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.

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-

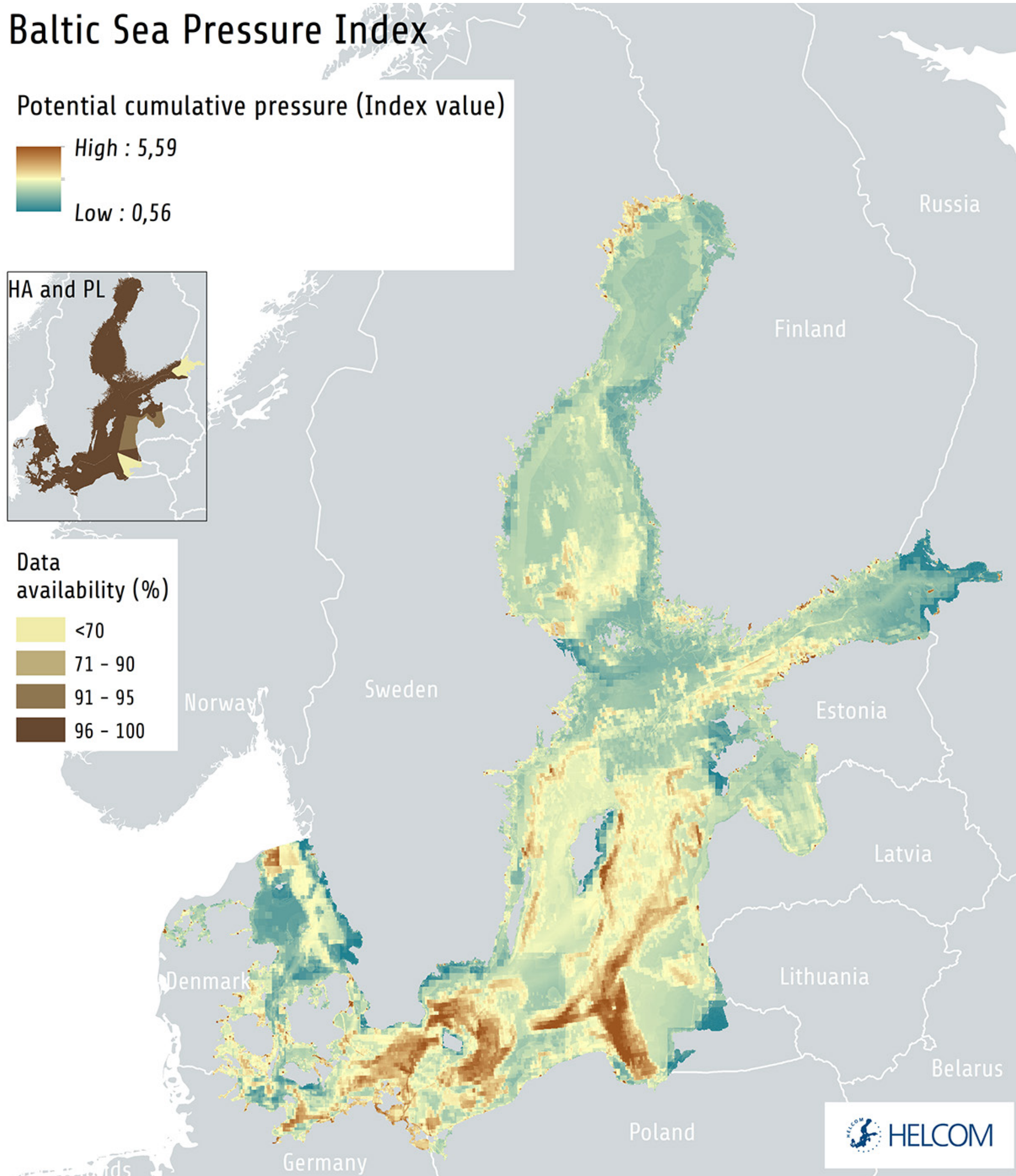

Figure 5.1. The Baltic Sea Pressure Index shows the spatial variation in the potential cumulative pressure on the Baltic Sea by combining data on several pressures. The index is based on the currently best available regional data, but spatial gaps may occur in some underlying data sets. The inset data 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 con-

