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 period (2011-2016) and current knowledge, less than 1 % of the Baltic Sea seabed is potentially lost due to human activities while roughly 40 % of the seabed area is potentially disturbed. 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 damage to the seabed, and hence to benthic habitats and species. Some activities may affect the seabed directly, but activities may also cause indirect effects, for example by increasing the level of turbidity or dispersal of sediments. Whether an activity leads to a permanent loss or a temporary disturbance of the seabed 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 in some cases lead to a new artificial type of habitat, for example when a construction gives rise to hard substrates in a naturally sand-dominated habitat. Such alterations may also lead to ecological changes that are undesirable (Tyrrell and Byers 2007). Many activities at sea may contribute to both permanent loss and disturbance of the seabed (Figure 4.7.1).

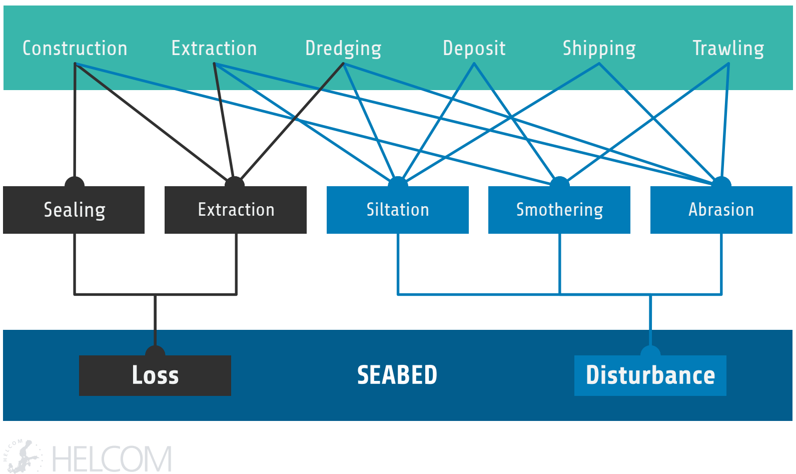

Figure 4.7.1.
Generalised overview of human activity types and the physical pressures they may exert on the seabed. The pressures are further grouped into those causing loss and disturbance of the seabed. Black lines link to potential physical loss of seabed habitats, and blue lines link to potential physical disturbance.

Estimating physical loss and 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). There is currently no regionally agreed method for assessing how loss and disturbance is causing adverse effects on the marine environment.

Human activities potentially attributed to seabed loss and disturbance

Construction and installations

Off-shore wind farms, harbours, 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 have similarities with those during seabed extraction or dredging (see below). Installation of off-shore construction may also encompass drilling, pile driving, 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 tens of metres from the wind turbine (van der Wal and Tamis 2014). The scour protection will give rise to a new man-made habitat.

Pipelines may be placed in a trench and then covered with sediment extracted elsewhere, so that the sediment composition differs from surrounding habitat (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 may occur up to a couple of metres from the cable (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 of the seabed depends on the hydrological conditions and on the properties of the mariculture, and currently limited information exists on the recovery rate when the pressure is removed (but see Kraufvelin *et al.* 2001).

Dredging

Dredging activities are usually divided into capital dredging and maintenance dredging. Capital dredging is carried out when building new constructions, increasing the depth in existing waterways, or making new waterways, while maintenance dredging is done in order to maintain existing waterways.

Dredging causes different types of pressure on the seabed; 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. Physical loss occurs during capital dredging, which usually occurs once at a specific location. It may also be connected to maintenance dredging when performed repeatedly at regular intervals. The physical loss is limited to the dredging site, whilst physical disturbance through sedimentation may have a wider spatial extent.

Disturbance through sedimentation may affect animals and vegetation even farther away from the dredging activity, on the scale of hundreds of metres (LaSalle 1990, Boyd *et al.* 2003, Orviku *et al.* 2008). In addition, remobilisation of polluted deposited sediments may contribute to contamination and eutrophication effects.

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 potentially causing loss of seabed: construction at sea and on the shoreline (including cables and pipelines, marinas and harbours, land claim, mariculture, extraction of sand and gravel, and dredging) (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, and trawling, were considered as causing physical disturbance (acting via the pressures of siltation, smothering, and abrasion). In addition, shipping was included as potentially causing physical disturbance (Figure 4.7.1).

The potential extent of loss and disturbance of the seabed was estimated by identifying the spatial distribution of human activities exerting these pressures. The extent of pressures was estimated based on information from 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 and therefore the categorisations used up to now are preliminary.

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 areas of benthic habitats. For more information, see the thematic assessment; HELCOM (2018E).

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 on 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 HELCOM (2018E).

Sand and gravel extraction

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

Sand and gravel extraction can be performed using either static dredging or trailer dredging. When static dredging is used, the exerted pressures are of similar type as during dredging, potentially leading to partial or complete physical loss of habitat (depending on the extraction technique and on how much sand or gravel is removed) and altered physical conditions (through changes in the seabed topography, increased turbidity caused by re-suspended fine sediments, smothering or siltation on nearby areas). When performing trailer dredging, the pressure exerted to the seabed is more limited compared to static dredging, although the dredged area is greater. The intensity of the pressure is also dependent on the site. In areas where sediment mobility and dynamics are naturally high, the impacts of sand and gravel extraction are typically lower than in areas with more stable sediment types.

