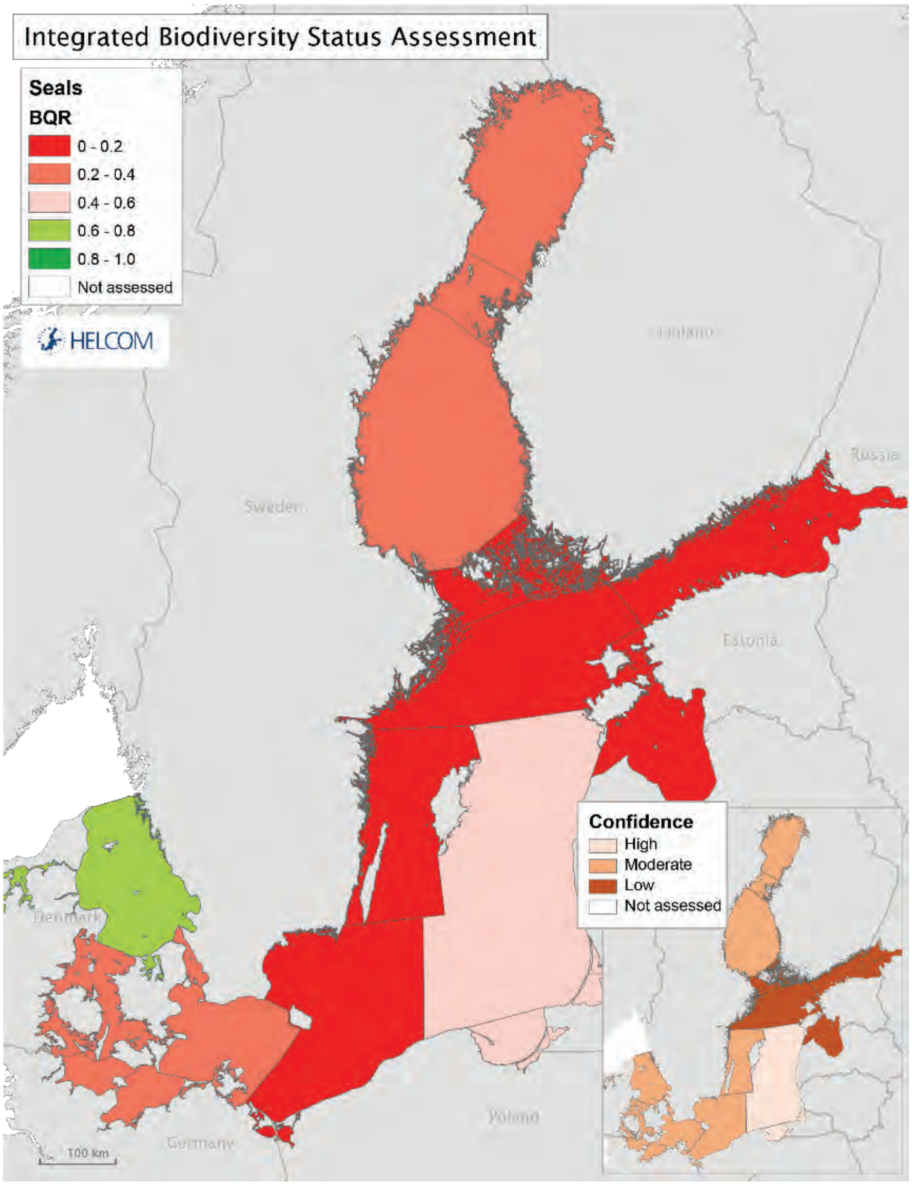


Figure 5.4.1. Integrated biodiversity status assessment for seals using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool. Biological quality ratios (BQR) above 0.6 correspond to good status. Green denotes good status and red not good status. 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 5.4.2–5.4.4). The confidence assessment is shown in the smaller map, with darker shaded areas indicating areas with lower confidence.

Results for species

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 (Figure 5.4.3). However the status of the grey seal in the overall assessment is not good (Figure 5.4.2). 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 (Core indicator report: HELCOM 2017aa). 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 (Core indicator report: HELCOM 2017ab).

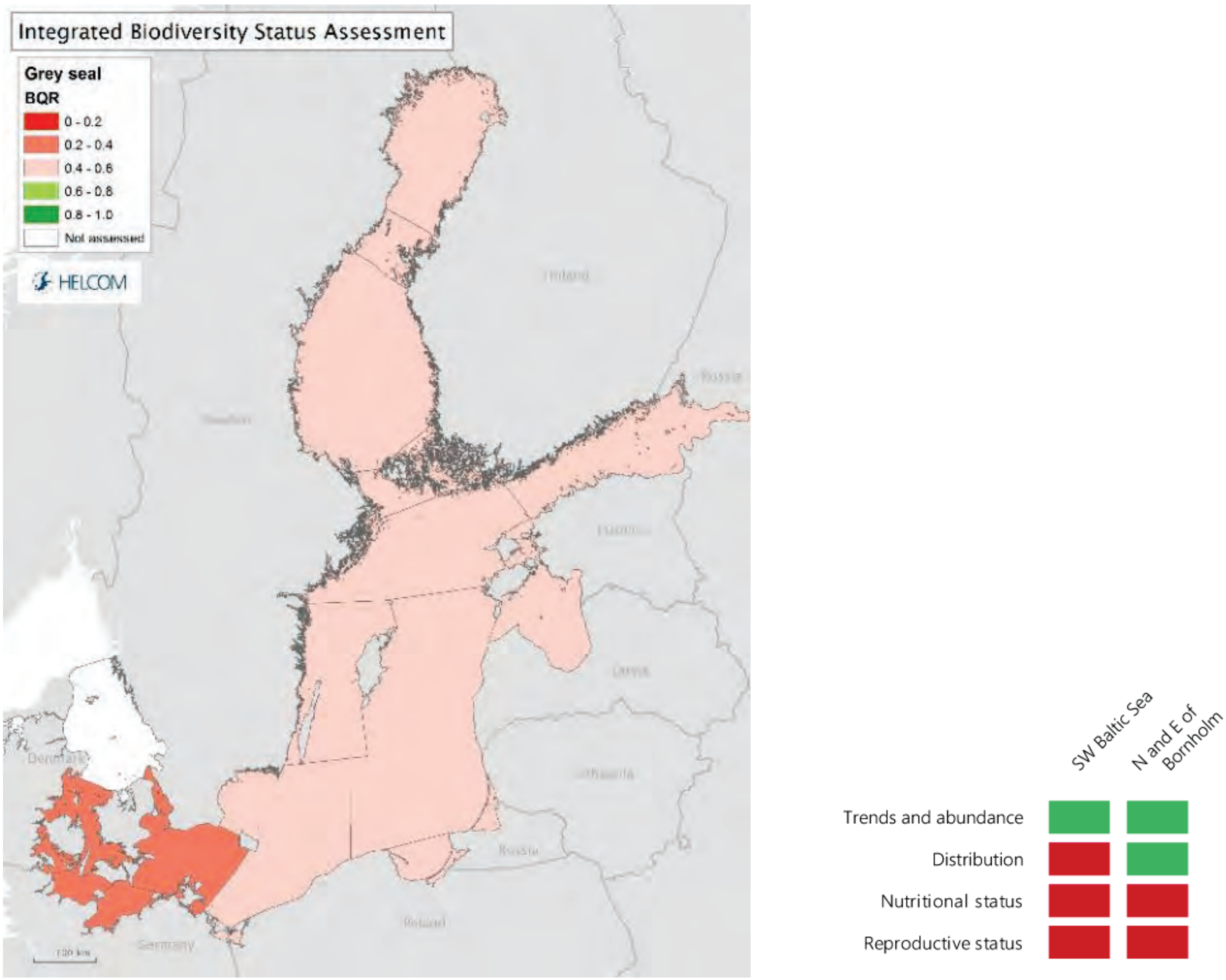


Figure 5.4.2. Integrated status of grey seal in the Baltic Sea using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool. The assessment is not applicable in the Kattegat (white area in the map). Biological quality ratios (BQR) above 0.6 correspond 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.

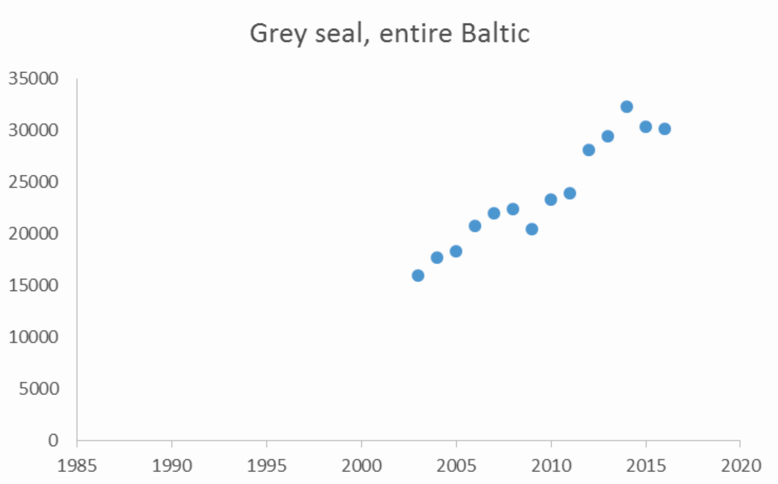


Figure 5.4.3. Developments over time in the counted number of grey seals hauling out in moulting time during 2003–2015. The growth rate is above the species specific threshold value. Although the population development can be followed reliably, it should be noted that not all individuals are encountered in monitoring.

Harbour seal (Phoca vitulina)

Of the three management units of harbour seals in HELCOM area, only the Kattegat population shows good status (Figure 5.4.4).

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 (Figure 5.4.5). 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 (Core indicator report: HELCOM 2017aa).

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 (total abundance estimate). The Kalmarsund population is also categorised as vulnerable in the HELCOM red list (HELCOM 2013b).

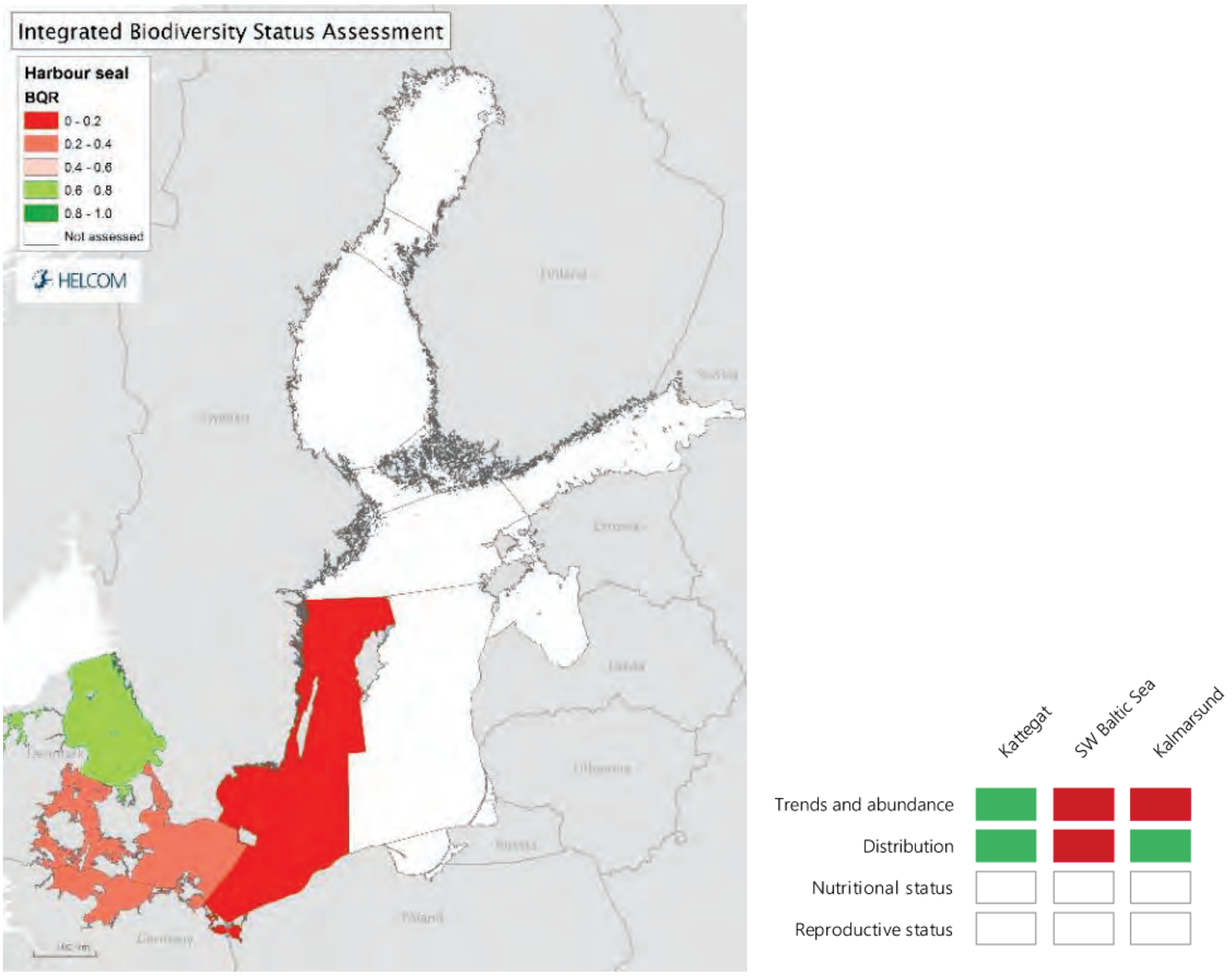


Figure 5.4.4. Integrated status of harbour seal in the Baltic Sea using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool, for those areas where the assessment is applicable. Biological quality ratios (BQR) above 0.6 correspond to good status. 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.

