5. Spatial distributions of ecosystem components, human activities, pressures, impacts and ecosystem services

The Baltic Sea is influenced by a range of pressures from human activities. In order improve its environmental status in an efficient and adequate way, it is of key importance to map activities which affect the marine environment, analyse what effects they have and how strong the effects are, and assess what this means for the ecosystem. Furthermore, while some activities and pressures might seem of little importance individually, their summed impact can be considerable when they occur in the same place, particularly in areas with sensitive species or habitats.

The HELCOM Spatial Distribution of Pressure and Impact Assessment (SPIA) analyses data on the distribution of ecosystem components (such as species or habitats), pressures and human activities, thus linking human activities with the pressure (or pressures) they cause. It links spatial information on ecosystem components with spatial information about pressures, identifying where they overlap and how sensitive a given ecosystem component is to a particular pressure. This provides an overview of the potential impact of a given pressure or subset of pressures on one or more ecosystem components, allowing us to trace which activity underpins the pressure(s) causing an impact. Each of these assessment steps can provide valuable contextual information to the results of the other assessments included in the holistic assessment of the state of the Baltic Sea.

The SPIA is an effective tool for deepening our understanding of how different pressures act on the Baltic Sea ecosystem, where they are most common, and in what areas different pressures co-occur (Box 5.1). This information can be important for management and planning purposes.

BOX 5.1.

Spatial analyses of pressures and impacts in HELCOM

The thematic assessment report on the spatial distribution of pressures and impacts analysis (HELCOM 2023e) clarifies the methodology of the HELCOM spatial pressures and impacts analysis (SPIA) for the years 2016-2021. The comprehensive approach of the SPIA differs from the other thematic assessments, which address topics in a more sectoral manner. It also differs by not comparing results against a threshold value but rather analysing where the cumulative pressure is likely higher or lower. The SPIA examines the spatial distribution and intensity of different human activities and pressures and uses the best available knowledge to quantify their combined effects. The maps are evaluated together with information on the sensitivity of each ecosystem component to each pressure in order to produce information about their potential impact on the environment.

State of the Baltic Sea
Third HELCOM holistic assessment 2016–2021

5.1. Spatial analyses of pressures and impacts

The SPIA tool used to assess the spatial distribution of pressures and impacts is highly versatile and can analyse any combination of pressures and ecosystem components to provide information about both the potential distribution and the potential impact. By combining all available information on pressures and impacts, the tool can also address the cumulative burden on the environment caused by human activities in the Baltic Sea region. The results are presented as two indices.

- The Baltic Sea Pressure Index gives information about which areas are likely to have the greatest pressure from human activities.
- The Baltic Sea Impact Index shows the distribution of the potential cumulative impact of these pressures on the environment. This is accomplished by considering the spatial distribution of species and habitats, as well as how sensitive these ecosystem components are to the different pressures.

The Baltic Sea Pressure and Impact indices for the years 2016-2021 are based on nationally reported spatial data sets for 28 human activities occurring in the Baltic Sea and 6 data sets of pres-