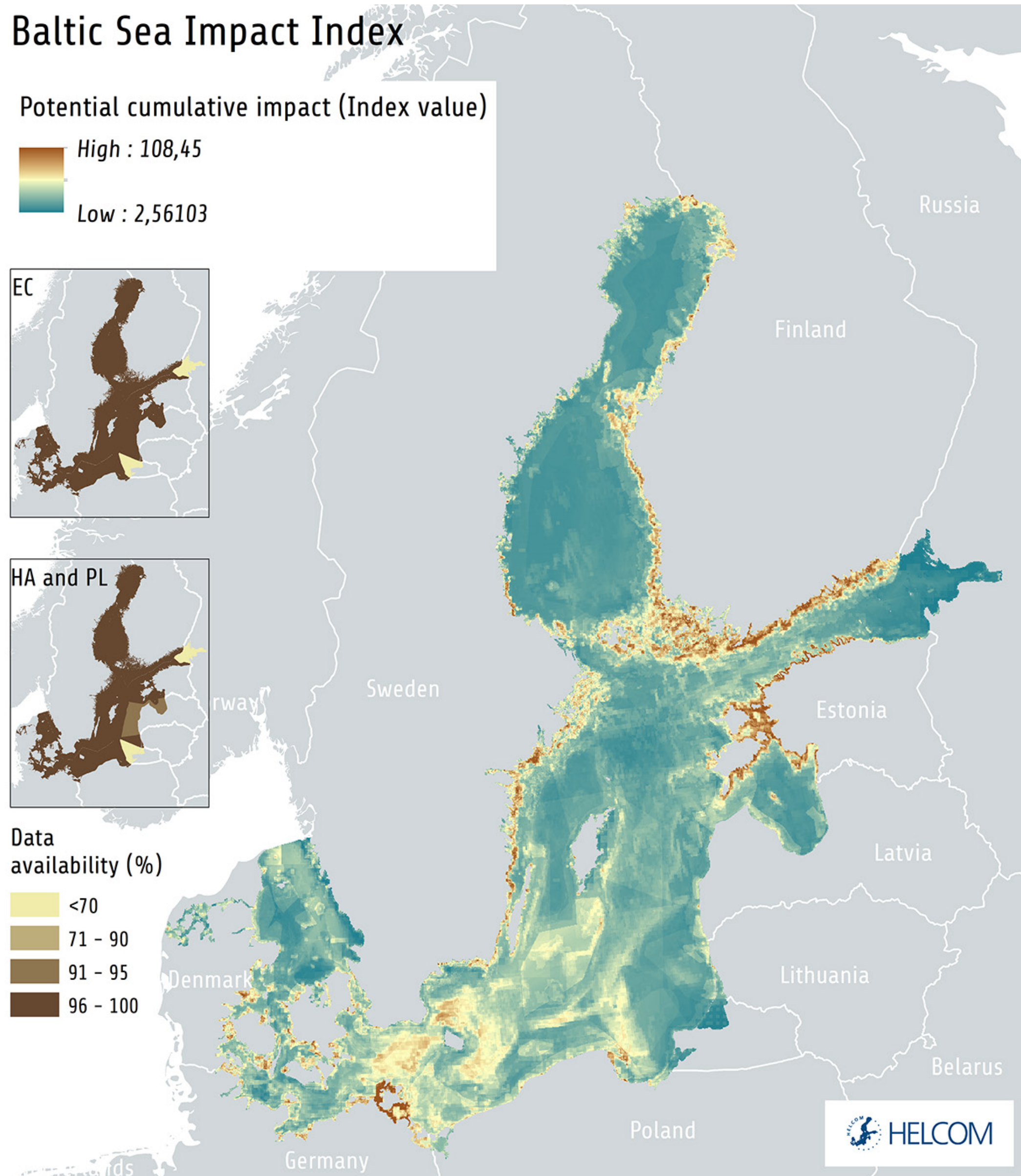

Figure 5.2. The distribution of the potential cumulative impact from human activities on the Baltic Sea environment, based on the Baltic Sea Impact Index. The analysis is based on the currently best available regional data, but spatial gaps may occur in some underlying datasets. The inset data availability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