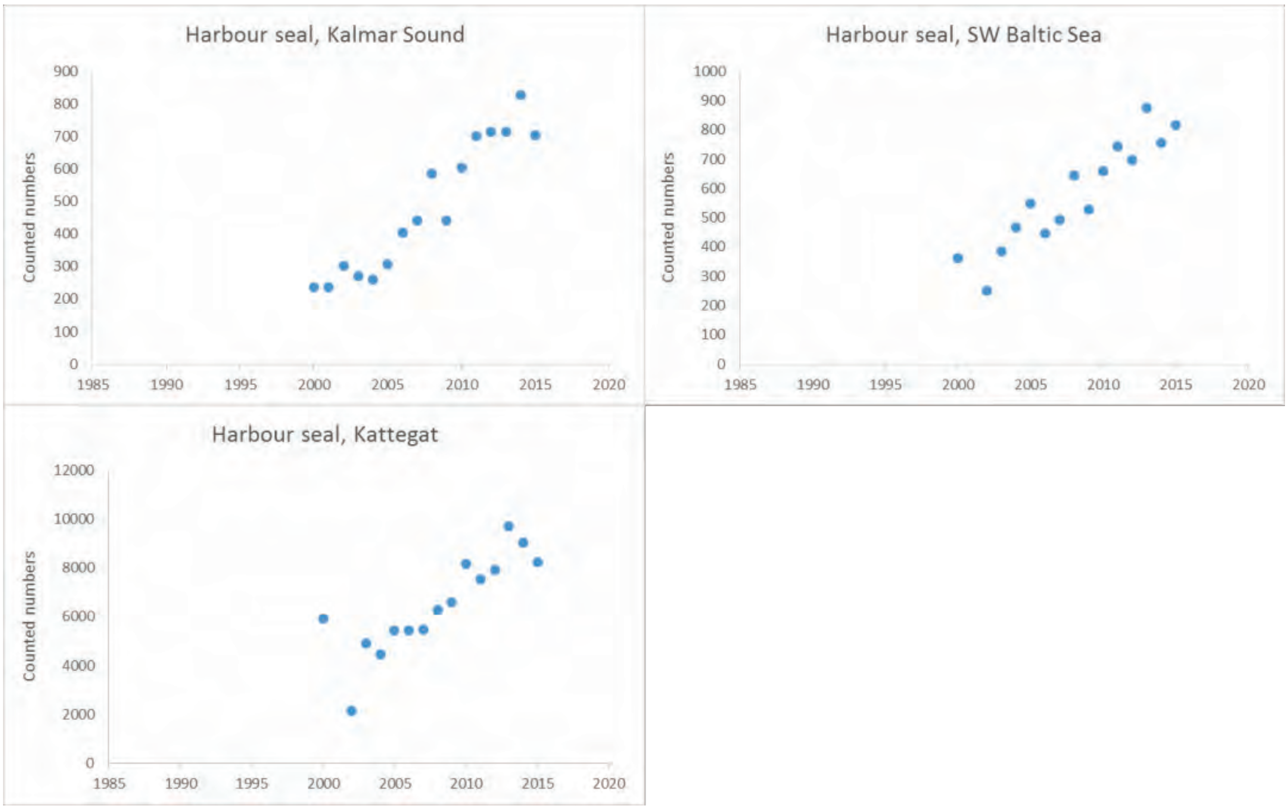


Figure 5.4.5. Developments over time in the counted number of harbour seals hauling out in moulting time. Upper left: The Kalmarsund population of harbour seals during 2000–2015. The growth rate is above the species specific threshold value, but since the total number of individuals is well below the limit reference level, the population is not in good status. Upper right: Southwestern Baltic harbour seal population since 2002. The annual growth rate is positive but it is still below the species specific threshold value. Lower left: Kattegat population achieves the threshold values for both the abundance and the growth rate. Although the population development can be followed reliably, it should be noted that not all individuals are encountered in monitoring.

Ringed seal (Phoca hispida)

The status of the ringed seal is not good (Figure 5.4.6). 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 (Figure 5.4.7, Core indicator report: HELCOM 2017aa). 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 2013b).

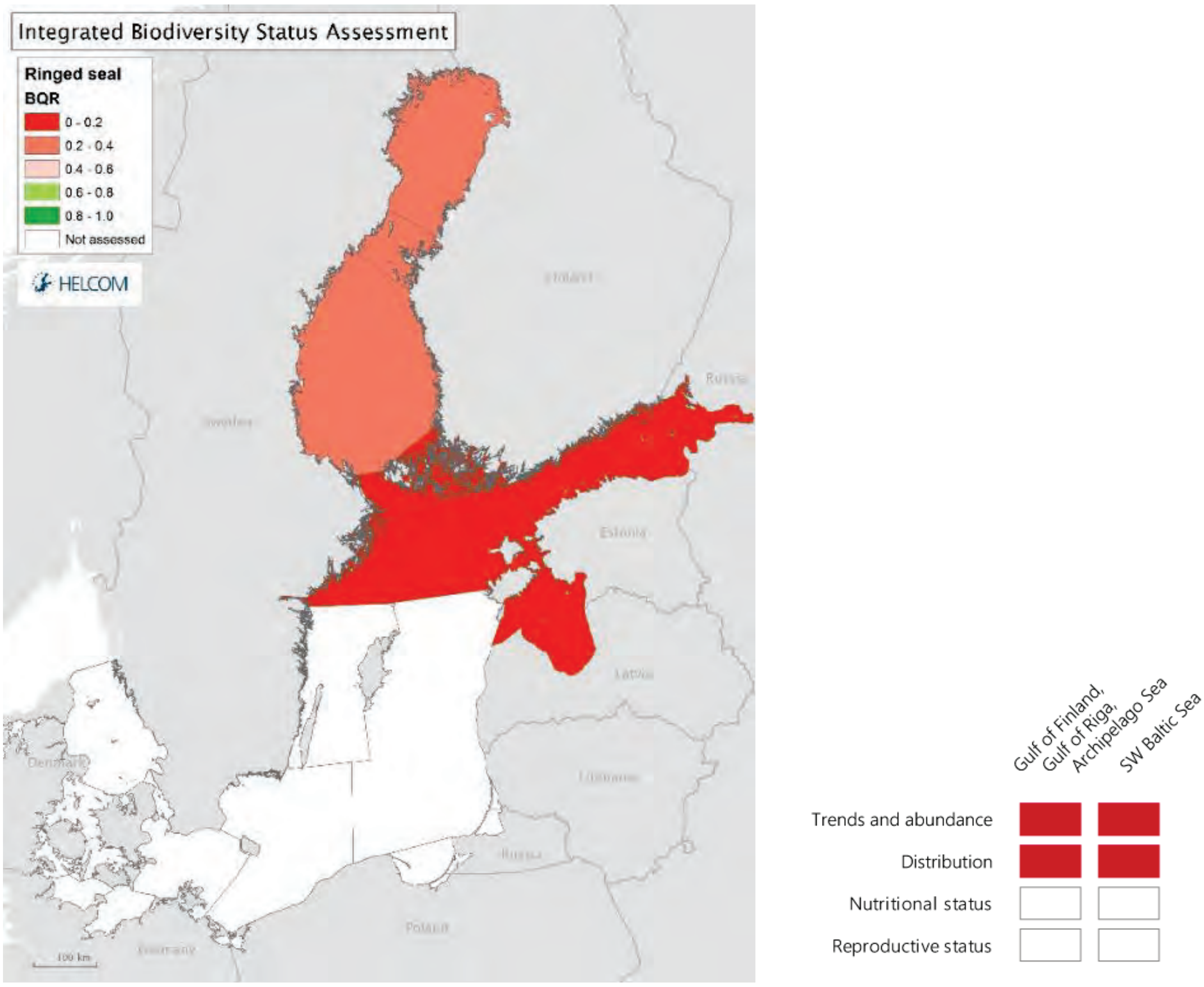


Figure 5.4.6. Integrated status of ringed seal in the Baltic Sea using the BEAT tool. Status is shown in five categories based on the integrated assessment scores obtained in the tool, for those areas where the assessment is applicable. Biological quality ratios (BQR) above 0.6 correspond to good status. 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

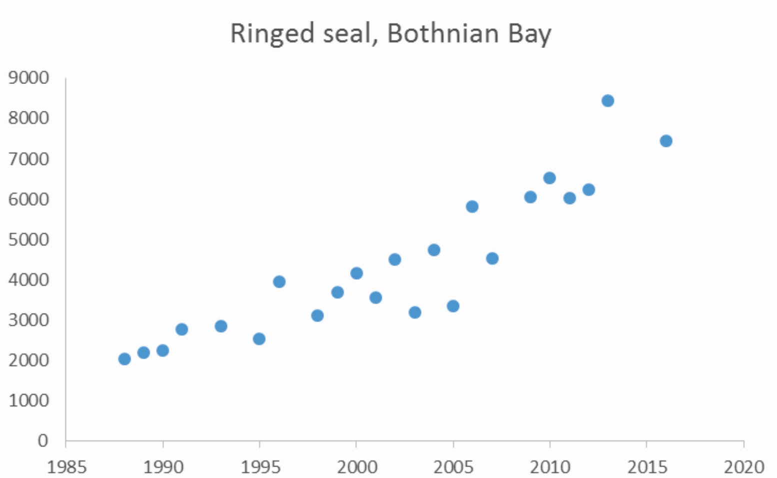


Figure 5.4.7. Developments over time in the counted number of ringed seals hauling out in moulting time in the Bothnian Bay since 1988. The annual growth rate is positive but it is still below the species specific threshold value. Although the population development can be followed reliably, it should be noted that not all individuals are encountered in monitoring. The number of ringed seals in the Bothnian Bay is estimated at more than 20 000.

Harbour porpoise

A major study conducted in 2011–2013 using passive acoustic recorders support that there are two sub-populations of harbour porpoise in the Baltic Sea: one mainly occurring east of Bornholm in the Baltic Proper and the other one occurring in southern Kattegat, the Belt Sea, and the southwestern parts of the Baltic Sea (Anonymous 2016, Figure 5.4.8). A recent population genomics approach also emphasised notable differences between the Kattegat, Belt Sea, Western Baltic and the Baltic Proper (Lah *et al.* 2016).

The Baltic Proper sub-population was categorised as critically endangered in the HELCOM red list (HELCOM 2013b). The number of animals in this sub-population is estimated to be around 500 animals (95 % confidence range 80 to 1091). A large part of this sub-population occurs around the shallow offshore banks southwest of Gotland in summer during calving and mating.

The Kattegat-Belt Sea-Western Baltic sub-population was estimated at around 40 500 animals (95 % confidence range 25 614 to 65 041) using a visual line transect survey (Viquerat *et al.* 2013). This sub-population was also assessed as threatened by HELCOM albeit with the lower threat status 'vulnerable'. However, based on a later survey of small cetaceans in European Atlantic waters and the North Sea (SCANS) the population has been stable over the past twenty-two years (Hammond *et al.* 2016).

The harbour porpoise requires strict protection under the EU Habitats Directive as a species listed under Annex IV (concerning Animal and plant species of community interest in need of strict protection). For the Habitats Directive's reporting period 2007 to 2012, the conservation status of harbour porpoise was assessed as in the worst status class ('unfavourable–bad') by all countries that reported on the species in the Baltic Sea region; Denmark, Germany, Poland, and Sweden.

The situation of the status for Baltic Proper harbour porpoise was recognised by the agreement on the conservation of small cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) and is reflected in the ASCOBANS recovery plan for Baltic harbour porpoises (Jastarnia plan; ASCOBANS 2009) and HELCOM Recommendation 17/2 (HELCOM 2013f).

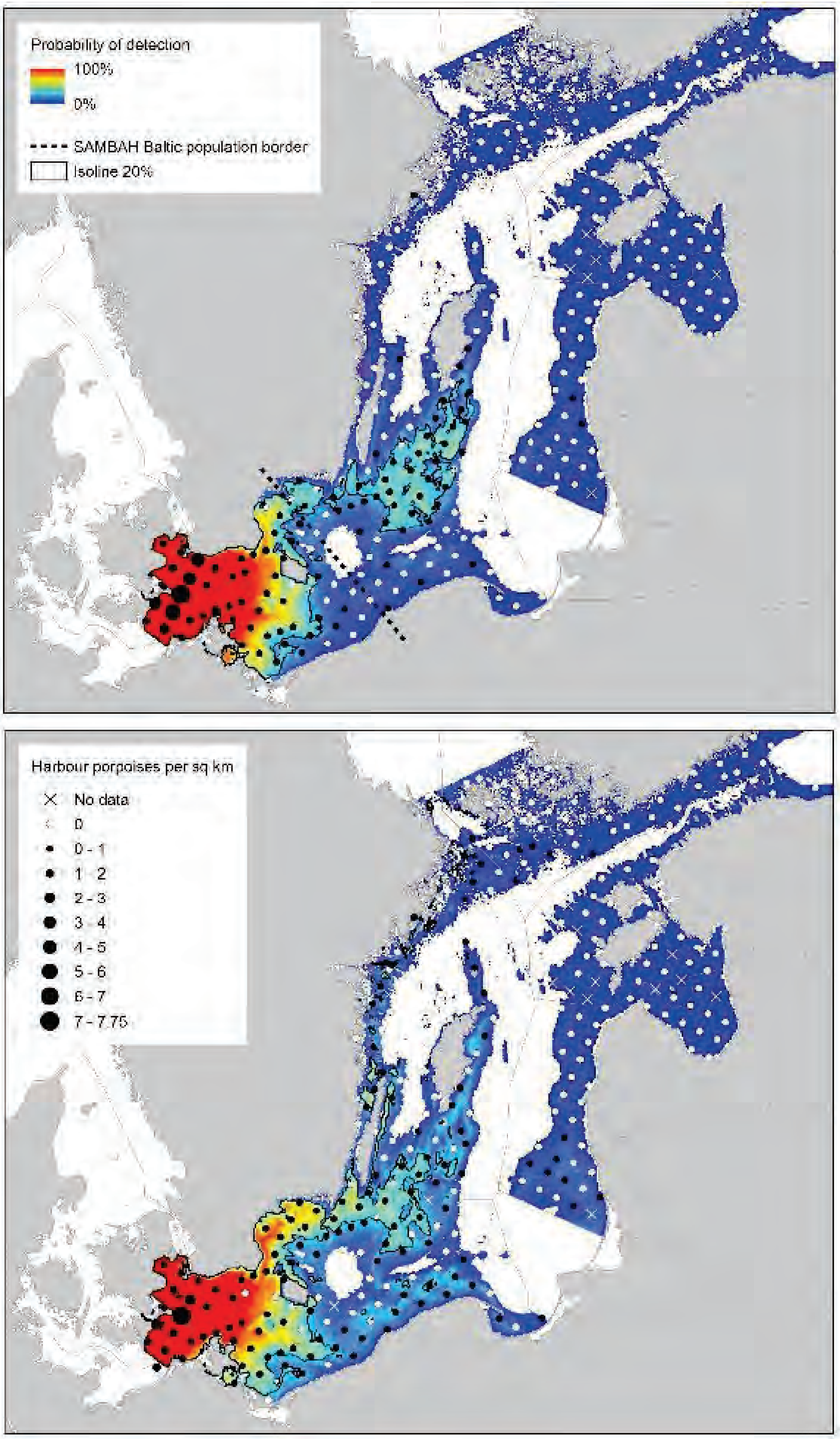


Figure 5.4.8. Predicted probability of detection of harbour porpoises per month between May and October (upper graph) and between November and April (lower graph). The black line indicates areas with 20 % probability of detection of harbour porpoise (Denoted 'Isohaline 20 %' in the legend). This area is approximately comparable to the area encompassing 30 % of the population, and the limit is often used to define high-density areas. The hatched line in the upper figure indicates the spatial separation between the Belt Sea and Baltic harbour porpoise populations during May to October according to SAMBAH (2016). White colour denotes areas that were not surveyed in SAMBAH (2016).

Box 5.4.2. Incidental by-catch of mammals in fishing gear

Drowning in fishing gear is believed to be the greatest source of mortality for harbour porpoise populations in the Baltic Sea, and is also a concern for seals (Core indicator report: HELCOM 2017ae). The risk of incidental by-catch is highest in various types of gillnets but other stationary fishing gear, such as fyke nets and push-up traps also have incidental by-catches (ICES 2013a, Vanhatalo *et al.* 2014).