There is high mortality of benthic organisms at the sites of sand and gravel extraction, as the species are removed together with their habitat (Boyd *et al.* 2000, 2003, Barrio Frojan *et al.* 2008). Since the extracted material is sieved at sea (to the required grain size) and the unwanted matter is discharged, the extraction may also result in changed grain size of the local sediment on the seabed. Adjacent areas are also affected by the activity albeit less severely (Vatanen *et al.* 2010).

Importantly, there are modern techniques and concepts which, if applied, can help to reduce the extent and intensity of physical disturbance of benthic organisms. 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'.

Deposit of dredged material

Deposit of dredged material may cause covering of the seabed, smothering of benthic organisms, and lead to loss of habitat if the sediment characteristics are permanently changed. In addition, increased turbidity during the activity causes increased siltation on the site and in its adjacent areas. In some cases, deposited material may contain elevated concentrations of hazardous substances or nutrients.

The impacts on the species depends mainly on the seabed habitat type, and the type and amount of deposited material. 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 unvegetated 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 disturbance is similar to that during dredging (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, ship-bow 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 in the vicinity of harbours. For larger vessels, the effect on turbidity has been observed down to depths of thirty metres (Vatanen *et al.* 2010). 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 one metre 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 of hard substrates, or may release hazardous substances that have been previously buried in the seabed (Jones 1992, Wikström *et al.* 2016).

Dredging causes different types of pressure on the seabed.

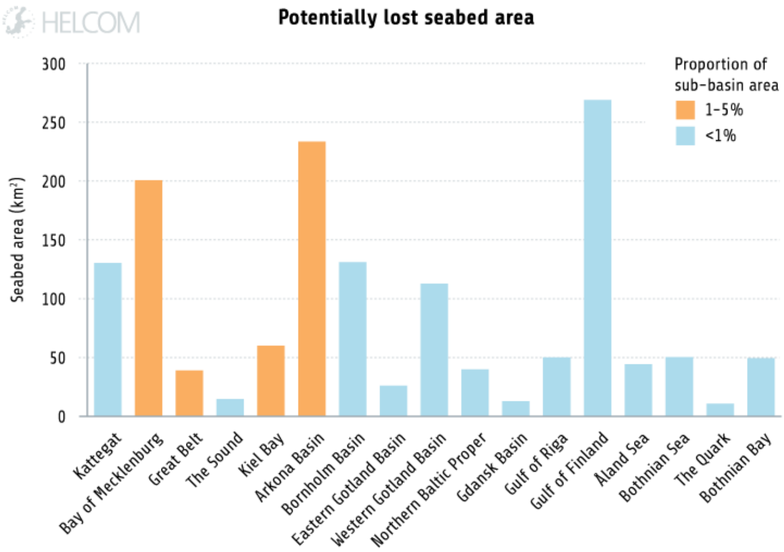

Figure 4.7.2.
Estimate of seabed area (km²) potentially lost due to human activities per Baltic Sea sub-basin. The estimation is calculated from spatial data of human activities causing physical loss, as listed in the text.

▸ 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 (up to the year 2016). 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 great Belt, the Arkona Basin and the Bay of Mecklenburg. 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 depositing of dredged material, harbours and marinas, and to a lesser extent offshore 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). ▸

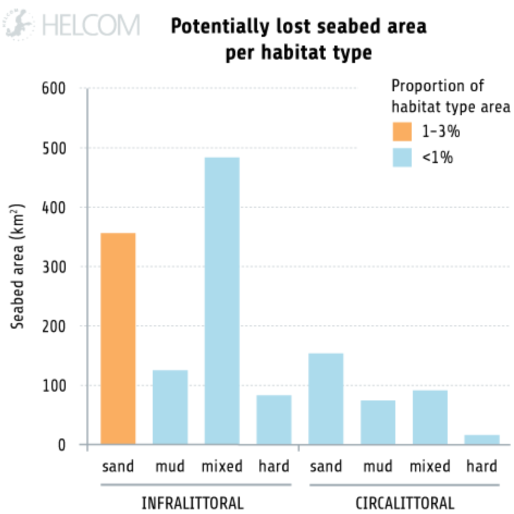

Figure 4.7.3.
Estimate of area of broad benthic habitat types potentially lost due to human activities. 'Infralittoral' is the permanently submerged part of the seabed that is closest to the surface, typically with benthic habitats dominated by algae. 'Circalittoral' is the zone below the infralittoral,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

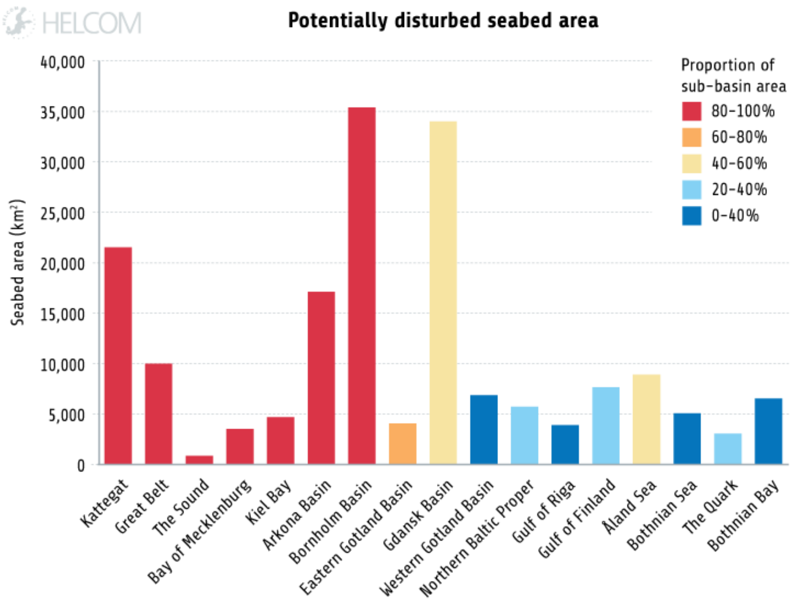

Figure 4.7.4.
Estimate of seabed area (km²) potentially disturbed in the Baltic Sea sub-basins. The color of the bars indicate the proportion of potentially disturbed seabed area per sub-basin. The area is estimated based on spatial information of the distribution of human activities connected to physical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