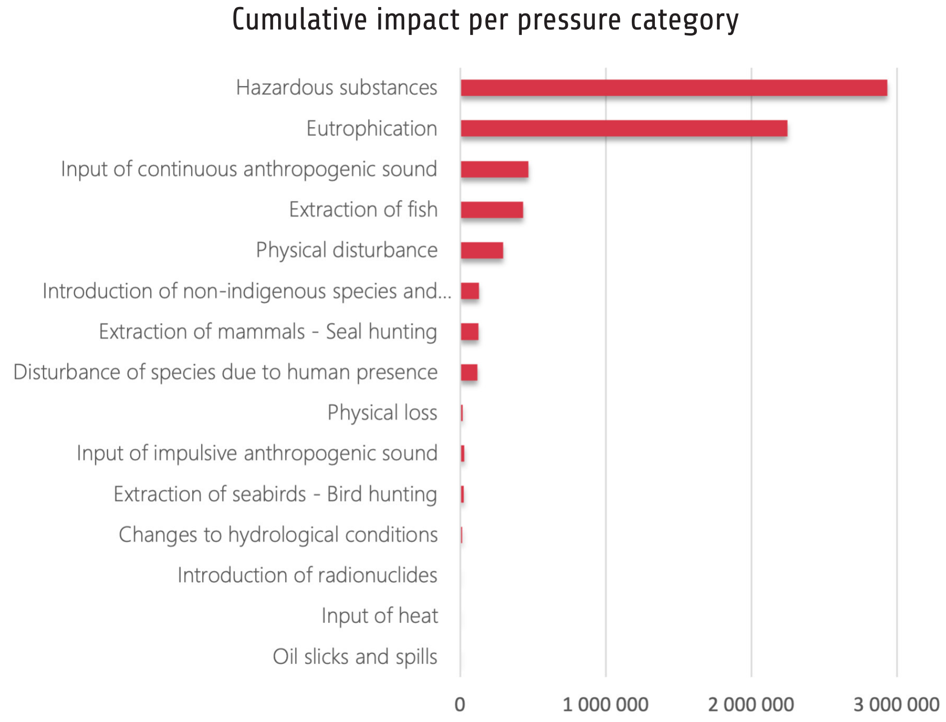

Figure 5.3. Ranking of pressures based on their potential cumulative impact measured by the Baltic Sea Impact Index. The values in the figure represent the sum of the impact index values for the whole assessment area. For details, see HELCOM (2023e).

tributors to the total impact. Both eutrophication and hazardous substances have a wide distribution throughout the Baltic Sea.

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.

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 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.