Incidental by-catches of harbour porpoise in the Kattegat and Belts Seas were calculated at 165 to 263 animals in 2014, based primarily on information from CCTV cameras on commercial vessels in combination with data on fishing effort (ICES 2016e). The numbers are however associated with high uncertainties, concerning both incidental by-catch numbers and estimates of fishing effort. Documentation of incidental by-catch of harbour porpoise in the Baltic Proper is only fragmented, typically amounting to a few animals per year from the countries reporting.

Based on interviews with fishermen from Sweden, Finland and Estonia, and accounting for the variability in seal abundance and fishing effort, and also for underreporting, the annual incidental by-catch of grey seals in trap nets and gill nets in these countries were estimated at around 2 180 to 2 380 individual seals in 2012 (Vanhatalo *et al.* 2014). There are no estimates of the incidental by-catch of ringed seals or harbour seals.

Recovery

Recognizing the importance of ensuring the long-term survival of the Baltic Sea seals, HELCOM agreed in 2006 on a Recommendation of the 'Conservation of seals in the Baltic Sea' (HELCOM 2006). The Recommendation is a regional agreement on joint management principles, management units for the different seal populations, limit reference levels for the respective management unit, and coordinated monitoring programmes. Today, the population trends are indicating recovery of most populations (Figures 5.4.3, 5.4.5, 5.4.7).

However, the overall status of the seal populations is still of concern, particularly for the ringed seal. Future perspectives are species specific, due to different habitat preferences and different pressures. Current ongoing pressures affecting marine mammals include climate change, fish stock depletion and contamination. Decimated populations are also threatened by mortality resulting from incidental by-catch, and harbour seals have previously been vulnerable to viral epidemics (1988, 2002 and 2014). For ringed seals available breeding sites in ice lairs are expected to decrease with climate change.

To protect the harbour porpoise, in particular the Baltic Proper population, minimizing incidental by-catches in fishing gear is crucial. The HELCOM Marine Protected Areas (see Figure 7.3 in Chapter 7) are also important to protect these species in the Baltic Sea region.

5.5 WATERBIRDS

The Baltic Sea is an important resting, feeding, breeding and wintering area for around 80 bird species. The waterbirds connect food webs in water with those on land, and by migration they also link the Baltic Sea with other marine regions. Many characteristic bird species have decreased over the last few decades, for example the common eider, which feeds on blue mussels at the seafloor, and the common gull, which scouts the sea surface for fish. A decline is also seen in long-tailed duck, whereas other species have increased; great cormorants and barnacle goose, for example. The changes are seen both during the wintering and the breeding season. Changes can be attributed to factors such as disruptions of food web structure, climate change and habitat alteration.

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.

Indicators included in the assessment

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; Core indicator reports: HELCOM 2017af-ag).

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.

For threats on waterbirds from incidental by-catch in gill nets, see Box 5.5.1, for hunting on waterbirds, see Chapter 4.6.

Integrated status assessment of waterbirds

None of the core indicators for waterbirds achieved good status. Among the species group of birds breeding in the Baltic Sea, declines were seen in benthic feeders (such as velvet scoter and common eider; Figure 5.5.1) and surface feeders. Declines were also seen within the species group of wading birds (such as the dunlin; Figure 5.5.2), 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 (such as Steller's eider; Figure 5.5.1).

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 (such as great crested grebe and great cormorant; Figure 5.5.3, Table 5.5.2).

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 (Table 5.5.1–2). 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 2013b). These declines are not reflected in the indicator results, which are only based on coastal counts.

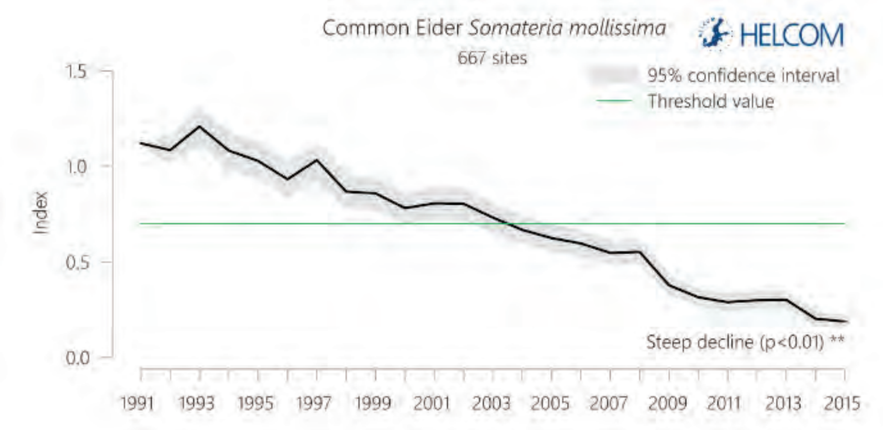
Table 5.5.1. List of species included in the core indicator 'Abundance of waterbirds in the breeding season'. Species groups not achieving good status according to the definition of the core indicators when applied at species group level, are highlighted in red. Species listed in Annex 1 of the Birds directive are marked *. The column to the right shows the status of the same species according to the HELCOM red list (which includes additionally fifteen species not included in the core indicators; HELCOM 2013b).

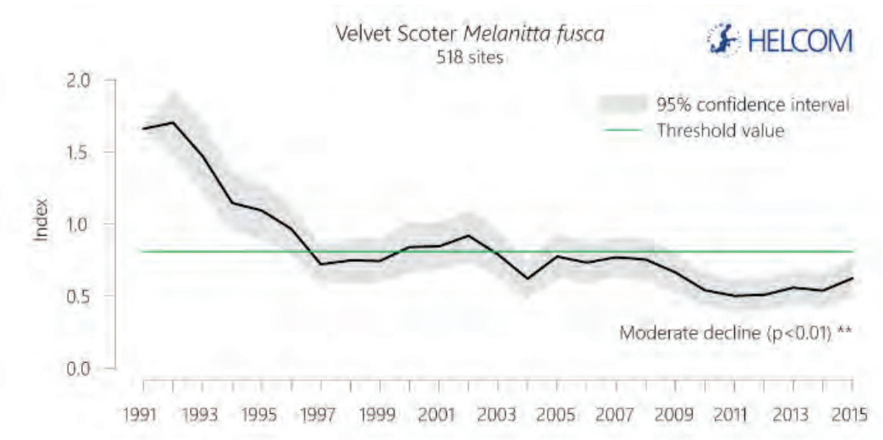
Species Group	Species	Scientific name	Trend since 1991	Threat status according to the HELCOM red list
grazing feeders	mute swan	*Cygnus olor*	↑	
	greylag goose	*Anser anser*	↑	
benthic feeders	tufted duck	*Aythya fuligula*	→	Near Threatened
	common eider	*Somateria mollissima*	↓	Vulnerable
	velvet scoter	*Melanitta fusca*	↓	Vulnerable
pelagic feeders	goosander	*Mergus merganser*	↓	
	red-breasted merganser	*Mergus serrator*	↓	
	great crested grebe	*Podiceps cristatus*	↑	
	great cormorant	*Phalacrocorax carbo*	↑	
	razorbill	*Alca torda*	→	
	common guillemot	*Uria aalge*	↑	
	black guillemot	*Cepphus grille*	↓	Near Threatened
surface feeders	Arctic skua	*Stercorarius parasiticus*	?	
	common gull	*Larus canus*	↓	
	great black-backed gull	*Larus marinus*	↓	
	herring gull	*Larus argentatus*	↓	
	lesser black-backed gull	*Larus fuscus*	→	Vulnerable
	little tern*	*Sternula albifrons*	→	
	common tern*	*Sterna hirundo*	↑	
	Arctic tern*	*Sterna paradisaea*	↑	
wading feeders	common shelduck	*Tadorna tadorna*	→	
	Eurasian oystercatcher	*Haematopus ostralegus*	↓	
	pied avocet*	*Recurvirostra avosetta*	↓	
	ringed plover	*Charadrius hiaticula*	→	Near Threatened
	turnstone	*Arenaria interpres*	↓	Vulnerable
	dunlin*	*Calidris alpine*	↓	Endangered

Table 5.5.2. Waterbird species included in the core indicator 'Abundance of waterbirds in the wintering season'. Species groups not achieving good status according to the definition of the core indicators when applied at species group level, are highlighted in red. The core indicator is based on counts along the coast, and does not include monitoring in open sea areas. Slavonian grebe, red-throated diver, black-throated diver, common eider, long-tailed duck, common scoter and velvet scoter are species with a large part of their population in the open sea areas, and may have different assessment results there. Species listed in Annex 1 of the Birds directive are marked with an asterix*. The column to the right shows the status of the same species according to the HELCOM red list HELCOM 2013b). Note that the HELCOM red list includes six additional species not included in the core indicators.

Species Group	Species	Scientific name	Trend since 1991	Threat status according to the HELCOM red list
grazing feeders	mute swan	*Cygnus olor*	↓	
	whooper swan*	*Cygnus cygnus*	↑	
	Bewick's swan	*Cygnus bewickii*	↓	
	mallard	*Anas platyrhynchos*	↓	
	Eurasian coot	*Fulica atra*	↓	
benthic feeders	common pochard	*Aythya farina*	↓	
	tufted duck	*Aythya fuligula*	↓	
	greater scaup	*Aythya marila*	↓	
	Steller's eider	*Polysticta stelleri*	↓	Endangered
	common eider	*Somateria mollissima*	↓	Endangered
	long-tailed duck	*Clangula hyemalis*	↓	Endangered
	common scoter	*Melanitta nigra*	↑	Endangered
	velvet scoter	*Melanitta fusca*	↓	Endangered
	common goldeneye	*Bucephala clangula*	↑	
pelagic feeders	smew*	*Mergellus albellus*	↑	
	goosander	*Mergus merganser*	↓	
	red-breasted merganser	*Mergus serrator*	↓	Vulnerable
	great crested grebe	*Podiceps cristatus*	↑	
	red-necked grebe	*Podiceps grisegena*	↓	Endangered
	Slavonian grebe*	*Podiceps auritus*	↑	Near Threatened
	red-throated diver*	*Gavia stellate*	↑	Critically endangered
	black-throated diver*	*Gavia arctica*	↓	Critically endangered
	great cormorant	*Phalacrocorax carbo*	↑	
surface feeders	black-headed gull	*Larus ridibundus*	↑	
	common gull	*Larus canus*	→	
	great black-backed gull	*Larus marinus*	→	
	herring gull	*Larus argentatus*	↓	

All bird species included in the core indicator-based assessment are also evaluated under the EU Birds Directive (EC 2009). There may be differences in the assessment outcomes of these two, due to differences in assessment methods and the spatial units considered. The HELCOM core indicator-based assessment is carried out for the entire Baltic Sea, using a regional threshold value, whereas the assessment under the EU Birds Directive is bounded by national borders and use different threshold values.





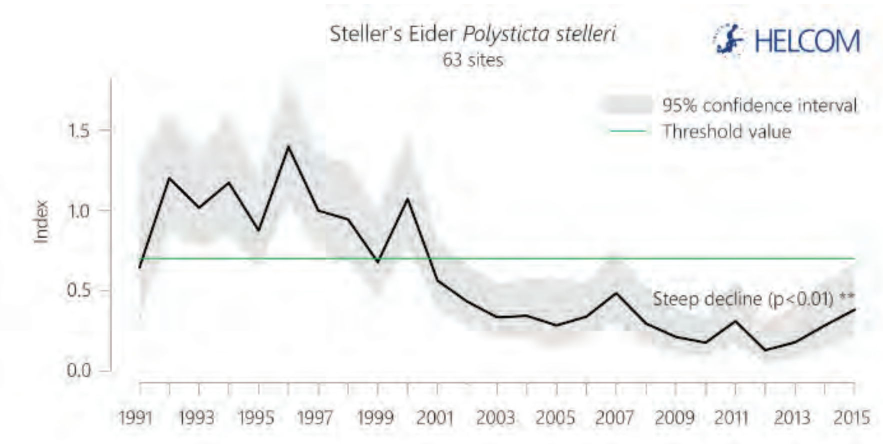


Figure 5.5.1. Temporal development in abundance index values of the benthic feeders common eider and velvet scoter during the breeding season and Steller's eider during the wintering season from 1991-2015. The green line denotes the threshold for good status. This is 70 % of the average of index values 1991-2000 (1.0) in species laying more than one egg per year (common eider and Steller's eider) and 80 % in species laying only one egg per year (velvet scoter). Source: Core indicator reports: HELCOM 2017af and 2017ag.

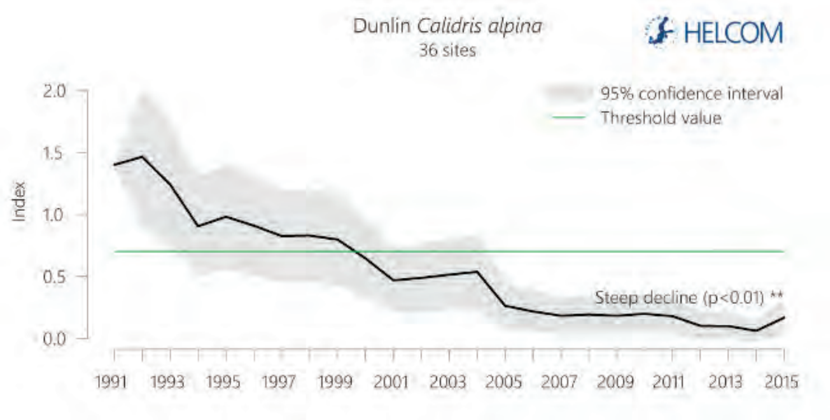
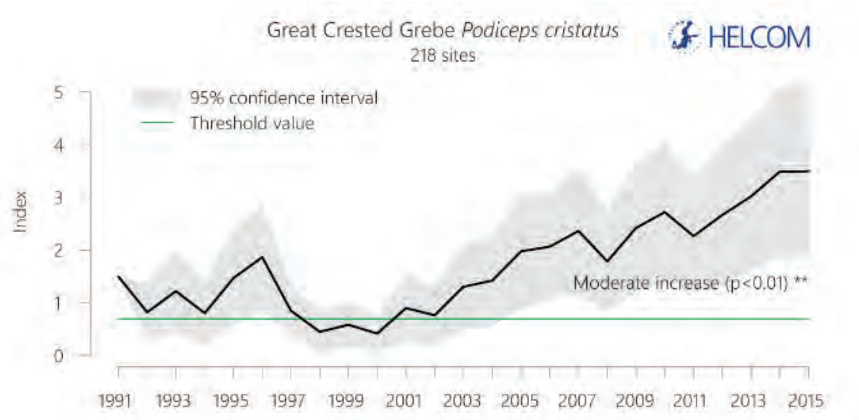


Figure 5.5.2. Temporal development in abundance index values of the wading feeder dunlin from 1991-2015. The green line denotes the threshold for good status. This is 70 % of the average of index values 1991-2000 (1.0) in species laying more than one egg per year. Source: Core indicator report: HELCOM 2017af.