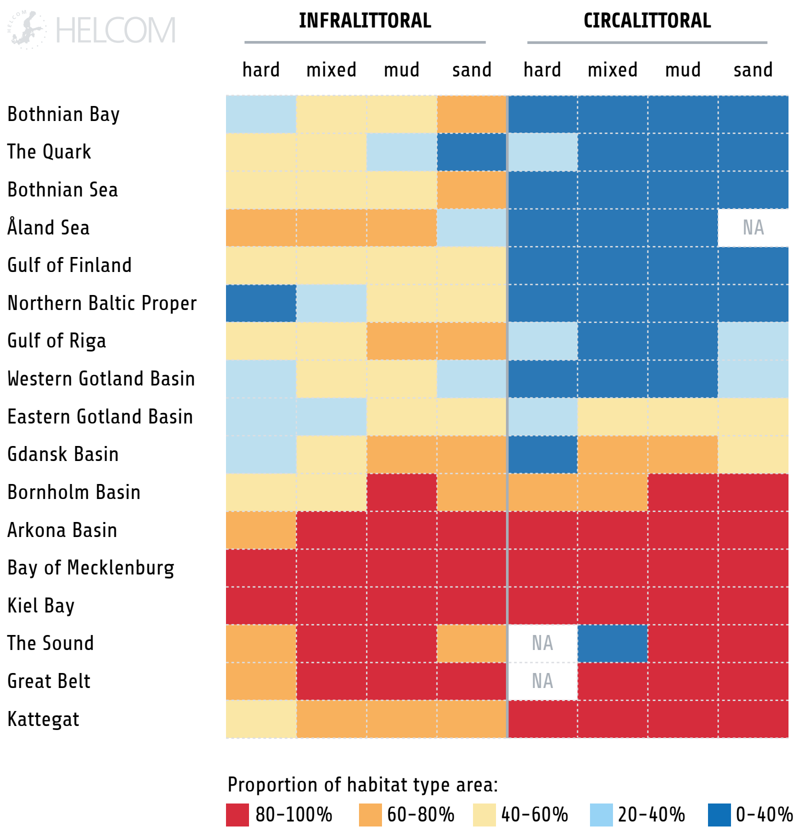

Figure 4.7.5.
Estimate of the proportion (%, given in ranges) of the different broad benthic habitat types potentially disturbed due to human activities per sub-basin. The estimate is based on the total number of human activities linked to potentially causing this pressure, and does not reflect the actual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

Estimated physical disturbance

Around 40 % of the Baltic seabed was estimated to have been potentially disturbed (180 000 km2) during 2011–2016. The spatial extent of potential physical disturbance to the seabed varied between 8 and 95 % per sub-basin (from around 900 to 35,500 km2; Figure 4.7.4). However, the estimation does not reflect whether these areas are associated with adverse effects to the benthic habitats, since 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, which is common in the southern parts of the Baltic Sea, shipping, and recreational boating. At a local scale, physical disturbance may be caused by dredging and the deposit of dredged material. The largest areas of potentially disturbed seabed were estimated in the Bornholm Basin and the Eastern Gotland Basin, which are also both comparatively large sub-basins (Figures 4.7.4 and 4.7.5). The sub-basins with the highest proportion of potentially disturbed seabed were found in the southern Baltic Sea, between the Kattegat and the Bornholm Basin.

Importantly, these estimates are based on best available data about the extent of the activities concerned. In some cases, due to limited data, areas licensed for an activity, such as dredging, deposit of dredged material and extraction of sand and gravel, were used in the calculations. This type of information does 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.

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.

Offshore wind farm in the Øresund strait, Denmark.

Pressures from human activities can be broadly categorised into inputs of substances (including for example nutrients and hazardous substances), inputs of energy (underwater sound), biological pressures (including for example extraction of fish and disturbance to species), and physical pressures (physical loss and physical disturbance to the seabed). The pressures affect both the biotic and abiotic parts of the marine environment, but in the end they have impacts on 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.
- 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.

6.1. Method overview

The assessment was based on information on the spatial distribution of human activities and pressures in the Baltic Sea during 2011–2016. The data represents a wide range of human activities and potential pressures of relevance to the region, based on the bulk list presented in Figure 3.1 (Chapter 3). In all, thirty-nine original data sets were aggregated into eighteen aggregated pressure layers representing levels at sea. The layers are described in more detail in the Thematic assessment (HELCOM 2018E). The Baltic Sea Pressure Index depicts the distribution of potential pressures in the Baltic Sea, based on these aggregated pressure layers. It should be noted, however, that the intensity of the pressures in relation to the impacts they may cause on the environment is typically not incorporated.