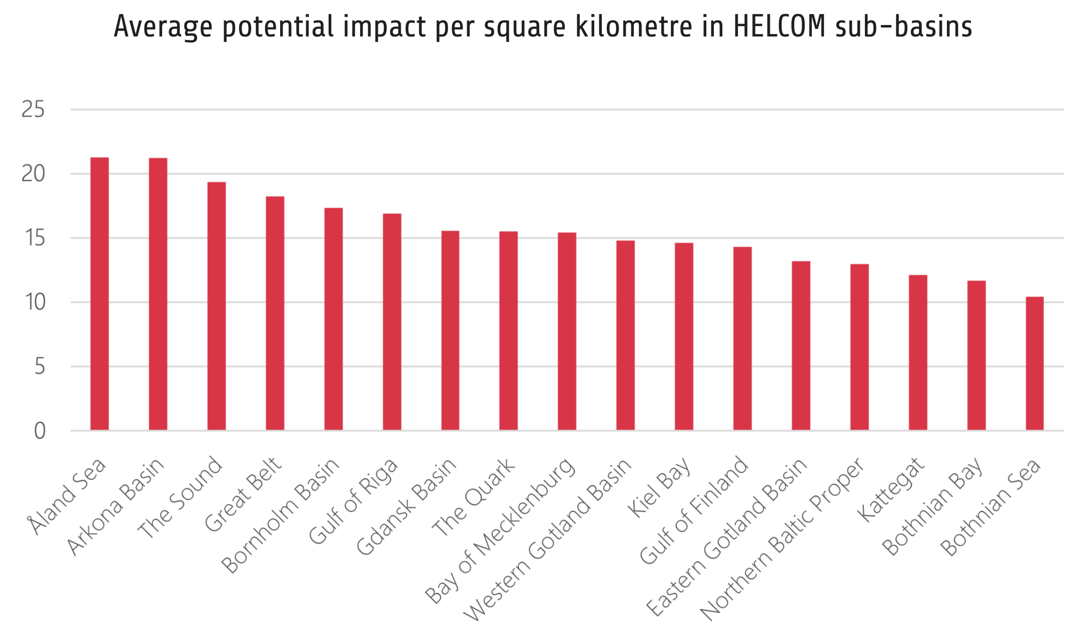

Figure 5.4. Average potential cumulative impact per square kilometre by HELCOM subbasin according to the Baltic Sea Impact Index 2016–2012. For details, see HELCOM (2023e).