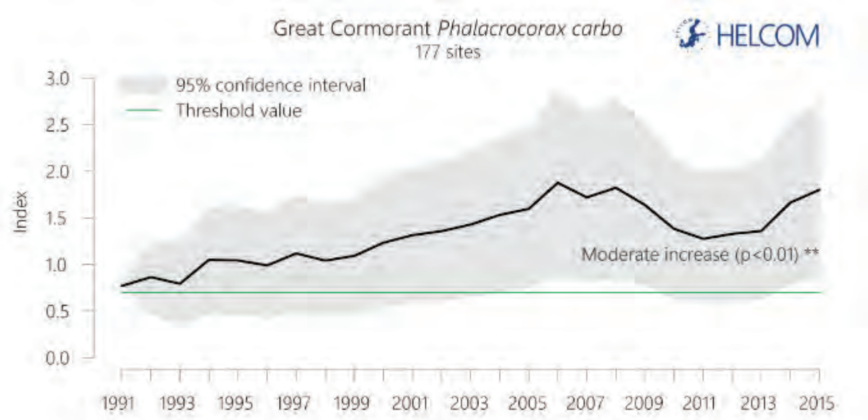


Figure 5.5.3. Temporal development in abundance index values of the pelagic feeders great crested grebe and great cormorant during the breeding season from 1991-2015. The green line denotes the threshold for good status. This is 70 % of the average of index values 1991-2000 (1.0) in species laying more than one egg. Source: Core indicator report: HELCOM 2017af.

Box 5.5.1. Incidental by-catch of waterbirds in fishing gear

Drowning in fishing gear is believed to be a strong pressure on the populations of divers, grebes, cormorants, alcids, mergansers and ducks, especially in wintering areas with high densities of waterbirds. Diving waterbirds are especially vulnerable to being entangled in gill nets and other types of nets, but incidental by-catches also occur in other types of fishing gear, such as longlines and traps (ICES 2013b).

A rough estimate indicated that between 100 000 and 200 000 waterbirds drown annually in the North and Baltic Seas, of which the great majority drowns in the Baltic Sea (Žydelis *et al.* 2009, 2013, Bellebaum *et al.* 2012).

Beside the assessment of incidental by-catch, the hunting bag (see Chapter 4.6) must also be taken into account because the total anthropogenic mortality has to be related to the population in order to assess its impact.

Red-listed species

The red listing provides additional information on the status of waterbirds in the Baltic Sea compared to that of the core indicators.

Twenty-three out of 58 bird species breeding in the Baltic Sea were listed in the HELCOM red list (HELCOM 2013b). The gull-billed tern (*Gelochelidon nilotica*) has been a regular breeding bird in the past but is now considered regionally extinct, and the Kentish plover (*Charadrius alexandrinus*) was categorised as critically endangered. Three species, the southern dunlin (*Calidris alpina schinzii*), the Terek sandpiper (*Xenus cinereus*), the Mediterranean gull (*Larus melanocephalus*) and the black-legged kittiwake (*Rissa tridactyla*), were classified as endangered. An additional eight species or subspecies were classified as vulnerable and nine as near threatened.

Sixteen out of 47 water bird species wintering in the Baltic Sea were listed. The red-throated diver and the black-throated diver, were classified as critically endangered. Seven wintering bird species were categorised as endangered, including five species of sea ducks. Three species were classified as vulnerable and four near threatened.

The red list includes eight species that are also included in the core indicator for breeding birds, and ten species that are included in the core indicator for wintering birds (Table 5.5.1 and 5.5.2). In some instances, the core indicator evaluations may show a good status for a red-listed species: Black guillemot, tufted duck, lesser black-backed gull and ringed plover have a good status according to the core indicator for waterbirds during the breeding season, but are red-listed by HELCOM (2013b). Bird species are also assessed in other contexts, such as national red lists, which may show different results. Such inconsistencies between assessments may occur due to differences in the applied assessment periods, but may also reflect different population trends in different parts of the Baltic Sea. For example, the lesser black-backed gull has decreased by around 40 % in Finland in 1991–2013 (Hario and Rintala 2016), while the core indicator shows a rather stable Baltic Sea population.

Impacts and recovery

Waterbirds are influenced by various human activities and pressures. Coastal developments, fishing, shipping, wind farms, recreation and hunting, for example, may lead to habitat loss and disturbance as well as mortality or alterations to the breeding and feeding environment (Larsson and Tydén 2005, Žydelis *et al.* 2009, Petersen *et al.* 2011, Schwemmer *et al.* 2011). Many species are also vulnerable to incidental by-catches in fishing gear (see Chapter 4.6 and Box 5.5.1).

However, species react in different ways to the pressures, resulting also in effects on species composition and food web structure. High numbers of a species do not automatically indicate good status or sustainable human activities. For example, an increase in birds feeding on pelagic fish can be a result of human induced disruption of the food web, such as overfishing of predatory fish, leading to higher abundance of the fish that these birds prefer to eat. But the birds also influence other species groups, such as fish and bivalve populations, according to their feeding.

Seabirds are protected by the EU Birds Directive, requiring the conservation of habitats in a way that allows birds to breed, moult, migrate and overwinter (EC 2009). Species listed in Annex 1 of the EU Birds Directive and important habitats for migrating species are targeted for special protection measures. The HELCOM Marine Protected Areas are largely congruent with protected areas under the Birds Directives (see Chapter 7). In order to protect migrating birds in the Baltic Sea region, HELCOM has adopted Recommendation 34/E-1 'Safeguarding important bird habitats and migration routes in the Baltic Sea from any negative effects of wind and wave energy production at sea' (HELCOM 2013g).

5.6 BIODIVERSITY SUMMARY AND FOOD WEB ASPECTS

Overall, the biodiversity assessment indicated that many species groups and habitats in the Baltic Sea have inadequate status. Only a few core indicators achieved the threshold values in at least part of the Baltic Sea, and none of them achieved the threshold values in all assessed areas.

Summary for benthic and pelagic habitats

The integrated assessment of benthic habitats indicated good status in five of twelve assessed open sea areas. The assessment however only represents soft-bottom habitats, focusing on impacts of eutrophication. The status of hard bottom areas in the open sea was not assessed due to lack of indicators. Based on the available indicators and data, coastal areas showed good integrated status of benthic habitats in about half of the Baltic Sea region, in terms of area covered (Chapter 5.1).

The integrated status of pelagic habitats was evaluated by core indicators representing phytoplankton biomass and the frequency of cyanobacterial blooms, and in five open sea sub-basins also zooplankton. The assessment indicated good status only in the Kattegat. Coastal areas achieved good status in about one quarter of the Baltic Sea region, in terms of area covered (Chapter 5.2).

In addition to the core indicators, information on status can be obtained from the most recent HELCOM red list assessment (HELCOM 2013b). Altogether 51 macroscopic species of benthic fauna were red-listed (however, not all species occurring in the marine region were evaluated). The list also included eleven species of macroscopic plants and algae, out of 317 assessed.

A HELCOM threat assessment for biotopes and biotopes complexes evaluated seventeen biotope complexes as threatened and aphotic muddy bottoms were categorised as critically endangered. The evaluation represents a minimum estimate as the assessment was limited by available data. Eight out of ten assessed biotope complexes (comparable to 'habitats' as defined in Annex 1 of the EU Habitats Directive), were categorised as threatened in the Baltic Sea (Chapter 5.1).

Summary for mobile species

The assessment of fish from a biodiversity perspective indicated good status for about half of the assessed coastal areas. The integrated status of pelagic fish in the open sea was assessed as good, but close to failing the threshold values in the Kattegat and the western Baltic Sea. Demersal fish were only assessed in the Kattegat and western Baltic Sea, showing not good integrated status. Additional assessment results for open sea fish are foreseen to be included in the updated assessment in June 2018. For example, an assessment of open sea demersal fish in the eastern Baltic Sea is currently lacking.

The core indicators for the migrating fish species salmon and sea trout show inadequate status in most areas where they were assessed. Fourteen species (out of around 230) of fish and lampreys were evaluated as threatened in the HELCOM red list. The list of critically endangered fish species included European eel and grayling, as well as the sharks porbeagle and spurdog in the Kattegat (Chapter 5.3).

Among the marine mammals, grey seal and ringed seal had inadequate status, and harbour seal had good status only in the Kattegat. Harbour porpoise is not as yet assessed by a core indicator, but both sub-populations occurring in the Baltic Sea are categorised as threatened in the HELCOM red list (HELCOM 2013b; Chapter 5.4).

Many bird species also showed a decline. The two core indicators for abundance of waterbirds during the breeding and the wintering season did not achieve good status. Benthic feeding birds exhibited not good status during both of these seasons. Grazing feeders achieved good status only in the breeding season, and surface feeders only in the wintering season. Pelagic feeders as a group achieved good status in both seasons. Twenty-three out of fifty-eight bird species breeding in the Baltic Sea where listed on the HELCOM red-list, and sixteen out of forty-seven bird species wintering in the Baltic Sea (Chapter 5.5).

Changes in the species and size structure

Most HELCOM core indicators focus on evaluating changes in the abundance of species or species groups. When combined, this information is also important for evaluating potential effects on the food web, since species are dependent on each other and connected in their feeding. Predatory species are dependent on a sufficient production of prey in order to maintain their populations. From the top-down perspective, a deficiency of predators may also lead to an increased abundance of their prey and a destabilisation of food web structure and function.

In addition to the changes in species structure, changes in the size structure are important signs of biodiversity status, and may have strong impacts on both food web productivity and stability. These aspects were only assessed to a limited extent by the current set of core indicators.

Species at higher trophic levels may be suitable indicators of food web changes, as they are not only exposed to pressures directly, but also to impacts that accumulate in the food web via their prey. The recent decline in nutritional status of some fish is an important signal of impacts on larger scale, not only reflecting changes at the species level. The condition and size structure of Eastern Baltic cod has declined sharply in the past years, potentially reflecting changes in many other parts of the ecosystem. Corresponding changes were seen in the pelagic fish in the 1990s, and they are currently at a lower level than observed in past decades (Chapter 5.3).

Similar changes may also be seen in other species groups. For example the core indicator for grey seal nutritional status did not achieve the threshold (Chapter 5.4).

Several potential explanations for the declines are being considered, including overfishing, contaminants and parasite infections, and many pressures are likely contributing. The widespread and increasing distribution of areas with low oxygen concentrations at the deep sea floor, attributed to accumulated nutrients, hydrodynamics and climatic factors, is a particular key area of concern (Chapter 1), potentially affecting both pelagic and benthic productivity, and hence the basis for ecosystem productivity. Long term data show that the oxygen debt below the halocline, mainly attributed to eutrophication, has increased over the past century, for example in the Baltic Proper (Chapter 4.1).

The management of pressures from human activities should also include consideration of climate change (Chapter 1), which is foreseen to affect species both directly (as increased temperature and changes in other hydrological conditions may directly affect species population growth and the distribution), and indirectly (via species interactions and changes in food availability).

Indicators of the food web status at lower trophic level are important since they may explain the reasons behind any large scale changes, but they are also critical from a management perspective in order to be able to detect potentially important changes at an early stage. The core indicator 'Zooplankton mean size and total stock' functions as a food web indicator by monitoring changes in both the abundance and size structure of primary consumers. The indicator showed a decrease in the proportion of large-sized taxa and groups in all sub-basins where it did not achieve the threshold value (Chapter 5.2). The 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. It is currently not assessed in the other sub-basins.

At the level of primary producers, an indicator on the ratio between diatoms and dinoflagellates was tested in the Eastern Gotland Basin. Both these groups of phytoplankton are important food for higher trophic levels, but shifts in the relative abundance may affect the nutrition of zooplankton and lead to subsequent changes in other parts of the food web (Chapter 5.2).

Habitat quality

For some core indicators, the inadequate status is also linked to changes in the physical habitat. The overall availability and quality of breeding and feeding areas for species is generally unknown at the regional scale. Particularly in coastal areas, a gradual deterioration due to construction, habitat disturbance or eutrophication, for example, is of concern. In addition, many Baltic rivers have lost their function as production areas for migrating fish species, due to damming of rivers, hydropower or dredging, exemplifying also the importance of interlinkages between marine areas and surrounding land.

Box 5.6.1. Reduced welfare from changes in perennial vegetation and fish stocks

Deterioration of marine biodiversity may result in welfare losses to society (see also Box 3.2). Although the effects may not be directly observable, people obtain benefits from knowing that the marine ecosystem and its species are thriving. The value for biodiversity is, for the most part, independent of the use of the marine environment, and more related to the knowledge that habitats and species exist and are in good health.

Improved biodiversity and marine health brings about increased economic benefits to citizens, which are lost if the state of the sea does not improve (cost of degradation). Some of these monetary benefits have been assessed in a stated preference choice experiment study in Sweden, Finland and Lithuania in 2011, which elicited citizens' willingness to pay for improvements with regard to aspects related to marine biodiversity (Kosenius and Ollikainen 2015). The valuation study estimated the benefits from increasing the amount of healthy perennial vegetation (such as underwater meadows) and the size of fish stocks in the Finnish-Swedish archipelago and the Lithuanian coast from current to good status. The benefits were based on people's willingness to pay for these improvements.

As the study was conducted only in three countries, the benefit estimates had to be transferred to the six other Baltic Sea countries to arrive at a regional estimate. Thus, only the estimates for Finland, Lithuania and Sweden are based on original valuation studies and data collection, and the estimates for Denmark, Estonia, Germany, Latvia, Poland and Russia are based on value transfer. The transferred value estimates were corrected for differences in price and income levels between the countries. The Finnish benefit estimate was transferred to Denmark and Germany, and the Lithuanian estimate to Estonia, Latvia, Poland and Russia. The choice of which estimates to transfer, and where to, was made based on average income levels.

Figure B5.6.1 shows the estimates per person. The results suggest that citizens' welfare would increase by 1.8–2.6 billion euros annually in the Baltic Sea region, if the state of the perennial vegetation and fish stocks improved to a good status (see also Supplementary report HELCOM 2017A). It is worth noting that there is more uncertainty about these estimates compared to the estimates for eutrophication and recreation, as some of the values are based on benefit transfer.