Additionally, thirty-six ecosystem component data layers, which represent the distribution of species and habitats, were included for assessing cumulative impacts using the Baltic Sea Impact Index (Thematic assessment: HELCOM 2018E). These data layers show ecosystem components in their current distribution, referring to the years 2011-2016. Hence, they 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). By this approach, the assessment focusses on identifying current potential impacts, given the existing status of species and habitats in the Baltic Sea, as assessed for selected pressures in Chapter 5.

The cumulative impact was 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 by sensitivity scores, which were obtained from a survey answered by over eighty selected experts 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 (Thematic assessment: HELCOM 2018E).

The Baltic Sea Impact Index evaluates in which areas human-induced pressures have potentially high or low cumulative impacts on the environment, relative to other areas. 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 positive or negative ecosystem feedbacks (Box 6.1). The current version of the BSII does not take these more complex linkages into account.

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 include spatial information on the Baltic Sea scale, so that the results will be comparable. The results give an estimation of potential pressures and impacts, created with the best available data. However, gaps and quality differences may occur in the underlying datasets. In some cases, it has not been possible to achieve data sets with full spatial coverage, but the layers have still been included in order to reflect the currently best available knowledge, rather than omitting this aspect. The completeness of data coverage for different geographical areas is shown on the side of each map.

The level of accuracy in detailed results needs to be evaluated on a case by case basis. 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.

The applied sensitivity scores are based on an expert survey, and the evidence base for linkages between human activities, pressures and impacts is to be addressed further in the future.

For more details, the underlying datasets and metadata can be viewed and downloaded from the HELCOM map and data service website. The assessment method is described in more detail in HELCOM (2018E), which also gives a collated view of the included data layers.

Container ship and white-tailed sea eagle.
© Cezary Korkosz

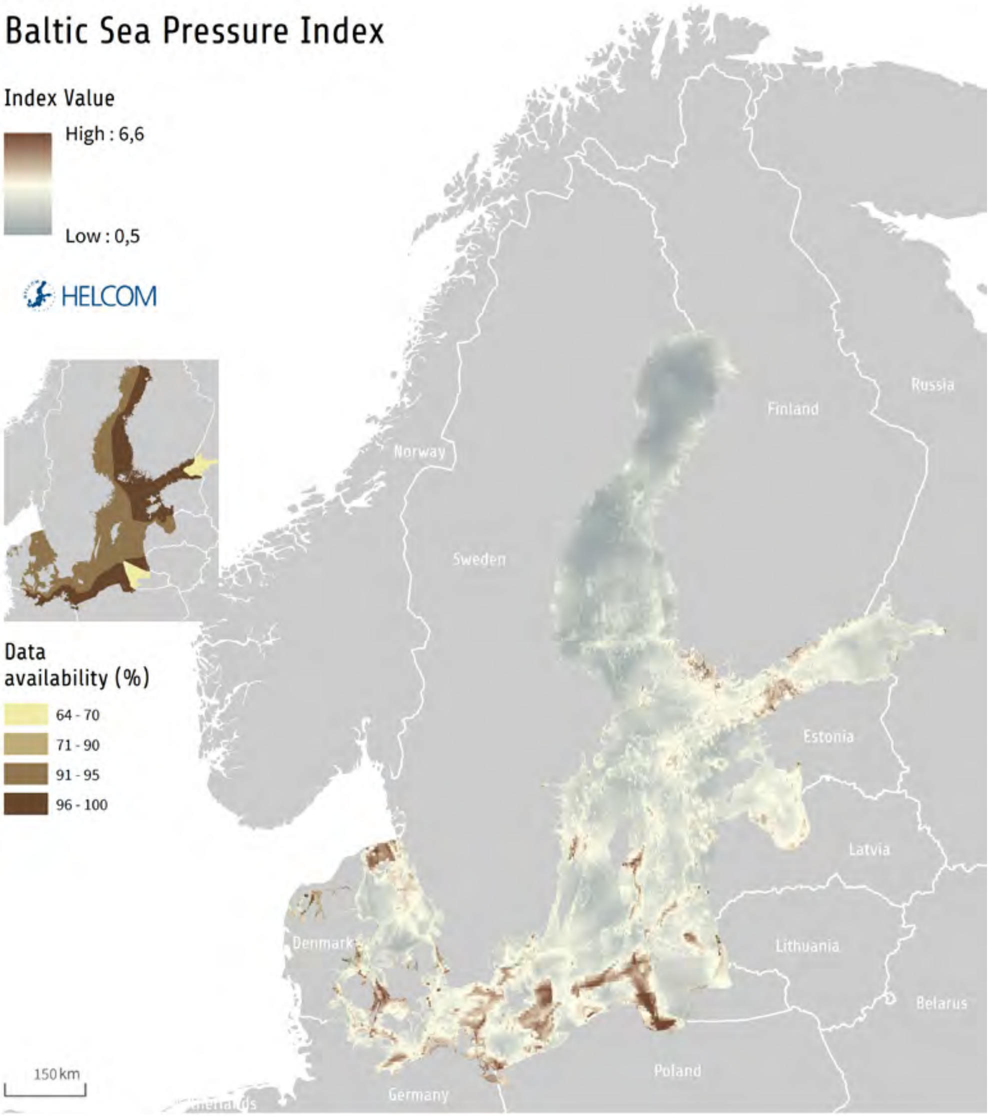

Figure 6.1.
The Baltic Sea Pressure Index shows spatial variation in potential cumulative pressure on the Baltic Sea, by combining data on several pressures together. The index is based on currently best available regional data, but spatial gaps occur in some underlying datasets, as identified in the smaller map.