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

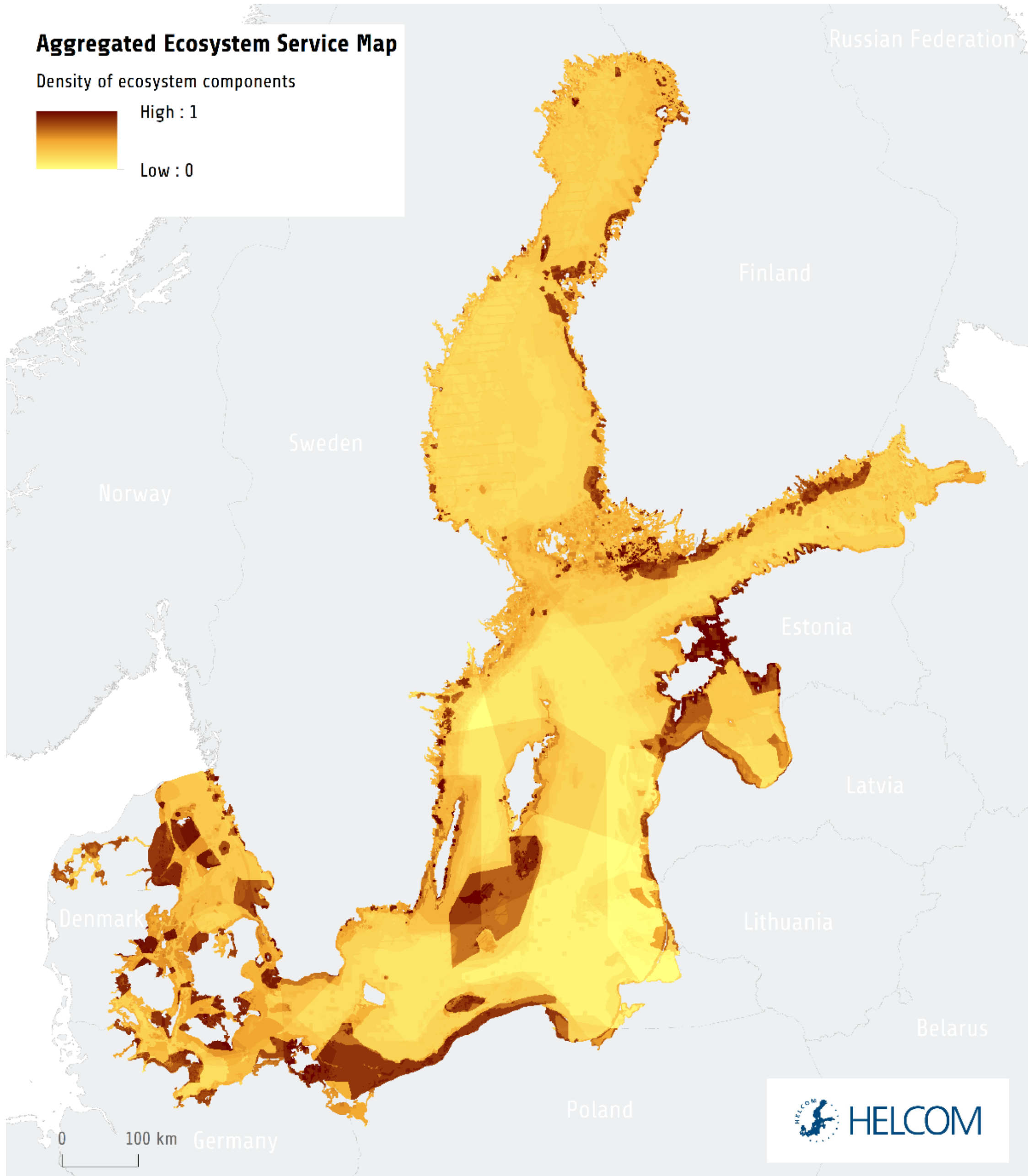

Figure 5.5. Illustration of areas with high potential to contribute to ecosystem services in the Baltic Sea. The map is made from 54 different ecosystem component layers based on their respective contribution to specific ecosystem services. For a more detailed description of the data and analyses, see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

concept covers aspects of the environment that are fundamental to human survival. The ecosystem produces goods that we value, such as wild fish and algae for nutrition. It also contributes to the regulation and maintenance of the ecosystem that we live in, through processes like carbon sequestration. Interacting with nature also provides non-material benefits, like recreation and cultural values. Analysing the environment using an ecosystem services approach is helpful for understanding and clarifying the connections between ecosystems and human well-being. The ecosystem services approach can thus support decisions and policy-making to ensure the sustainable use of resources (Martin-Ortega *et al.* 2015). Analyses of ecosystem services can help clarify potentially complex relationships between nature and society. As ecosystem services link the state of the ecosystem with societal well-being, such analyses are an effective tool for evaluating the trade-offs between alternative sea uses, and between different management and protection options. However, both the ecosystem services approach and its branch, ecosystem accounting, are fairly new concepts in comparison established environmental assessment tools. Further development of their knowledge base, information base and appropriate application is needed.

A mapping approach building on the data layers developed for use in the assessment of the spatial distribution of pressures and impacts demonstrates the potential contribution of ecosystem services in the Baltic Sea region (Figure 5.5). An aggregated map of ecosystem service potential was created using an extension of the Baltic Sea Impact Index calculation tool (Ruskule *et al.* 2023). This updated evaluation used 54 different ecosystem component layers, including benthic habitats, pelagic species, habitat-building species, mobile species and their key habitats. The tool aggregates the spatial extent of the ecosystem components contributing to the provision of a particular ecosystem service and combines the results for all the layers. The precision of the resulting map is still comparatively low because it only considers the presence or absence of ecosystem components, not their quantity or quality, and it only reflects the ecosystem services that were included in the exercise. Nevertheless, it provides a rough illustration of potential key areas for ecosystem services in the Baltic Sea, thus supporting key management actions, such as protection and the determination of acceptable levels or locations of pressures to achieve good environmental status.

5.4. How can maritime spatial planning support the Baltic Sea environment?

Maritime spatial planning (MSP) is the spatial planning of activities at sea. The processes used in MSP involve a holistic, multisectoral effort at national scales and can serve as a key component in the implementation of several shared environmental objectives for the Baltic Sea. Maritime spatial planning is thus becoming an increasingly important instrument for the development of ecosystem-based management, facilitating or enabling work towards reaching a good environmental status of the Baltic Sea environment (Box 5.3).

The current state of maritime spatial planning in the Baltic Sea

All Baltic countries that are also members of the European Union have implemented their first (or, in some cases, second) generation of maritime spatial plans, in alignment with the EU Maritime Spatial Planning Directive (EC 2014). Important topics for future iterations of the plans are dealing with climate change, meeting the visions of the European Green Deal (EC 2019), monitoring and evaluating the existing plans, and the cooperative development of coherent plans to better support an ecosystem-based approach towards reaching good environmental status.