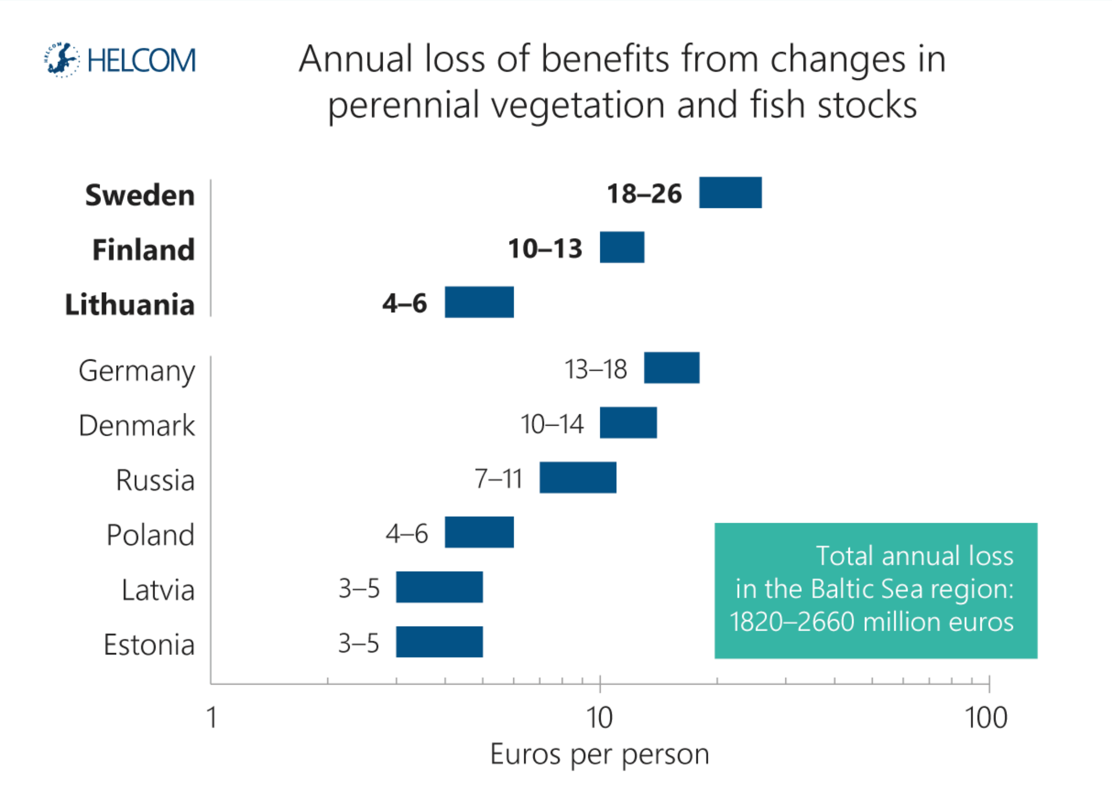


Figure B5.6.1. Benefit losses related to perennial vegetation and fish stocks. Note that estimates for Finland, Lithuania and Sweden are based on original valuation studies and data collection, and estimates for the six other countries are based on value transfer from Finland (Denmark and Germany) and Lithuania (Estonia, Latvia, Poland and Russia). The range comes from the 95 % confidence intervals for the value estimates reported in the original study. Value estimates are in purchasing power parity adjusted 2015 euros. Source: Kosenius and Ollikainen (2015).

Chapter 6. Cumulative impacts on the marine environment

Human activities in the Baltic Sea and its catchment area create a variety of potential pressures. Cumulative impacts on species and habitats are caused by multiple pressures taken together. If each of the pressures is considered individually, they may appear to be at sustainable levels. However, when summed together, their total impact may be considerable if they take place in the same area, in particular when acting on sensitive habitats. The Baltic Sea Impact Index estimates the cumulative burden on the environment based on spatial information at a regional scale, showing higher impacts in coastal areas, which host more diverse benthic habitats, and in the southwest Baltic Sea, where human population density is higher and the narrow straits and shallow bays make the natural environment easily accessible to humans.

Pressures from human activities can be broadly categorised into inputs of substances (for example nutrients, litter or contaminants), inputs of energy (underwater sound), biological pressures (introduction of new species, disturbance of species and extraction of species, for example), and physical pressures (disturbance to the seabed, loss of seabed or changes to hydrological conditions). The pressures affect both the biotic and abiotic parts of the marine environment, but in the end they cause impacts to species in different parts of the food web.

The spatial distribution of pressures and impacts in the Baltic Sea was evaluated using two methods: the Baltic Sea Pressure Index (BSPI) and the Baltic Sea Impact Index (BSII). The Baltic Sea Pressure Index evaluates the distribution of pressures and assesses where their current cumulative distribution is highest.

6.1 METHOD OVERVIEW

The basis for the assessment was spatial information on the distribution of 54 human activities and pressures in the Baltic Sea during 2011–2015. The data represents a wide range of human activities and potential pressures of relevance to the Baltic Sea (Figure 3.3, Chapter 3), and were compiled into 19 pressure layers for the assessment (Figure 6.1, Supplementary report: HELCOM 2017F). It should be noted, however, that these pressures layers depict the distribution of potential pressures in the Baltic Sea, and that the actual intensity of the pressures in relation to impacts they may cause on the environment is not included.

The Baltic Sea Impact Index estimates the cumulative impacts in the Baltic Sea, by additionally using information on which species and habitats are likely to be present in an area.

In all, 42 data layers representing the distribution of species and habitats within the years 2011–2015 were, as far as available, included (Supplementary report: HELCOM 2017F). These data layers show ecosystem components in their current distribution, and do not include information on where species would occur if there were no pressures due to human activities. For example, the distribution of cod spawning areas is shown based on information on currently functional spawning areas, which have a clearly more limited distribution compared to the past (Köster *et al*. 2017). Hence, the assessment focusses on identifying current potential impacts, given the existing status of species and habitats in the Baltic Seam as assessed for selected pressures in Chapter 5.

Cumulative impacts were estimated by combining the information on species and habitats with the information on the distribution of pressures, using estimates of the sensitivity of species and habitats to the different pressures.

The sensitivity was estimated at a three-level scale by sensitivity scores. The scores were obtained from a survey answered by over eighty selected experts in the Baltic Sea region, representing marine research and management authorities in seven Baltic Sea countries. The results were evaluated for compatibility with a literature review study on physical loss and disturbance of benthic habitats, and assessed in relation to a self-evaluation of the experts on their confidence in their replies (Supplementary report: HELCOM 2017F). Hence, the BSII evaluates areas where human induced pressures potentially have relatively high or low cumulative impacts on the marine environment. In reality these impacts are often synergistic, so that the total effects of the pressures may be larger than their sum, and there may be ecosystem feedbacks (Box 6.1). The current version of the BSII does not take these more complex linkages into account.

The results of the BSPI and BSII are an estimation of potential pressures and impacts, created with best available data, but gaps may occur in the underlying datasets. Thus, areas with low impact may imply data gaps and different areas cannot be directly compared at this time. The underlying datasets and metadata can be viewed and downloaded from the HELCOM map and data service.

Confidence aspects

The assessments of cumulative pressures and impacts are both directly dependent on the quality of the underlying data layers. The aim has been to collect and collate spatial information that is regional, so that the results will be comparable across areas.

In some cases, it has not been possible to achieve data sets with full spatial coverage, but layers have still been included in order to reflect the currently best available knowledge at regional scale. This concerns in particular data layers on impulsive noise, contamination, dredging and habitat-forming species.

Further, the level of spatial detail of individual data layers vary. While some maps provide information on a relatively detailed spatial scale, other layers are at present not detailed enough to be relevant at a more local scale, for example those showing species distributions.

There is also some remaining uncertainty regarding the applied impact scores, as the number of replies for some combinations of pressures and ecosystem components was low in the expert survey (Supplementary report: HELCOM 2017F).

Thus, the focus of the assessment is to give a broad regional overview, whereas the level of accuracy in detailed results need to be evaluated on a case by case basis. The input data may be further improved before the updated version of this report (due in June 2018), in cases where new information becomes available.

6.2 CUMULATIVE PRESSURES IN THE BALTIC SEA MARINE AREA

Although human activities take place almost everywhere in the Baltic Sea, they are mainly concentrated near the coast and close to urban areas. The distribution of potential cumulative pressures from human activities across the Baltic Sea becomes evident in the Baltic Sea Pressure Index (Figure 6.1). The most widely distributed pressures at regional scale were nutrient inputs, extraction of fish, underwater sound, contamination, and non-indigenous species.

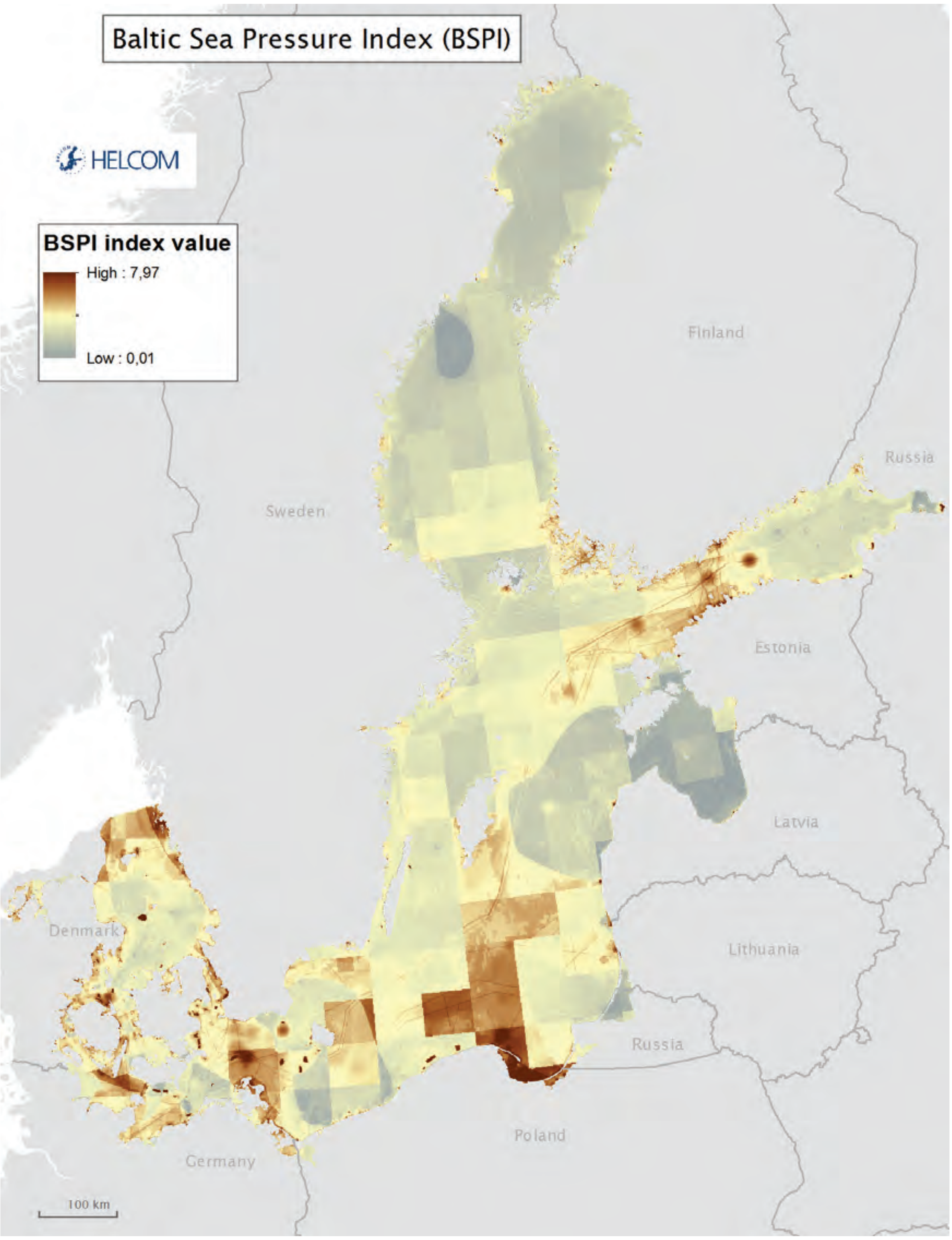


Figure 6.1. Baltic Sea Pressure Index showing distribution of potential cumulative pressures at sea. The method for assessment is described in the supplementary report (HELCOM 2017F). The Baltic Sea Pressure Index is an estimation of potential pressures based on currently best available regional data, but spatial and temporal gaps may occur in the underlying datasets.

6.3 CUMULATIVE IMPACTS IN THE BALTIC SEA MARINE AREA

The assessment of potential cumulative impacts indicates that there are great differences in the level of cumulative impacts between different areas of the Baltic Sea. The southwest areas and many coastal areas experience higher potential cumulative impacts than the northern areas and many open sea areas (Figure 6.2). However in areas with poor data coverage the potential cumulative impacts may be underestimated.

The pressures potentially responsible for causing most impacts in the Baltic Sea region were inputs of nutrients, contamination, continuous sound and non-indigenous species as well as extraction of fish (Figure 6.3). These are also the pressures which are most widely distributed in the Baltic Sea, and all the species and habitats have sensitivity to these pressures. Other pressures that were associated with high sensitivity scores, had lesser influence to the overall regional scale as they were not as widely distributed (see supplementary material (HELCOM 2017F) for the sensitivity estimates)

By considering the spatial distribution of species and habitats with respect to how they overlap spatially with different pressures, the Baltic Sea impact index identifies the species and habitats that are potentially most impacted overall. The most widely impacted ecosystem components (species or habitats) in the Baltic Sea were the water-column habitats which cover the entire sea area (deep water and surface water), the widely distributed benthic circalittoral habitats, and the marine mammals (Figure 6.3).

Shallow vegetated habitats were typically estimated as sensitive to several pressures and therefore the cumulative impacts were especially high in the coastal sea areas. In addition, more ecosystem component layers were represented in coastal areas compared to the open sea (for example macrophytes and blue mussel), which generated higher impact index values (Figure 6.2). Due to the large scale of impact values obtained (large difference between maximum and minimum values) in the Baltic Sea Impact index, areas subject to low and medium impact may be hard to differentiate in Figure 6.2 creating an impression of widely undisturbed areas, especially in the open basins of the Baltic Sea.

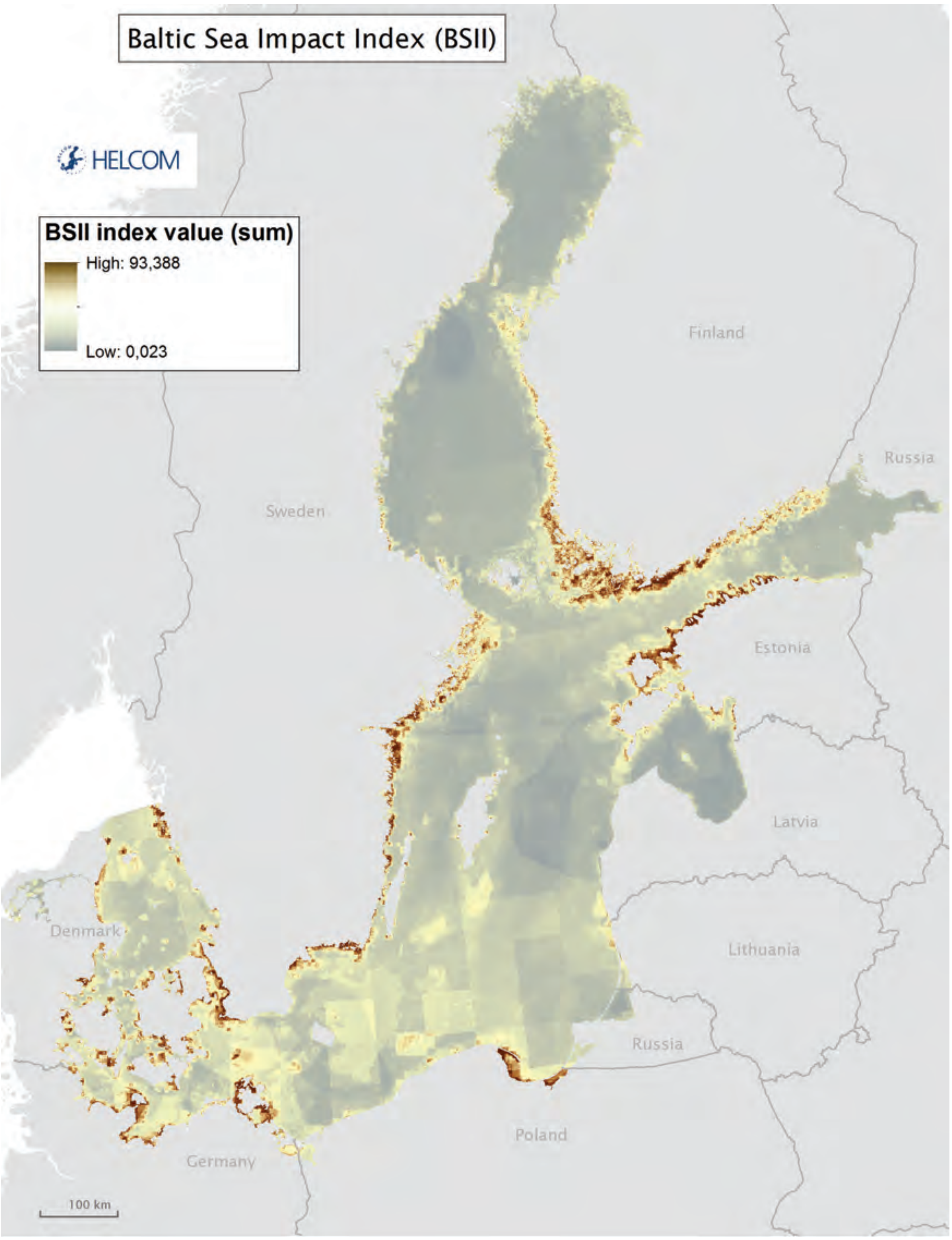


Figure 6.2. Map of the cumulative impacts of anthropogenic pressures based on the Baltic Sea Impact index. The cumulative impacts are calculated based on the method of the Baltic Sea Impact Index as the 'sum of impact'. The method for assessment is given in the supplementary material (HELCOM 2017F). The Baltic Sea Impact Index is an estimation of cumulative impacts based on currently best available regional data, but spatial and temporal gaps may occur in underlying datasets.