6.2. Cumulative pressures on the Baltic Sea marine area

Pressures from human activities occur everywhere in the Baltic Sea, but are mainly concentrated near the coast and close to urban areas (Figure 6.1). The most widely distributed pressures at the regional scale are nutrients (including nitrogen and phosphorus), hazardous substances, non-indigenous species, and extraction of fish.

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 Baltic Sea 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

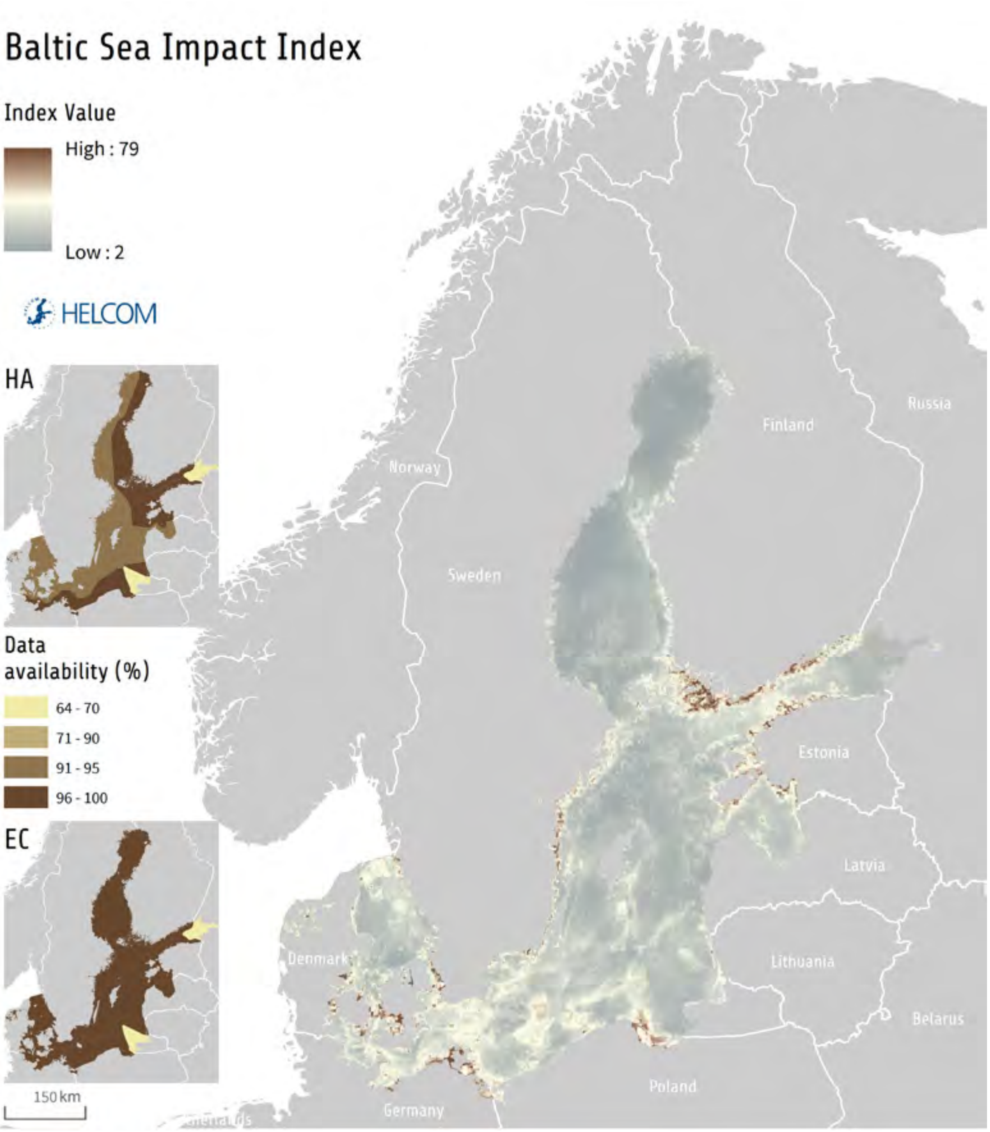

Figure 6.2.
Distribution of cumulative impact from human activities on the Baltic Sea environment, based on the Baltic Sea Impact Index. The index addresses the total added impact from pressures on species and habitats, focusing on spatial variation to identify areas subjected to potentially higher and lower impact. The analysis is based on currently best available regional data, but spatial gaps occur in some underlying datasets, as identified in the smaller map (EC=Ecosystem components layers, HA=human activities and pressures data sets).

poor data coverage the potential cumulative impacts may be underestimated.

Most of the identified impacts were attributed to nutrient concentrations and hazardous substances, followed by non-indigenous species, and the extraction of fish (Figure 6.3). Nutrient concentrations included phosphorus and nitrogen concentrations, and the theme representing the extraction of fish included cod, sprat and herring extraction (Thematic assessment; HELCOM 2018E). The results reflect that these are the pressures which are most widely distributed in the Baltic Sea, and to which many species and habitats are sensitive. Other pressures, such as oil slicks and spills, physical loss and physical disturbance, were associated with high sensitivity scores but had lower influence to the overall regional scale as they are not as widely distributed.