BOX 5.3.

What is maritime spatial planning?

Maritime spatial planning (MSP) is spatial planning at sea using a holistic, multisectoral effort. A key aim of MSP is to delineate human uses in such a way that sensitive environmental areas are not significantly negatively affected. Furthermore, the MSP process should serve as a platform for the involvement of all relevant stakeholders in determining how society should use the sea.

The Baltic Sea Action Plan includes MSP as a horizontal topic. Through the Baltic Sea Action Plan, HELCOM countries have agreed to:

— **Utilize maritime spatial planning (MSP) applying an ecosystem-based approach to support BSAP objectives and targets and contributing to sustainable sea-based activities**

The maritime spatial plans are implemented nationally. Thus, the inclusion of coastal areas or related sectors, and the formal status of the plans, varies between countries in HELCOM.International cooperation between neighbouring countries and within regional seas is of high importance in MSP and is a cornerstone of the formation of a coherent framework. In HELCOM, the HELCOM-VASAB MSP working group addresses a number of joint challenges for MSP in the Baltic Sea with its regional MSP roadmap for 2021-2030, including knowledge development, regional collaboration, environmental considerations, a sustainable blue economy and climate change (EC 2022).

How can MSP make a difference for ecosystems and societies?

Maritime spatial planning can potentially have positive or negative effects on the marine environment, depending on where and how space is allocated for different uses. It is essential that knowledge about how different human activities may affect both the local and the broader ecosystem are included in the planning process in order to ensure long term sustainability.

Because planning considers social, economic, cultural and other relevant aspects while also aiming to enhance marine nature values, it can help countries integrate key environmental considerations into their planning in a holistic way. When applied optimally, MSP can make a difference for Baltic Sea ecosystems and society by guiding or directing the locations of different types of human uses of the sea in a way that maximizes the possibility for a positive sustainable future. For example, planning efforts can enhance nature conservation by facilitating a Baltic Sea network of marine protected areas or can improve marine ecosystem services by securing space for different sea uses in a manner that protects and improves long-lasting ecosystem functions and the provisioning of key ecosystem services.