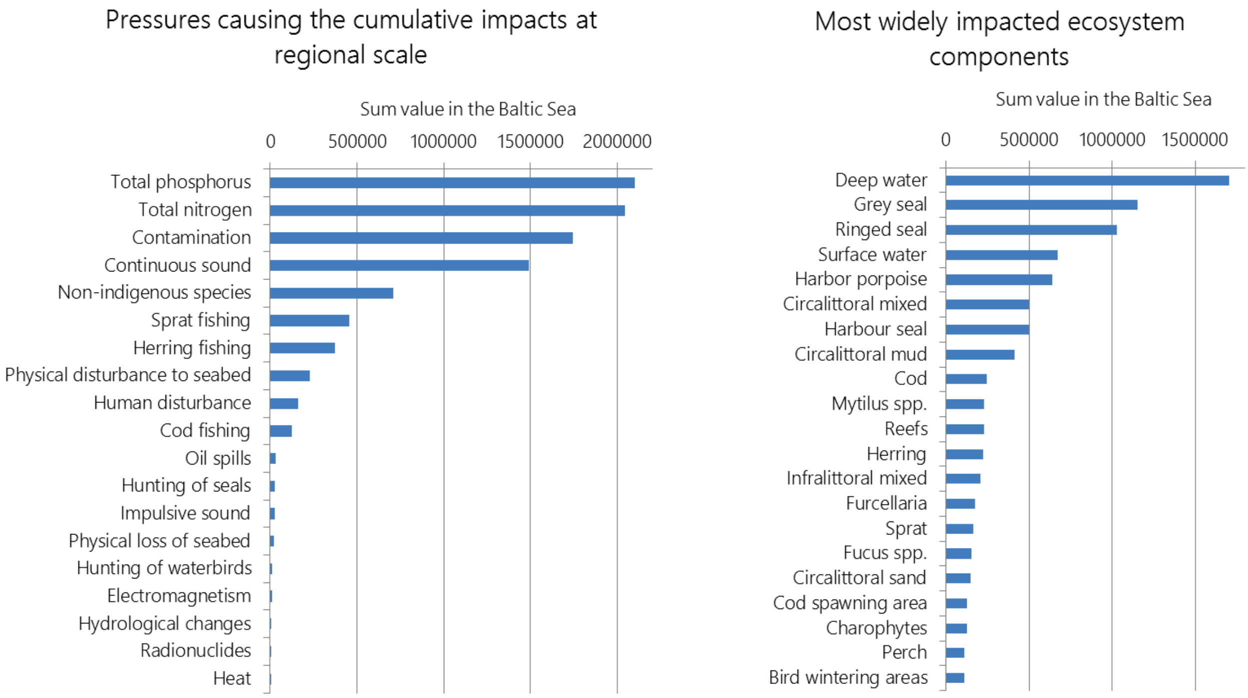


Figure 6.3. Ranking of pressures causing the cumulative impacts at regional scale (left panel) and listof most widely impacted ecosystem components (species or habitats; right panel). Note that the least impacted ecosystem components are not shown. The 'sum value' for pressures is calculated as the sum of impacts from each pressure on all studied ecosystem components at Baltic Sea scale. For ecosystem components it is calculated as the sum of impacts from all pressures on the each ecosystem component.

6.4 CUMULATIVE IMPACTS ON BENTHIC HABITATS

A separate analysis was carried out for potential cumulative impacts on only the benthic habitats, as these are particularly affected by physical pressures. In this case the evaluation was based on pressure layers representing physical loss and physical disturbance to the seabed, combined with information on the distribution of eight broad benthic habitat types and five habitat-forming species (Supplementary report: HELCOM 2017F)

The evaluation suggests that benthic habitats are potentially impacted by loss and disturbance in all sub-basins of the Baltic Sea, but the highest estimates were found for coastal areas and in the southern Baltic Sea (Figure 6.4). The most impacted sub-basins were identified as the Kiel Bay, the Sound and the Bay of Mecklenburg (Figure 6.5). As the shallow waters usually host more diverse habitats, the impacts also accumulate more in coastal areas.

The human activities behind the cumulative impacts on benthic habitats, according to this assessment, are bottom trawling, shipping and sediment dispersal caused by various construction and dredging activities and disposal of the dredged sediment.

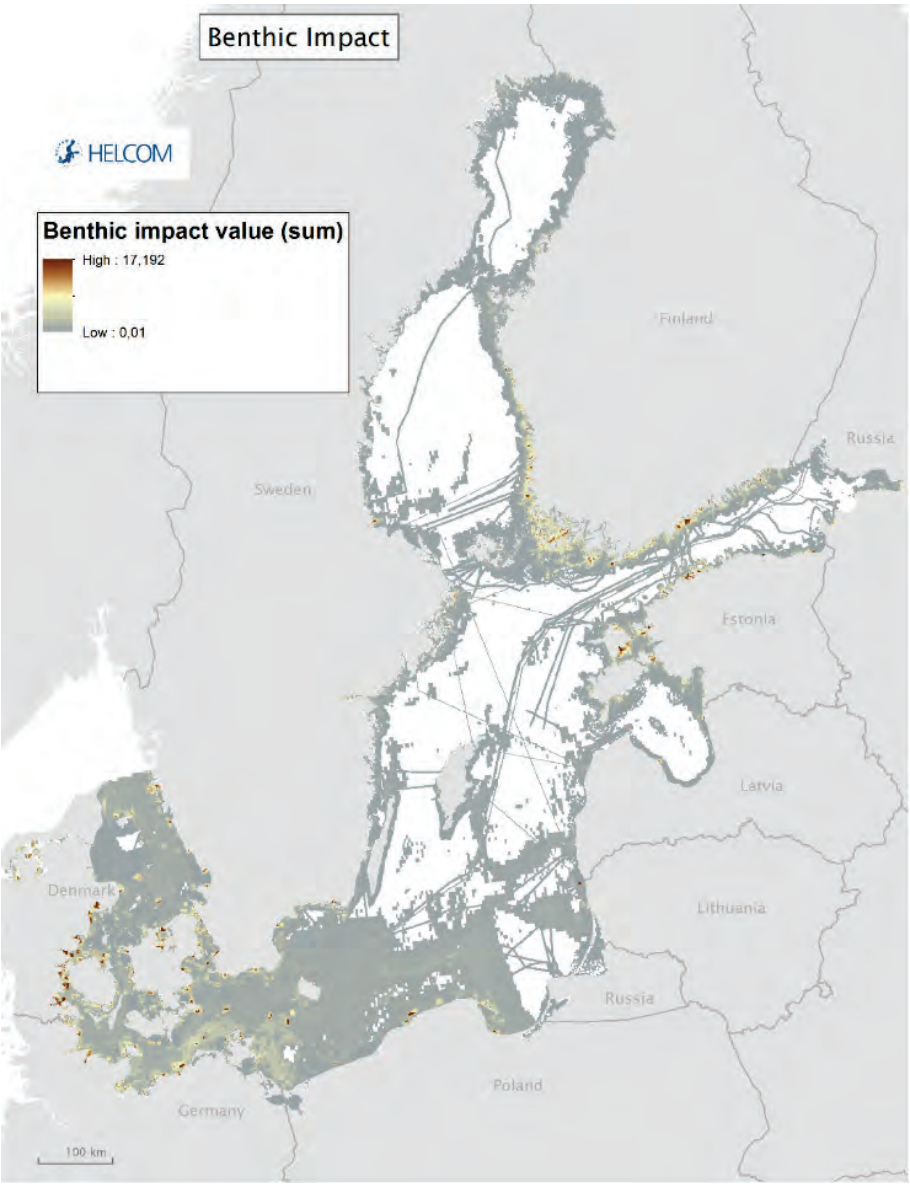


Figure 6.4. Map of potential cumulative impacts on benthic habitats in the Baltic Sea. The cumulative impacts are calculated based on the method of the Baltic Sea Impact Index as the 'sum of impact', specifically for the two pressures 'physical loss' and 'physical disturbance. Benthic habitats were represented by eight broad scale habitat types (see Chapter 4.7) and five habitat forming species (*Furcellaria lumbricalis*, *Zostera marina*, *Mytilus edulis*, *Fucus* spp. and Charophytes). The method for the assessment is given in the supplementary material (HELCOM 2017F). The cumulative impact has been estimated based on currently best available data, but spatial and temporal gaps may occur in underlying datasets. Areas in white in the map are not covered by any of the pressures associated with impact on the seabed.

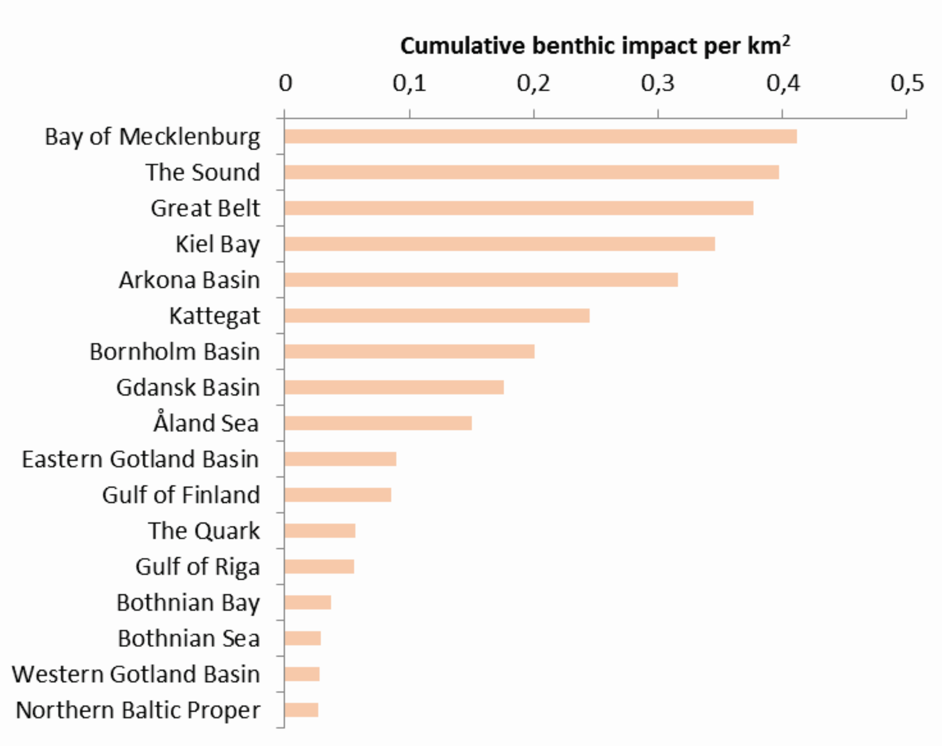


Figure 6.5. Cumulative impacts on benthic habitats in the Baltic Sea sub-basins. The values are calculated as the 'sum of impact' from physical loss and physical disturbance on the studied benthic habitat types and habitat forming species, divided by the area of the sub-basin. The estimates are based on currently best available regional data, but spatial and temporal gaps may occur in underlying datasets.

Box 6.1: How are species affected by human impacts

One human activity can cause many different pressures, and each of these pressures can affect organisms in various ways. The effects can also be hierarchically dependent. For example, the input of chemical substances can lead to reduced available energy of a species due to the energy exerted in combating the chemical. This can lead to reduced energy reserves for reproduction, resulting in negative population effects. Such cascading effects can also result in changes in community composition and biodiversity.

The Baltic Sea impact index uses sensitivity scores based on a regional scale expert survey in order to cover a broad range of topics in a similar way and makes use of existing expertise on the different ways in which pressures may impact the environment. The results can be further validated by a review of selected linkages, available in the literature.

Examples on how such pathways can be outlined systematically using a literature analysis tool are given below. The examples are shown for selected pressures affecting seagrasses and blue mussels, which are keystone species providing habitat for a huge number of other species which interact and are also dependent on one another.

Sea grasses

Major threats to seagrass result from nutrient inputs and habitat loss, the majority of which are from land such as from the oversupply of fertilisers or improperly treated waste water. The increased nutrient levels favour phytoplankton and epiphytes growing on seagrasses, leading to overgrowth and shading and finally to a reduced biomass of seagrass. This effect can be exacerbated by increased current velocities, caused for example by construction activities: snails, normally grazing on seagrass for epiphytes and thus, mitigating the overgrowth effect, are washed away and disappear. Dredging activities bury seagrass and consequently have a direct impact. Additionally, re-suspension of sediments reduces light availability, leading to decreased photosynthesis and decreased growth. Some antifouling additives from ship coating reduces the photosynthetic efficiency of seagrass. Herbicides from agriculture may also affect seagrass and cause similar effects. Increased water temperatures caused by climate change not only affect growth and survival of seagrass but may also favour the spreading of pathogens, such as the potentially epidemic wasting disease which has been responsible for major seagrass declines in the past. Additional important pressures affecting seagrass meadows are for example oxygen depletion and increased sulphide concentrations, direct and indirect effects of fisheries, and acidification (Figure B.6.1.1).