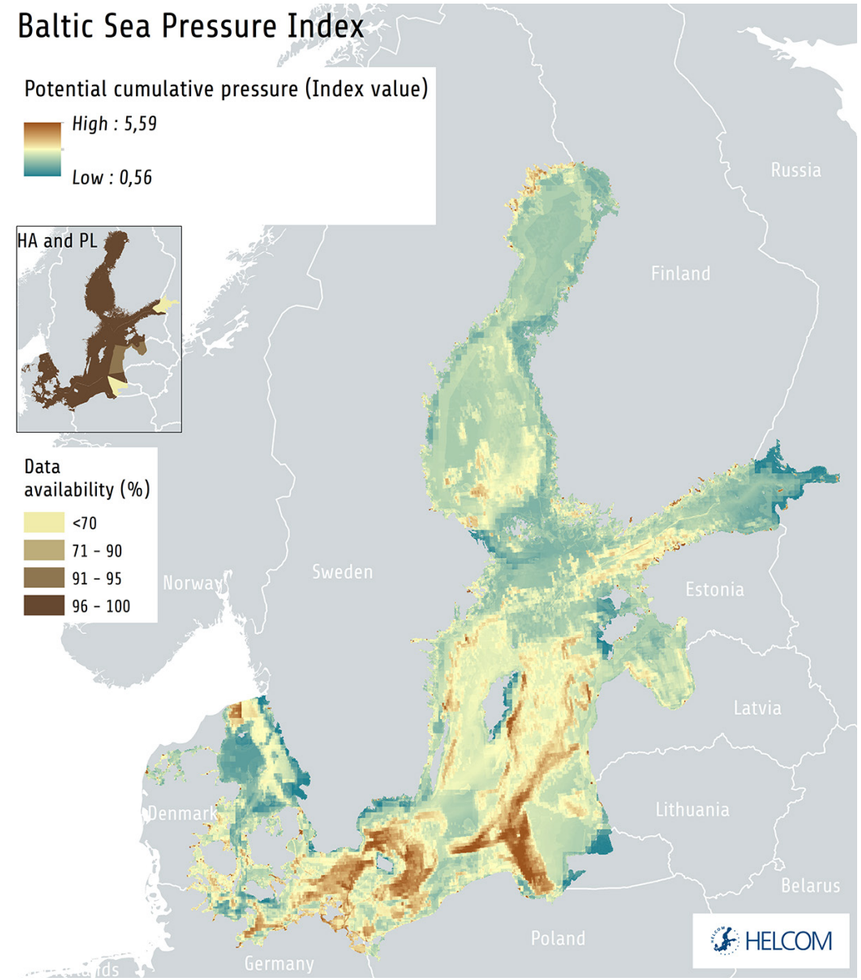

Figure 5.1. The Baltic Sea Pressure Index shows the spatial variation in the potential cumulative pressure on the Baltic Sea by combining data on several pressures. The index is based on the currently best available regional data, but spatial gaps may occur in some underlying data sets. The inset data availability map shows data availability for human activities (HA) and pressures (PL). Source: HELCOM 2023e.

sures estimated by direct measurements at sea. These data were compiled into 17 aggregated pressure layers which were used in the assessment. In addition, 57 spatial data sets representing different ecosystem components were included in the assessment. The thematic assessment report (HELCOM 2023e) gives a detailed description of the method and a complete account of all data layers, their sources and how they were developed.

The results show that hazardous substances and eutrophication are the two most influential pressures in terms of both potential cumulative pressures and impacts. When the cumulative pressure was estimated without including the spatial overlap with ecosystem components, the highest level of pressure was found in open sea areas (Figure 5.1).

The cumulative impact index indicated that there are potential cumulative impacts on the environment from human activities throughout the Baltic Sea, but there were some clear spatial differences. Shallow coastal areas are generally subject to the highest levels of cumulative impact, as these are areas where a high number of human activities and ecosystem components occur together (Figure 5.2).

The SPIA tool also enables dedicated analyses of combinations of pressures and ecosystem components. When the analysis was narrowed to only consider the combined potential impact of hazardous substances and eutrophication, the result was largely similar to the potential cumulative impact of all pressures together, demonstrating that these pressures are the main contributors to the total impact. Both eutrophication and hazardous substances have a wide distribution throughout the Baltic Sea.