By considering how the spatial distribution of species and habitats overlap spatially with different pressures, the Baltic Sea Impact Index identifies the parts of the biological ecosystem that are potentially most impacted overall. The most widely impacted ecosystem components in the Baltic Sea were the deep water habitats and productive surface waters, the marine mammals (grey seal, harbour porpoise, ringed seal, and harbour seal), as well as cod (Figure 6.4). Relatively high impacts are seen in many coastal areas, which reflects that shallow habitats typical for these areas were assessed as sensitive to several pressures, and that more ecosystem components are represented in coastal areas than in the open sea.

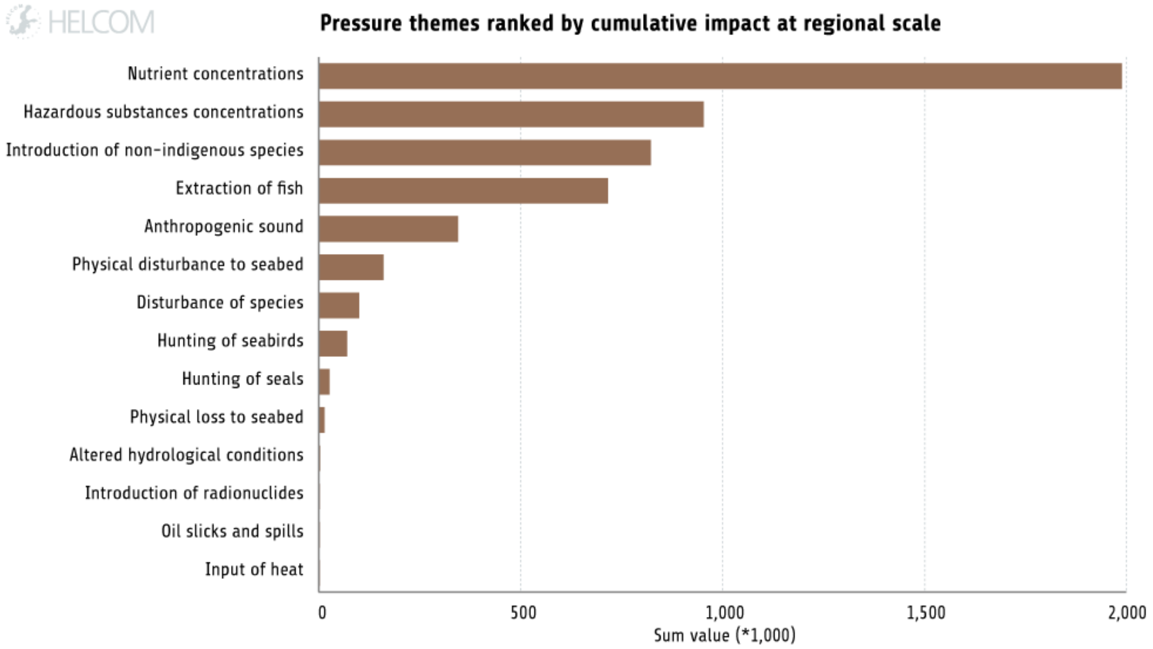

Figure 6.3.
Ranking of pressures themes attributed to cumulative impacts at regional scale in the Baltic Sea Impact Index. The 'Sum value' is calculated as the sum of impacts from each pressure on all studied ecosystem components at Baltic Sea scale. For further explanation to the pressures, see HELCOM (2018E).

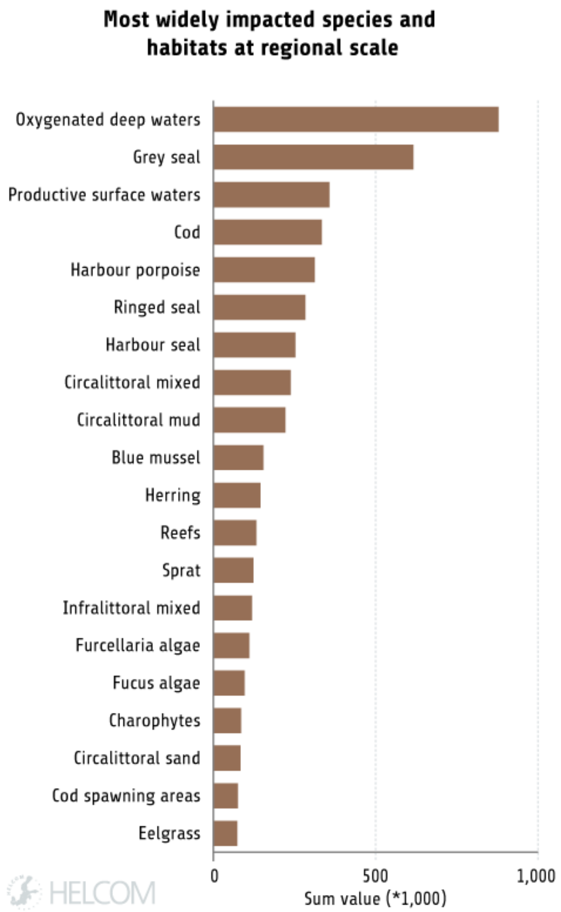

Figure 6.4.
List of most widely impacted ecosystem components (species or habitats), according to the Baltic Sea Impact Index. Note that only results for the twenty most impacted ecosystem components are shown. The 'Sum value' is calculated as the sum of impacts from all pressures on each ecosystem component.

6.4. Cumulative impacts on benthic habitats

A separate analysis was carried out for potential cumulative impacts on benthic habitats only, 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, which have been identified as relevant for the HELCOM area[1].