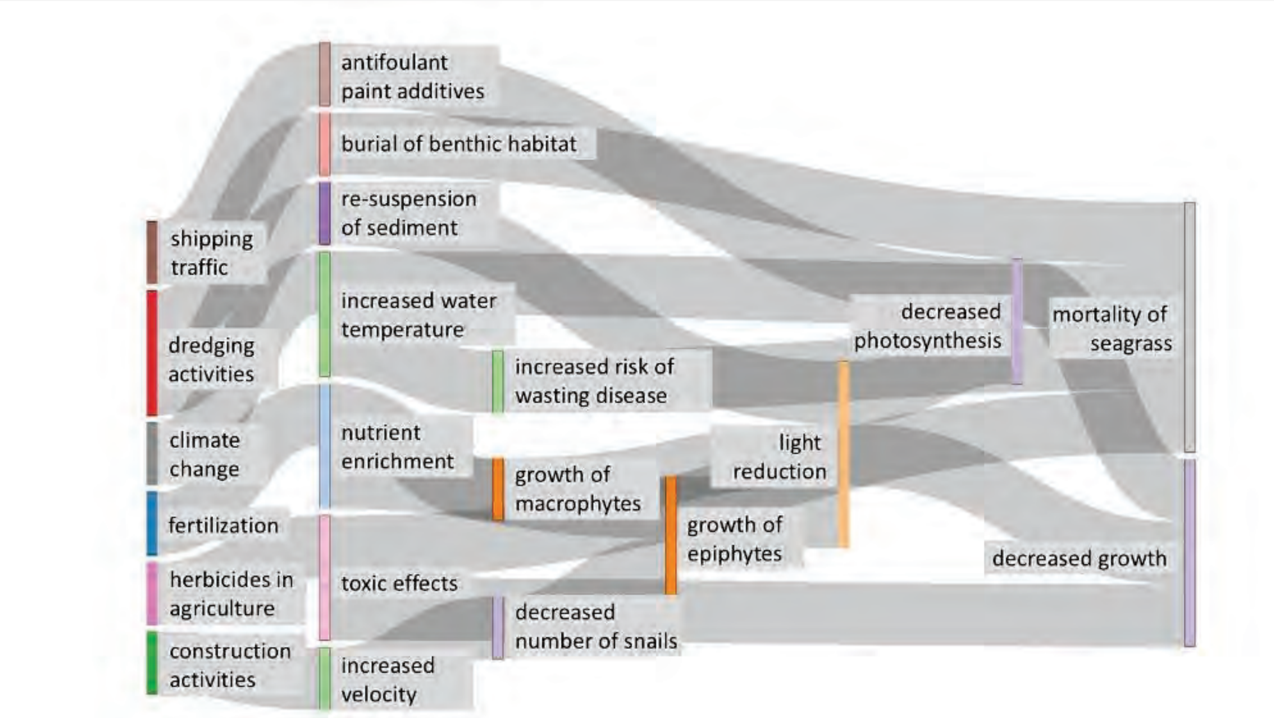


Figure B.6.1.1. Effects of selected human activities on seagrass meadows. Based on systematic literature review using the LiACAT tool (HELCOM 2016h).

Blue mussels

Blue mussels are sensitive to heavy metals and other pollution, since they are filter feeders and accumulate metals directly. Sources of contaminants are industries, land-based activities, air deposition, and activities at sea, such as harbours, shipping, industry, and oil spills. The defence mechanisms that are induced in the mussels are energetically costly for them, and alter heart rate and respiration. Additionally, physical condition is impaired, growth is reduced and mortality increases. The magnitude of these effects is dependent on environmental factors such as salinity, temperature and oxygen conditions. Changes in water temperature can be caused by local industrial heat sources or by climate change. In combination with acidification, effects on early development stages and on shell thickness have been observed. Moreover, shell growth and mortality are negatively affected by the interactive effects of reduced salinity and increased temperature. The dredging effects caused by fisheries activities may lead to decline of blue mussel by removal of species and abrasion of the seabed. The invasive species *Crassostrea gigas* is considered to compete with blue mussels and may alter the effects of anthropogenic pressures due to different tolerance levels towards the pressures (Figure B.6.1.2).

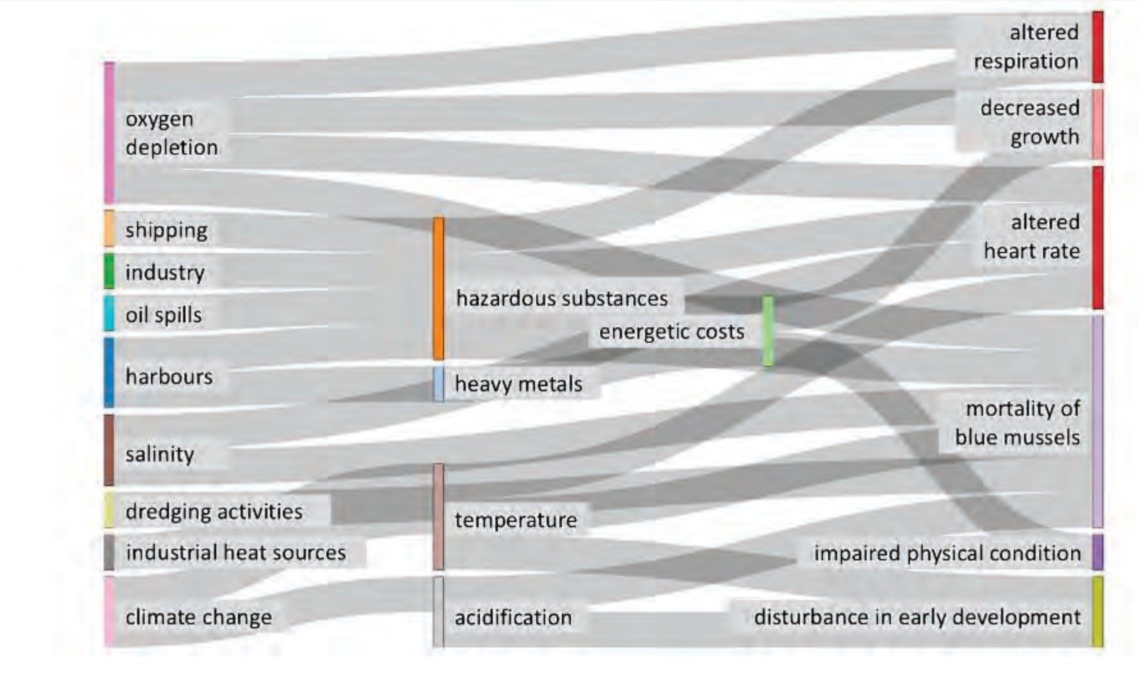


Figure B.6.1.2. Effects of selected human activities on blue mussels to show the linkage framework. Based on systematic literature review using the LiACAT tool (HELCOM 2016h).

Chapter 7. HELCOM actions to improve the Baltic Sea

Measures to improve the Baltic Sea environment are undertaken by many actors and at many levels; jointly at the regional level through HELCOM, by countries at national, county and local levels, and by initiatives in the private sector. Different types of measures are taken such as technical improvements to minimize impact, economic and legislative measures, and measures directed towards raising awareness and incentives for changes in behaviour. In the Baltic Sea, where the transboundary aspects of environmental problems are highly evident, HELCOM plays a central role in coordinating the management objectives and their implementation in line with the Helsinki Convention.

A straight-forward conclusion from the results presented in this report is that the measures currently in operation have not been sufficient to reach a good overall environmental status in all areas of the Baltic Sea. However, for some measures already in place, such as reduction of nutrient loads, it will take time, perhaps even several decades, before the full effects can be measured in the environment. In order to evaluate if current measures are sufficient to reach good environmental status more accurate estimates of foreseen effects of measures than exists today will be needed. Achievements gained via coordinated actions taken by HELCOM can however still be measured, as exemplified in this chapter.

7.1 PROGRESS IN ACHIEVING THE BALTIC SEA ACTION PLAN

The Baltic Sea Action Plan and the HELCOM Ministerial Declarations (HELCOM 2007, 2010b, 2013a) contain agreements on nearly 180 concrete actions for achieving the regionally agreed objectives. A little more than half of those actions are carried out jointly in HELCOM, for example through the development of common management guidelines and 'HELCOM Recommendations' which are joint agreements on approaches or measures to address certain activities and pressures or areas of concern. Joint actions refer also to joint regional regulatory initiatives of the Contracting Parties in other intergovernmental contexts such as within the International Maritime Organization. Today, 126 HELCOM Recommendations are implemented to support a regionally coherent marine management. Other actions are implemented at the national level, for example through national legislation or national restoration activities.

By 2016, about 60 % of the agreed joint regional actions had been carried out. Of the actions implemented at the national level, between 30 and 65 % have been accomplished by all countries (Figure 7.1). The HELCOM actions are not limited to concrete measures but include also other types of actions needed to support management towards the goals of the Baltic Sea Action Plan, including monitoring, improving the knowledge base, and coming to an agreement on how to assess the state of the Baltic Sea (Figure 7.2). The joint indicators and assessment tools which form the base of this report are one example of the actions that have been worked on by HELCOM technical working groups and expert networks for a number of years.

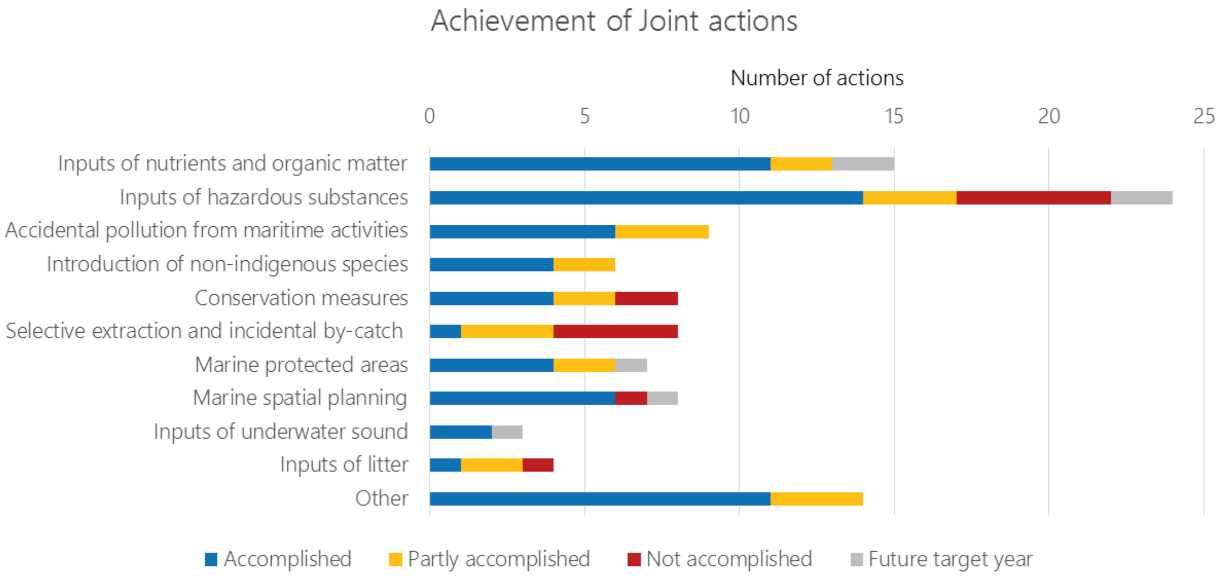


Figure 7.1. Status of implementation of joint actions taken in HELCOM, June 2016. Accomplished: the action has been implemented. Partly accomplished: there is an ongoing activity to implement the action. Not accomplished: no ongoing activity to implement the action.

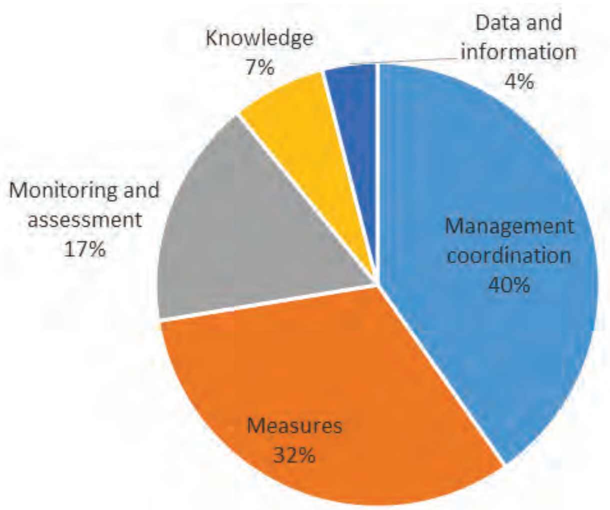


Figure 7.2. Different types of HELCOM actions. The actions agreed in HELCOM are of various character. 'Measures' refers to actions that directly aim to reduce pressures or improve the state of the environment, through restoration activities, for example. 'Management coordination' include development of joint principles for management of the marine environment, such as common management plans, guidelines, assessment tools, and classification systems. 'Monitoring and assessment' includes the development and implementation of monitoring programmes and the production of assessment reports. 'Knowledge' on particular topics is enhanced through targeted reviews and evaluations and the promotion of information sharing, for example. Access to 'Data and information' is continuously improved to ensure support for decision making and conducting assessment.

Both the follow-up of the implementation of the Baltic Sea Action Plan and this report serve the Contracting Parties to consider further necessary steps to reach a good environmental status for the Baltic Sea as required both by HELCOM and, for those Contracting Parties being EU Member States, by the Marine Strategy Framework Directive. As examples of ongoing HELCOM work, activities have already started to build on the knowledge base to develop targets for pressures effecting the seafloor and underwater sound. It has also been agreed by the HELCOM Contracting Parties to speed up the implementation of the marine litter regional action plan, continue its battle against eutrophication, especially to cut inputs of phosphorus, and start to expand a regional action plan on underwater sound. Protection and conservation of biodiversity continues to be a focal area for HELCOM work.

7.2 EXAMPLES OF ACHIEVEMENTS RELATED TO THE BALTIC SEA ACTION PLAN

Eutrophication: Nutrient reduction targets

A key commitment in the Baltic Sea Action Plan is the agreement of reduction targets for input of nutrients in order to combat the eutrophication of the Baltic Sea. This is the first regional agreement setting concrete Maximum Allowable Inputs to the Baltic Sea based on the best available scientific knowledge and communicating the necessary reductions to the individual coastal countries. The countries have flexibility regarding which measures they choose to utilise to meet their target as long as they also comply with the existing individual requirements and standards. In addition, certain reduction potential has been indicated for transboundary waterborne inputs of phosphorus and nitrogen originating from the downstream countries in the catchment areas as well as airborne nitrogen inputs from non-Contracting Parties and shipping, in line with the polluters-pay principle.

HELCOM regularly assesses the progress in reaching the nutrient reduction targets. The achievements differ between countries. For total nitrogen and phosphorus, inputs were reduced to the level below the targets for the sub-basins Bothnian Sea, Danish Straits and Kattegat while for instance the phosphorus input to the Baltic Proper and Gulf of Finland are still more than 50 % short of their reduction targets (see also Figure 5.1.1.1).

Hazardous substances: Reduction of pollution hot spots

HELCOM's pollution hot spot programme was established in 1992, and resulted in the elimination of 41 industrial hot spots by 2013. The hot spots included sites affected by chemical, cookery, fertilizer, combustion, food-processing, fish-farming, metal-processing, mining, pulp and paper, oil refinery, and metal smelter industries. While at least three pulp and paper mills and two food processing plants were closed down, the other sites had to comply with the requirements of relevant HELCOM Recommendations to be deleted from the list of hot spots. The status of compliance is evaluated by experts from HELCOM countries. Additionally, many industries are connected to municipal sewerage systems listed as municipal hot spots, out of which 53 were removed from the list by 2013.