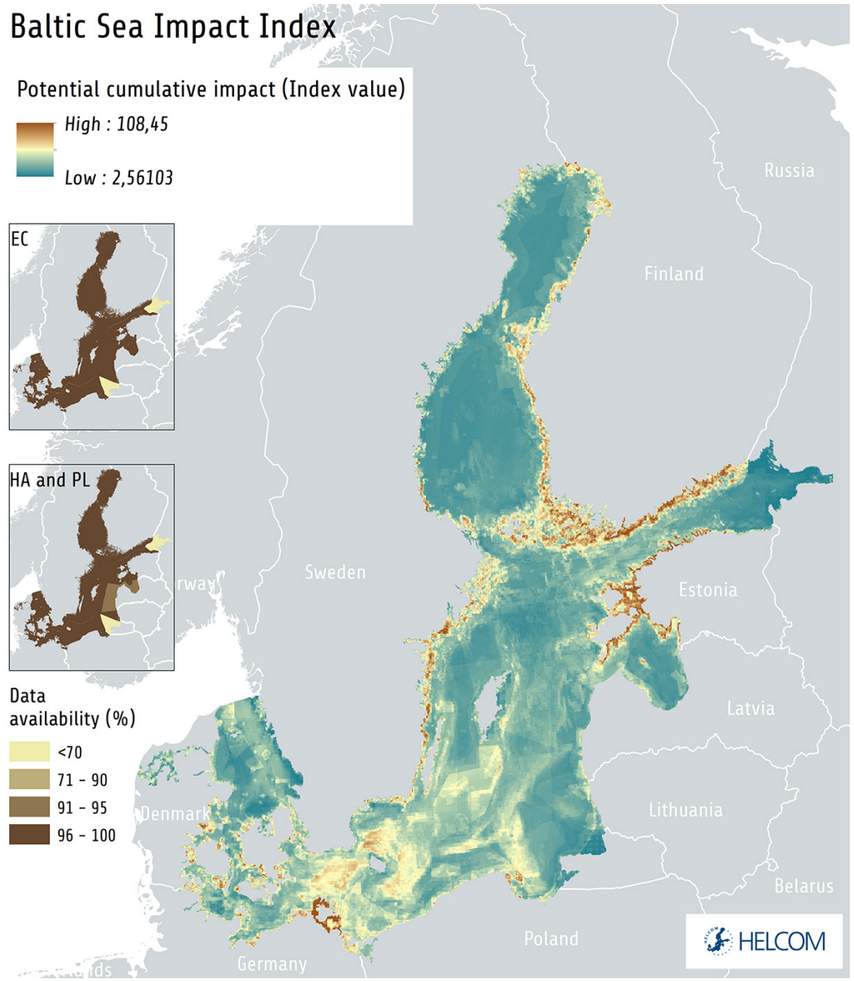

Figure 5.2. The distribution of the potential cumulative impact from human activities on the Baltic Sea environment, based on the Baltic Sea Impact Index. The analysis is based on the currently best available regional data, but spatial gaps may occur in some underlying datasets. The inset data availability maps show data availability for human activities (HA), pressures (PL) and ecosystem components (EC). Source: HELCOM 2023e.

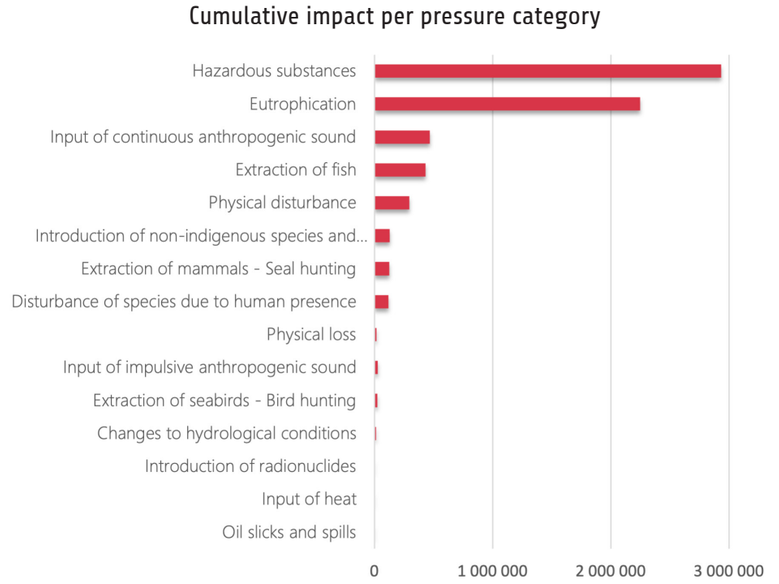

Figure 5.3. Ranking of pressures based on their potential cumulative impact measured by the Baltic Sea Impact Index. The values in the figure represent the sum of the impact index values for the whole assessment area. For details, see HELCOM (2023e).

5.2. Top pressures causing impacts on the Baltic Sea environment

Further analyses of the Baltic Sea Impact Index showed that "hazardous substances" and "eutrophication" were the pressures that contributed most to the total impact, comprising more than three quarters of the total impact (Figure 5.3). This reflects the fact that these pressures have the widest spatial distributions, and many species and habitats are highly sensitive to them. Other pressures that ranked high in the analyses were "input of continuous anthropogenic sound", "extraction of fish" and "physical disturbance". These pressures also have a wide distribution, but they were found to occur closer to the related human activities than hazardous substances and eutrophication. Furthermore, the number of ecosystem components (species and habitats) that are sensitive to these pressures is somewhat lower. Other pressures had a more limited distribution and a lower contribution to the total impact. However, many species and habitats in the Baltic Sea are also highly sensitive to such lower-ranking pressures, "physical loss" being a clear example. Even though they have limited contribution to the total potential cumulative impact at the scale of the whole Baltic region, their impact on a local scale can be high. Grey seals (*Halichoerus grypus*) and bottom-water habitats not influenced by permanent anoxia are the ecosystem components most affected by potential cumulative impacts, partly due to the large extent of these ecosystem layers compared to other layers.