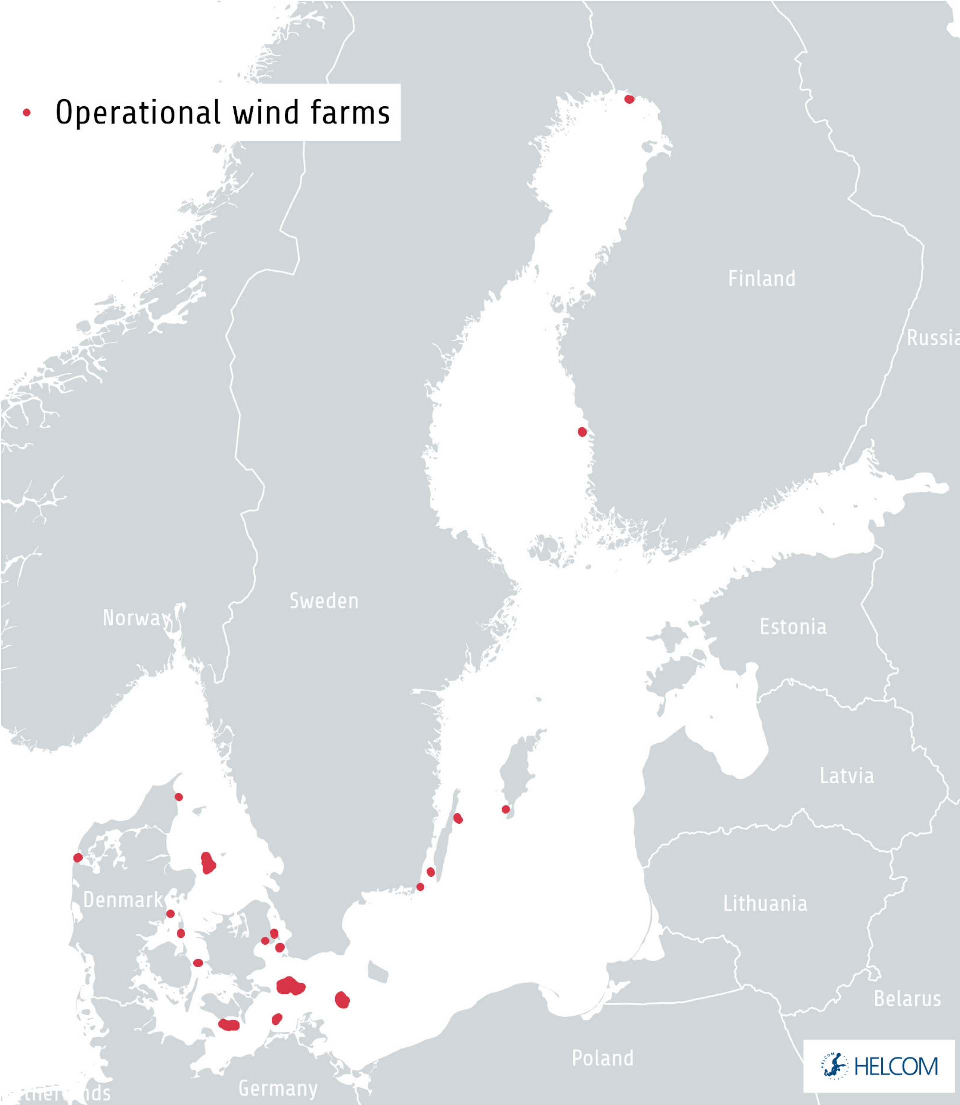

Figure 5.6. Operational wind farms in the Baltic Sea during 2016–2021. Several more offshore wind farms are currently in planning. The expansion of offshore wind is a key topic for sustainable environmental management, in which MSP plays a central role. Please note that the symbols in the map are enlarged to make them visible at this scale. Source: HELCOM 2023e.

Figure 5.7. Several human activities coexist within the Baltic Sea, interacting with or affecting the marine environment.

The role of maritime spatial planning in HELCOM

HELCOM plays an important role as a regional anchor that can help countries around the Baltic Sea harmonize their national MSP processes. This is important because most fundamental aspects of MSP are actually transboundary, including the distribution of human activities, as well as environmental pressures and biodiversity. The regional perspective on the Baltic Sea provided in HELCOM, its data coordination, resources and the institutionalized knowledge of its community all support maritime spatial planning.

Successful planning in alignment with the ecosystem approach is vital to our prospects of reaching a healthy and long-term sustainable Baltic Sea environment. The development of ecosystem-based approaches in MSP can also support the implementation of ecosystem-based management efforts more widely.

The Baltic Sea Action Plan includes measures to be implemented by countries by 2030, at the latest, to support our shared objectives for the Baltic Sea environment. The BSAP gives an important role to maritime spatial planning and outlines both the direct and indirect ways that Baltic countries should carry out planning towards this aim (HELCOM 2021).

Key topics where work in HELCOM could support regionally harmonized maritime spatial planning include the development of cumulative impact assessments of the plans on a regional scale, which would supplement the national coverage of impact assessments by countries, facilitating their coherence. Work in HELCOM should also contribute to the general development and exchange of knowledge about cumulative impact assessment in relation to strategic environmental objectives. In this regard, HELCOM also serves as a common point for collaborations with other regional seas by actively sharing information and knowledge. Dedicated projects shared by countries around the Baltic Sea to support MSP have been instrumental in strengthening regional coordination in recent years and in opening connection points between marine protection, regional development and maritime spatial planning.

Joint efforts to increase the resilience of our aquatic ecosystems to climate change is a cornerstone question for maritime spatial planning in countries around the Baltic Sea, as well as globally. This runs in parallel with necessary actions to reduce the loss of biodiversity and reach environmental protection targets (see Chapter 4), and needs to be harmonized with them. Current key challenges to which maritime spatial planning can contribute are to take areas vulnerable to climate change into consideration in spatial planning, facilitate management of coastal areas to minimize damages caused by extreme weather events, identify areas for renewable energy, and make sure that environmental pressures caused by human activities are minimized (Figure 5.6-5.8). All of these challenges will benefit from regional work in HELCOM.