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 6.5). The most impacted sub-basins were identified as the Sound, Bay of Mecklenburg, and the Kiel Bay (Figure 6.6). As the shallow waters usually host more diverse habitats, the impacts also accumulate more in coastal areas.

The top human activities causing cumulative impacts on benthic habitats, according to this assessment, are bottom trawling, shipping, recreational boating and sediment dispersal caused by various construction and dredging activities and depositing of dredged sediment (for more details, see Thematic Assessment: HELCOM 2018E).

1 Eight broad scale habitats (Circalittoral hard substrate, Circalittoral mixed substrate, Circalittoral mud, Circalittoral sand, Infralittoral hard substrate, Infralittoral mixed substrate, Infralittoral mud and Infralittoral sand) and five habitat forming species (*Furcellaria lumbricalis*, *Zostera marina*, *Mytilus edulis*, *Fucus* spp. and *Charophytes*).

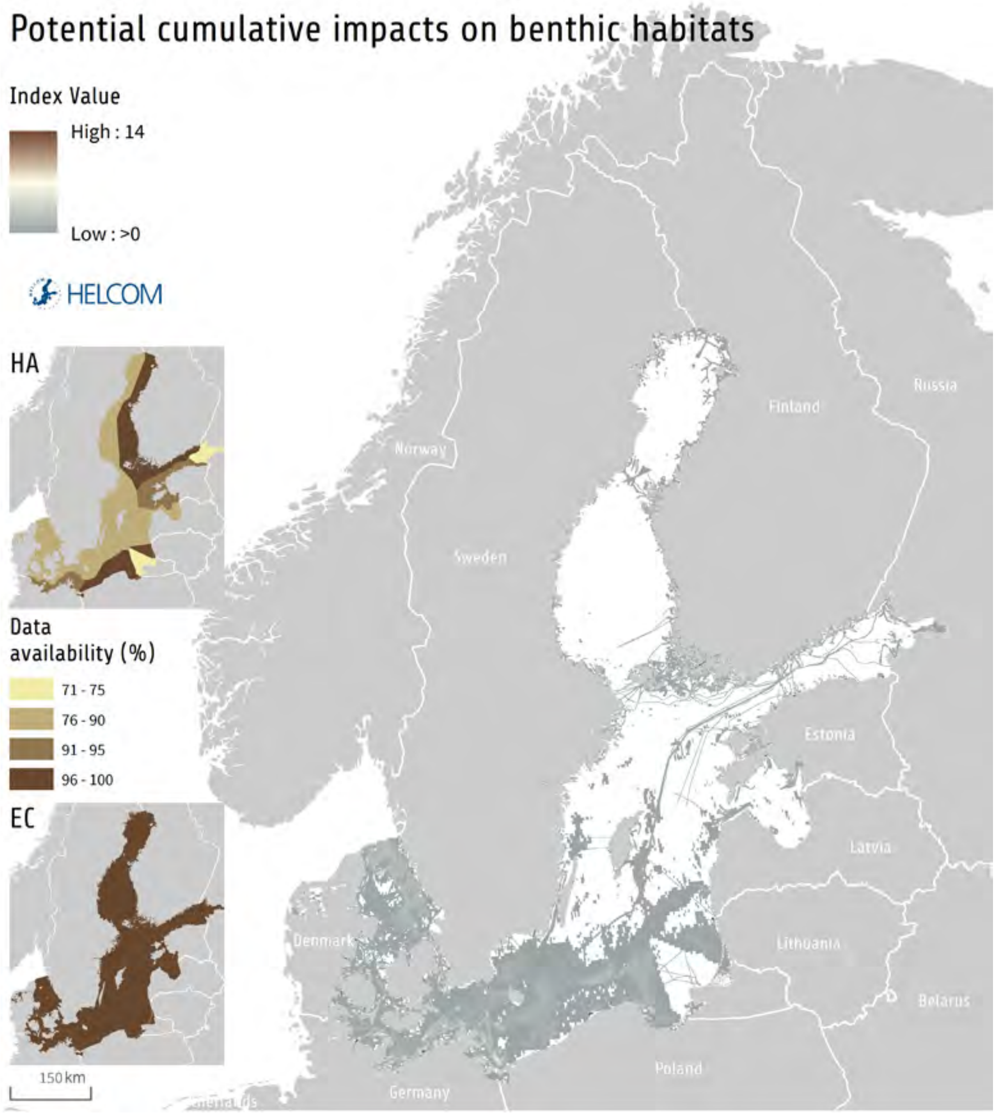

Figure 6.5.
Map of potential cumulative impacts on benthic habitats in the Baltic Sea. The cumulative impacts are calculated based on the method of the Baltic Sea Impact Index as the 'sum of impact', specifically for the two pressures physical loss and physical disturbance. Benthic habitats were represented by eight broad scale habitat types and five habitat forming species (*Furcellaria lumbricalis, Zostera marina, Mytilus edulis, Fucus* spp. and *Charophytes*). White color on the map indicates areas where impact is assessed as zero, due to absence of pressures or ecosystem components, or both. The analysis is based on currently best available regional data, but spatial gaps occur in some underlying datasets, as identified in the smaller map (EC=Ecosystem components layers, HA=human activities and pressures data sets).