The results of these analyses clarify the spatial patterns and relative intensities of the potential cumulative pressures and impacts in the Baltic Sea. They do not provide information on the absolute magnitudes of potential pressures or impacts but instead evaluate their relative levels in different parts of the region. Hence, the indices that are produced are not status assessments in the same way as the HELCOM indicator-based evaluations. They are best used as a means to describe and communicate relative patterns and intensities of pressures and impacts in different parts of the Baltic region. They can highlight areas that are facing the highest relative potential cumulative pressures and impacts, based on the currently best available regional data. Spatial gaps occurring in some underlying datasets are indicated in the results with separate data availability maps.

The accumulation of impacts in shallow areas can also be analysed by looking at the average impact per square kilometre within HELCOM subbasins (Figure 5.4). Many of the subbasins facing the greatest potential impact have a large share of relatively shallow areas. This is particularly true for the Åland Sea, the Sound and the Great Belt. However, there are also subbasins with broad open sea areas that rank relatively high, mainly because of the pressure from commercial fishing with bottom-contacting fishing gear. The lowest average impact was found in basins with vast open sea areas compared with their coastal regions, such as the Bothnian Sea and Bothnian Bay. These are also areas where widely distributed and high-ranking pressures, such as bottom trawling, eutrophication and inputs of sound, are generally lower.

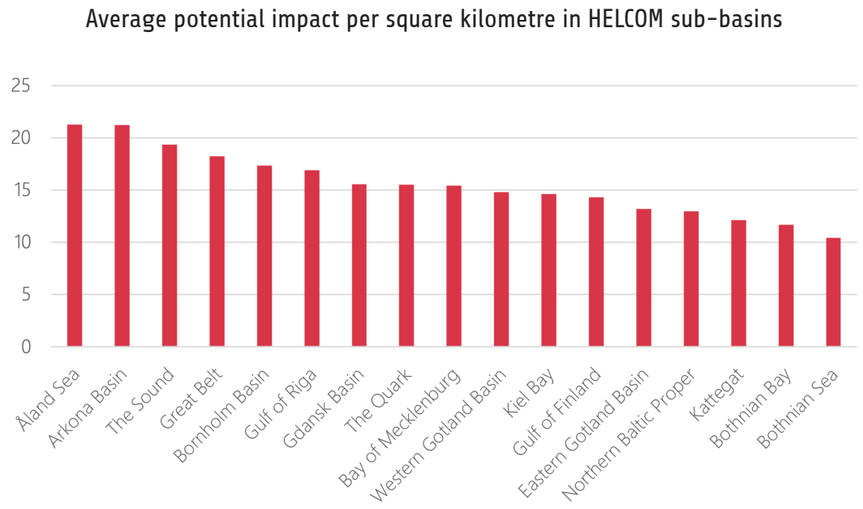

Figure 5.4. Average potential cumulative impact per square kilometre by HELCOM subbasin according to the Baltic Sea Impact Index 2016–2012. For details, see HELCOM (2023e).

BOX 5.2.

The SPIA tool

The increasing use of sea areas leads to complex patterns of interactions between human activities, pressures and ecosystem components. Tools to assess the spatial distribution of pressures and impacts are helpful for evaluating the spatial distribution of human activities and pressures and the combined and cumulative impact of human-induced pressures on the environment, as well as for identifying potential key areas of concern and in need of enhanced management efforts.

The HELCOM SPIA tool is an open-source tool which is free for everyone to use. Users can analyse the spatial distribution of pressures and impacts in the Baltic Sea using HELCOM datasets as the input. The SPIA tool is available as an ArcGIS Pro desktop toolbox and as a web-based online tool, with functionalities that can be used to present and explore the results in various ways The user can select which layers to explore and include in the calculation. The assessment can be run for the whole Baltic Sea or separately for an individual HELCOM subbasin. Results appear in the tool's map viewer, where it is possible to explore and download the map together with a statistics matrix of the result. In the interactive map viewer, the results can be compared with any pressure or ecosystem layer used in the calculation. The map viewer can also be used to explore the contribution of pressure and ecosystem layers to the total impact in a selected location.