The remaining 20 industrial hot spots and 23 municipal or combined municipal and industrial sites have been incorporated to the 2013 Ministerial Declaration, with a target year for deletion of 2016. Of these, one pulp and paper industry site and seven municipal or combined municipal and industrial sites have been removed from the list as of June 2017. Nineteen industrial hot-spots still exist in the Baltic Sea catchment area, including five pulp and paper industry plants, two hazardous waste landfills, a mining waste site, one chemical and one pharmaceutical industry, one power plant, one oil bunkering station, one oil refinery, and six other industries (metal and steel industries, for example).

Maritime activities: Nitrogen Oxide Emission Control

In line with the 2010 HELCOM Ministerial Declaration, HELCOM countries have taken the initiative and prepared the necessary submissions within HELCOM to cut nitrogen oxide emissions from ships. The reduction will be achieved by the designation of the Baltic Sea as a Nitrogen oxide emission control area (NECA) under the International convention for the prevention of pollution from ships (MARPOL). In 2017, a Nitrogen oxide emission control area (NECA) for ships operating in the Baltic Sea and a similar control area in the North Sea have been adopted under Annex VI of MARPOL. Both NECAs are expected to result in reduction of 22 000 tonnes of annual total nitrogen deposition to the Baltic Sea region compared to a scenario without NOx Emission Control Areas (EMEP 2016). Out of the foreseen reduction, 7 000 tons is estimated to be cut from direct deposition to the Baltic Sea surface, and the remaining 15 000 tons to be cut from deposition to the Baltic Sea catchment area. The NECA regulations are directed to new ships and do not address existing ships. Ships built in or after 2021 will have to use new technology, resulting in circa 80 % lower nitrogen oxide emissions. Hence, a period of fleet renewal for about two decades is expected before the regulation will show the effect described, even if emissions are cut earlier with every new ship. Parallel work to promote green shipping technology and the use of alternative fuels, such as liquefied natural gas, has been undertaken by HELCOM to enable emission reductions sooner.

Maritime activities: Reduction of sewage from passenger ships

HELCOM countries have agreed in the Baltic Sea Action Plan on a joint submission to the International Maritime Organization (IMO) in order to develop regulations of ship sewage covered by Annex IV of MARPOL. The 2010 submission to the IMO prepared within HELCOM led to amending Annex IV so it would enable special areas (within these areas) not be limited to addressing sanitary concerns of sewage, but also nutrient content. The proposal also led to the designation of the Baltic Sea as a special area.

As a result of the steps taken by HELCOM countries, the Baltic Sea is the first area in the world to receive the status of a special area for sewage from passenger ships, and to have this status enforced by IMO. Based on a decision at IMO in 2016, the regulation is set to come into effect in June 2021 for existing passenger ships registered for twelve or more passengers. After this date, sewage discharges from passenger ships will only be allowed into port reception facilities, or alternatively at sea after treatment with advanced on-board sewage treatment plants which reduces the nutrient content of the sewage. For new passenger ships, the regulations come into effect on or after 1 June 2019. For direct passages between St Petersburg and the North Sea, there is an extension until 1 June 2023.

Biodiversity: Marine protected areas

Spatial protection is central to the biodiversity agreements in the Baltic Sea Action Plan and designation of marine protected areas has been a key instrument for protection of biodiversity in the Baltic Sea for more than thirty years. As the first marine region in the world in 2010, the Baltic Sea reached the target of conserving at least 10 % of coastal and marine areas set by the United Nations Convention on Biological Diversity. Today the area protected through marine protected areas has reached 12 % (Figure 7.3). The protection is however not evenly distributed between sub-basins or between coasts and open sea, and the aim remains to reach the target in all offshore sub-basins (Figure 7.3).

A specific aim for the HELCOM network of marine and coastal Baltic Sea protected areas (HELCOM MPAs) is to be 'ecologically coherent', meaning that a network of protected sites should be designed so that it delivers more benefits than individual areas. The HELCOM assessment of ecological coherence (HELCOM 2016b) showed that two of the evaluated aspects were at an acceptable level for supporting a coherent marine protected area network: the areal representation of different types of broad scale habitats and the replication of a set of indicative species and biotope complexes. However, the evaluation indicated that the connectivity, which measures how well the network supports the migration and dispersal of species is not yet optimised.

HELCOM is now working towards the development of a method to assess the management effectiveness of HELCOM marine protected areas and the network. Such an assessment will be important to corroborate environmental positive effects and the marine protected area management.

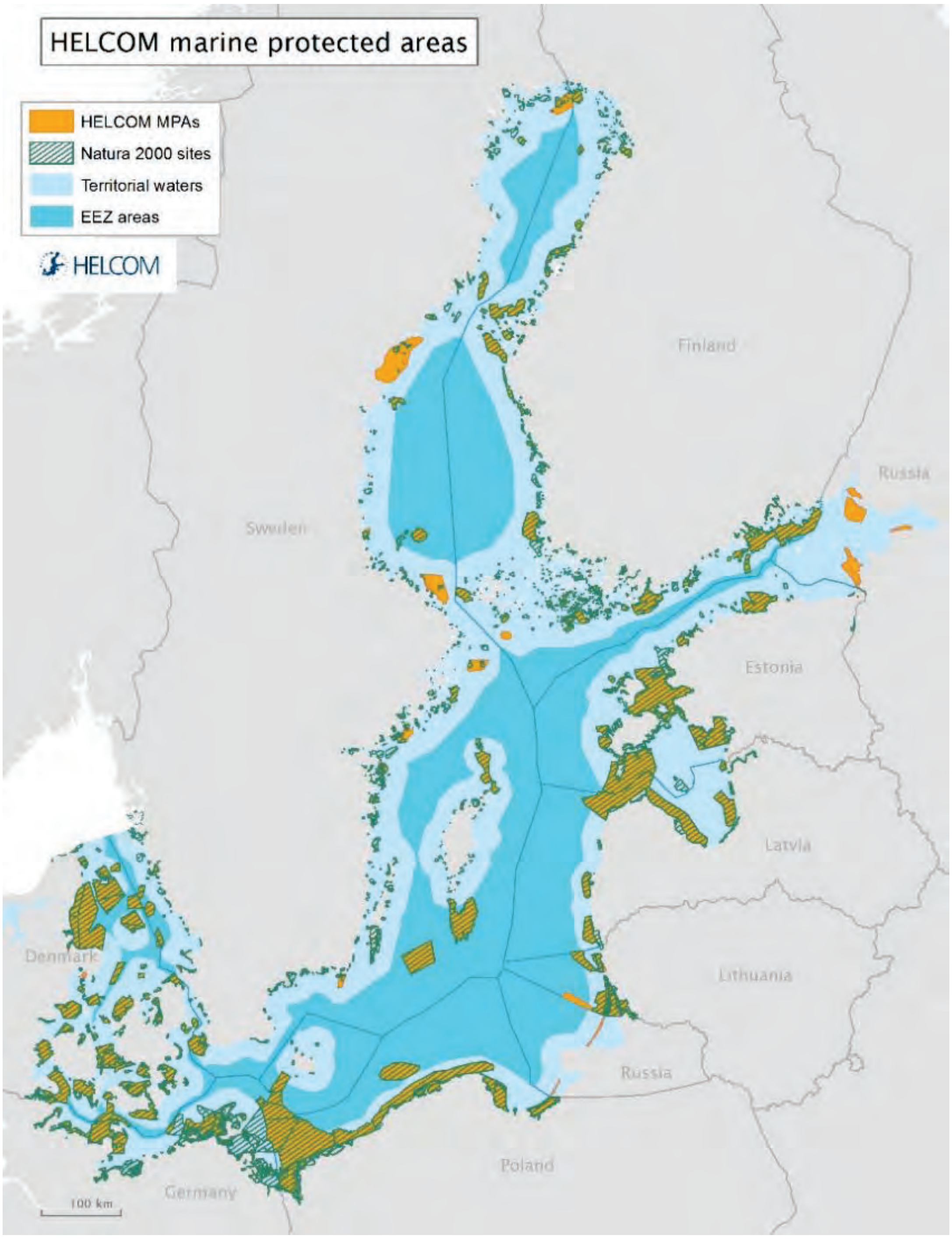


Figure 7.3. Marine protected areas in the Baltic Sea. The Baltic Sea reached the target of conserving at least 10 % of coastal and marine areas set by the UN Convention on Biological Diversity. Today the area protected by these has reached 12 %.

Chapter 8. Planned further work

The results presented in this first version of the State of the Baltic Sea report will be further elaborated and selected data will be updated or refined. The HELCOM community will analyse these first results in order to agree on the conclusions and give them further consideration in relation to ongoing regional activities.

HELCOM will from mid-2017 to mid-2018 update the assessment results of this first version of the State of the Baltic Sea report, and a consolidated and finalized version of the report will be published in June 2018. The revised version will include data for the year 2016, extending the assessment period to 2011–2016, and further additions and improvement to the data and the report, as identified by the Contracting Parties, HELCOM working groups and experts.

8.1 FORESEEN UPDATES

The update of the 'State of the Baltic Sea' report will include, for example, a reflection of changes in status since the HELCOM initial holistic assessment (HELCOM 2010) and a development of summaries and key messages for policy makers. Updates and improvements of figures and underlying data will also be made (Table 8.1). The updated version is foreseen to include, inter alia, results from the Sixth HELCOM Pollution Load Compilation (PLC-6), ICES advice on commercial fish covering the years 2011-2016, and possible inclusion of new indicators currently under development.

In the updated report, HELCOM aims to include a chapter on the conclusions and a future outlook, based on an analysis of the first results and on considerations within HELCOM.

Table 8.1 Updates for final version of the State of the Baltic Sea report. This table presents a non-exhaustive list of improvements to the State of the Baltic Sea report to be implemented by June 2018.

Location	**Comment**
Overall	Reflect as far as possible the change in status since the first holistic assessment, acknowledging that there are new methods and indicators introduced; Reflect and interpret relationships between the individual chapters, providing for a more holistic assessment; Include as feasible an analysis on why the objectives of the BSAP have not been reached yet.
Executive summary	A more narrative approach could be taken to the summary; Develop key messages for policy makers
Chapter 1	Figures 1.4-1.6 showing trends in sea ice, temperature, salinity: The layout to be modified to help distinguish trends in the figures; Add figure on long-term trends of oxygen concentration; Figure 1.8 showing spatial information on oxygen conditions; update the map and include also oxygen situation on the Gulf of Finland. Maps to show extent of O2-deficiency areas or O2-free zones instead of the distribution of O2 concentrations.
Chapter 3	Investigate the possibility to include overview of other economic sectors with the aim to assess the relative importance of the different sectors to each country and the region as a whole.
Chapter 4	Chapter 4.1 on eutrophication: Add outcome from HELCOM PLC-6, for example source apportionment. Chapter 4.3 on marine litter: Categories of litter on the seabed to be included if available by the 2018 update. Chapter 4.4 on underwater sound: Add figures from the BIAS project on soundscape maps; Add a table showing impulsive events reported to the regional registry, Improve information on the distribution of harbour porpoise in the southwestern Baltic Sea in figure 4.4.3.

	Chapter 4.5 on non-indigenous species: Some Contracting Parties have identified the need to update the AquaNIS data base, at the latest when 2016 data are added as a basis for updating the indicator evaluation. Chapter 4.6 on commercial fish: take note of a decrease in the fishing mortality of sprat as evident in the ICES advice of 2017. Chapter 4.7 on seabed loss and physical disturbance: Consider including a figure on the relative distribution of human activities connected with pressures causing physical disturbance in the Baltic Sea sub-basins (provided sufficient certainty in the underlying data.
Chapter 5	Chapter 5.3 on fish: to be updated based on ICES 2017 Advice, including information on Eastern Baltic cod. Chapter 5.4 on mammals: consider updating information on harbor porpoise in the Kattegat–Belt Sea–Western Baltic based on results from the SCANS survey; The text for the ringed seal refers mostly to the population of the Gulf of Bothnia, therefore it should be checked if the development over time could be shown for the whole Gulf of Bothnia and not just for Bothnian Bay (Fig 5.4.7); underline that the question of genetic distinction of harbour porpoises from the Western and Baltic Populations has not been clearly solved, taking into account that these populations can mix. Chapter 5.5 on birds: Include figure on trend over time in the bird indicator
Chapter 6	Checking and analysis of the sensitivity scoring Check the application of the layers on leisure boating (which currently overestimates the impacts on benthic habitats), hydrological conditions (to check if it is underestimated), seal hunting, the estimated loss and disturbance of benthic habitats from bathing sites, dredging and disposal of dredged material The colour scheme of the map of the BSPI/BSII should be revised for a better understanding it would be good if low impact is light grey, so there is a smooth transition to white with no impact / no data
New chapter	Conclusion and future outlook to be added, including future policy perspectives

The sections below present the planned data updating as well as desired improvements to the spatial data sets on human activities and pressures, which underlie the assessments of seabed loss and physical disturbance and cumulative impacts (Chapters 4.7 and 6). The update also includes an evaluation of the spatial datasets on ecosystem components used in the Baltic Sea Impact Index (Chapter 6).

Indicators – general update to include 2016 data

Underlying data for indicators will be updated to include data from 2016 when the 'State of the Baltic Sea' report is updated in 2018.

Spatial data sets on human activities and pressures

Selected human activity/pressure layers will be further developed and fine-tuned, pending resources and taking into account the work and review by relevant working groups. This includes the following datasets:

- Human activity “Dredging”, used in the aggregated pressure layer “Physical loss” and “Physical disturbance”
- Human activity “Cables” , used in “Electromagnetism”
- Human activity “Fossil fuel energy production”, used in the aggregated pressure layer “Input of heat”
- Pressure layers representing concentrations of nutrients and hazardous substances, including complementing these with additional data.
- Data layers relating to commercial fishing will be updated based on new vessel monitoring system data (VMS) to be provided by ICES following the HELCOM request in 2017 for ICES advice.

Ecosystem component spatial data

More precise spatial data on ecosystem components will be developed for selected layers, pending resources. In particular, the pelagic habitat layer ‘Productive surface waters’, and the deep water habitat layer ‘Bottom oxygen’ have been identified for update or improvement, as well as the data set on mammal distribution, to provide more detailed information on occurrence in coastal areas.

In addition, the following datasets have been identified to be improved, pending available data and resources: ‘Broadscale habitats’ and ‘Natura2000 habitats’ (Additional national datasets could be incorporated), Fish (For the abundance maps of cod, herring and sprat, as well as pikeperch and perch recruitment areas, improved data could be used if available), and ‘Habitat forming species’ (Results from new mapping could be incorporated, if available).

8.2 WHAT HAPPENS NEXT?

HELCOM is carrying out a regional consultation of the first version of the 'State of the Baltic Sea' report, encouraging international non-governmental and intergovernmental organizations to give feedback on the report. The report is also available for use by the HELCOM countries in national consultation. The comments received through the regional consultation, or material thereof, will be considered in parallel with the updating of the report which is outlined in this chapter.

HELCOM will now analyse these first results in order to agree on the conclusions and further consideration when consolidating the report in 2018, including in the next Ministerial meeting, and to reflect on those conclusions and a future outlook in the updated version.

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