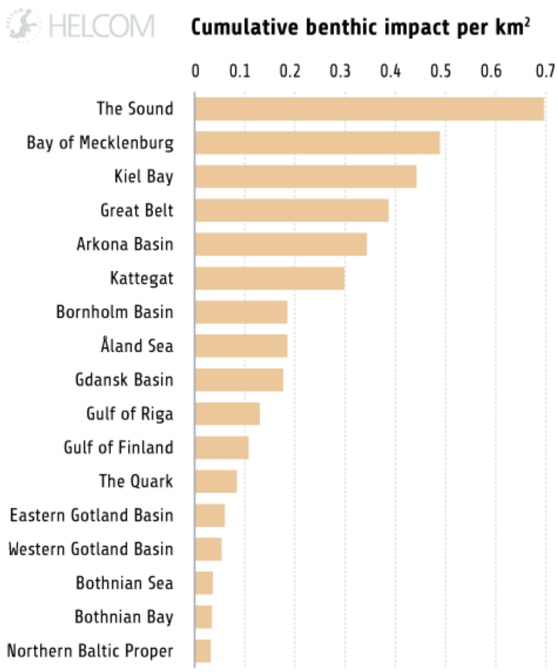

Figure 6.6.
Cumulative impacts on benthic habitats in the Baltic Sea sub-basins. The values are calculated as the summed impact from physical loss and physical disturbance on the studied benthic habitat types and habitat forming species, divided by the area of the sub-basin. The estimates are based on 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. Deposit of dredged material in sea grass covered areas and dredging activities, bury and extract seagrass, respectively, and therefore 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 reduce 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).

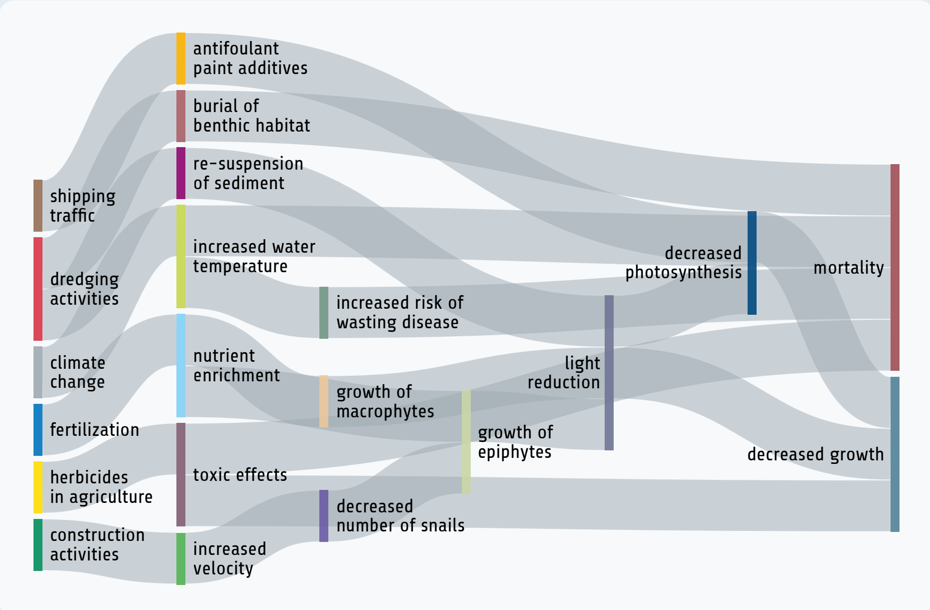

Figure B.6.1.1.
Effects of selected human activities on seagrass meadows. Based on systematic literature review using the LiACAT tool (HELCOM 2016f, Eilers *et al.* 2018).

Box 6.1. (continued)

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. Seabed disturbance caused by fishing activities may lead to the decline of blue mussel, by removal of species and abrasion. 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).

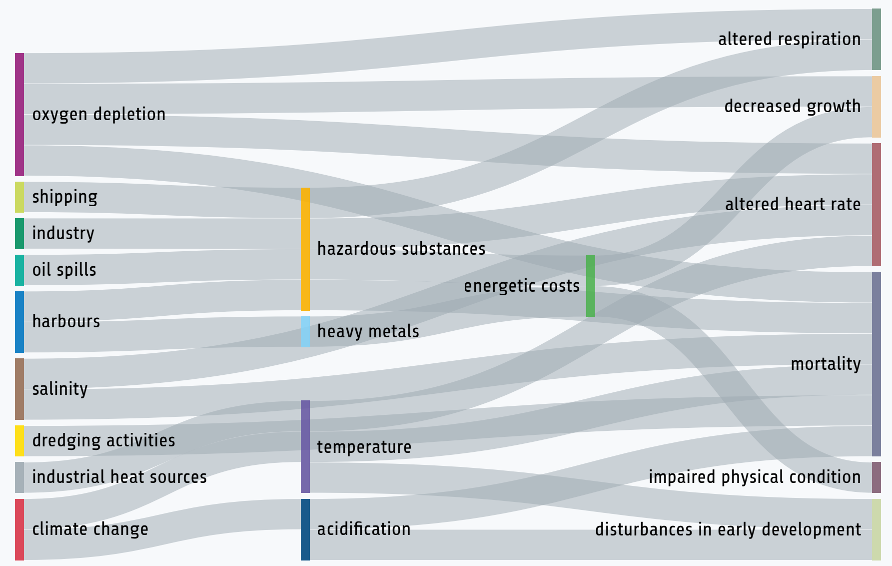

Figure B.6.1.2.
Effects of selected human activities on blue mussels to show the linkage framework. Based on systematic literature review using the LiACAT tool (HELCOM 2016f, Eilers *et al.* 2018).