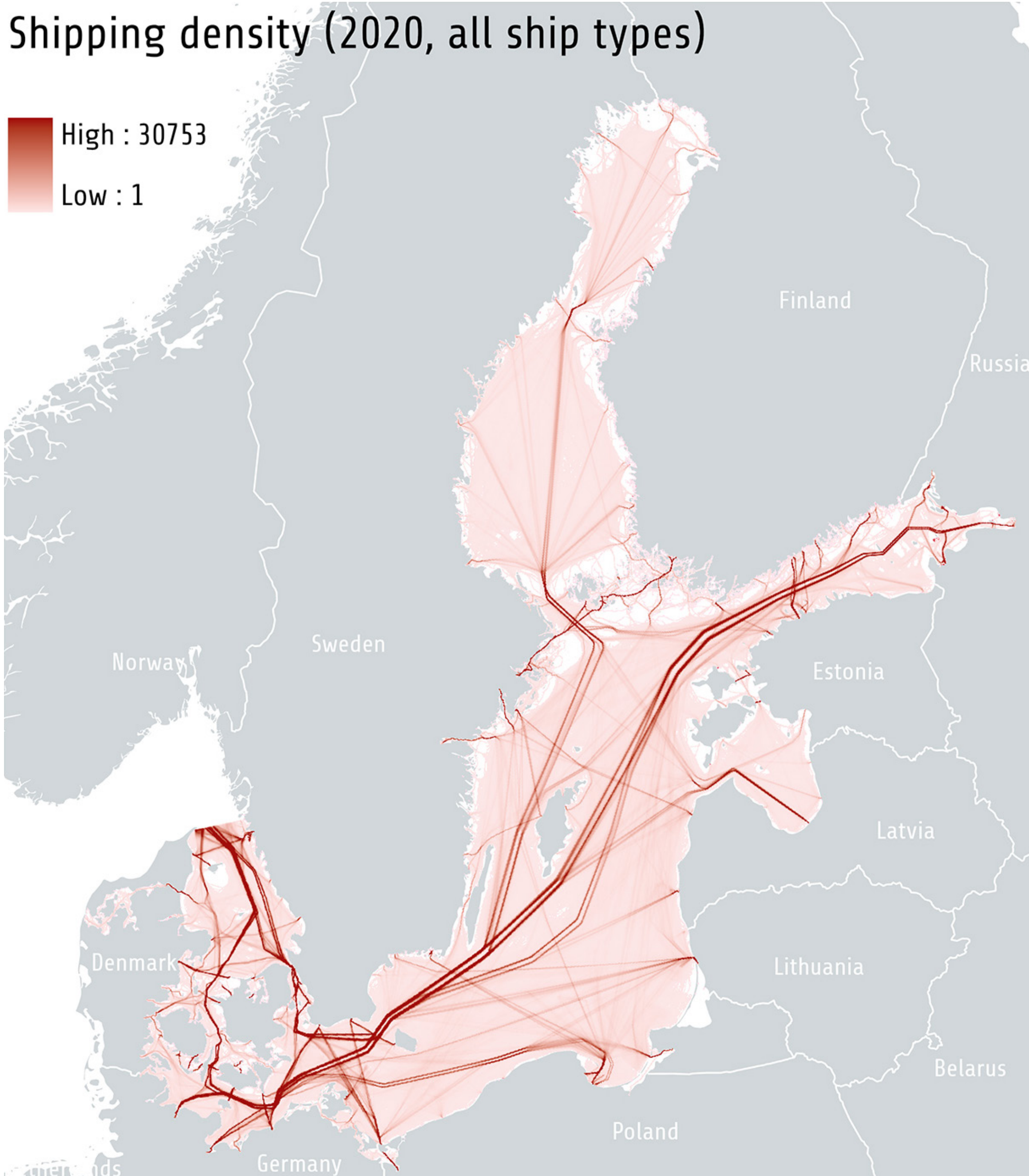

Figure 5.8. Key shipping lanes in the Baltic Sea.