5.3. Spatial analyses of ecosystem services

The status of the environment is directly linked to our use of the sea, which provides us with both direct and indirect benefits. Having a marine environment in good status offers several benefits that are currently not fully provided across the Baltic Sea, such as clear and oxygen-rich waters, healthy fish stocks, safe fish and seafood for human consumption, good quality coasts and beaches, and healthy marine biodiversity. Reaching good environmental status in national marine waters by 2040 is collectively estimated to be worth 5.6 billion euros per year to society (HELCOM 2023d). Not achieving good status of the marine environment affects different groups of society by, for example, decreasing the opportunities for fishing or causing impacts on human health, including for future generations (HELCOM 2023d).

Ecosystem services is a collective term for all the direct and indirect contributions that healthy ecosystems make to human well-being, as a result of functions and processes in the ecosystem (Potschin & Haines-Young 2016b). The ecosystem services

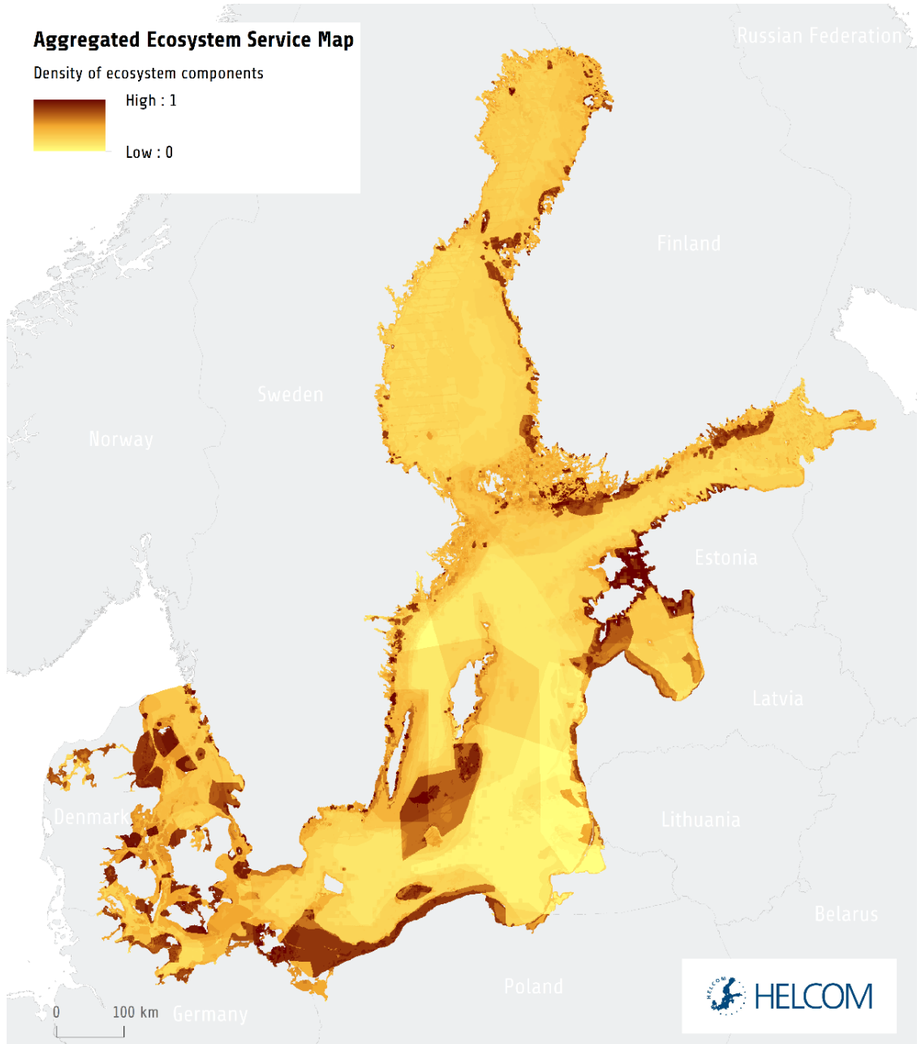

Figure 5.5. Illustration of areas with high potential to contribute to ecosystem services in the Baltic Sea. The map is made from 54 different ecosystem component layers based on their respective contribution to specific ecosystem services. For a more detailed description of the data and analyses, see HELCOM (2013d–e) and Ruskule *et al.* (2023).