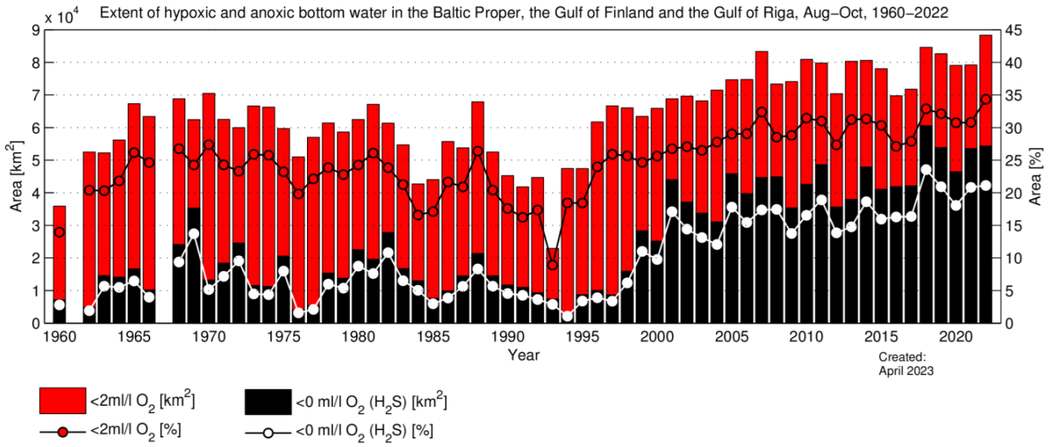

Figure 2.8. The extent of areas with hypoxic (<2 mL O_2 L^{-1}) and anoxic (<0 mL O_2 L^{-1}) bottom water in the Baltic Proper, the Gulf of Finland, and the Gulf of Riga during regular cruises in August–October during 1960–2020. Source: Hansson and Viktorsson 2023.

2.2.3 Effects of climate change on biogeochemical cycling and oxygen conditions

The impact of climate change on biogeochemical cycling is predicted to be considerable, but smaller than the impacts of nutrient inputs, even when recent nutrient reductions are considered.

Even in a future climate, implementing the nutrient reduction targets of the Baltic Sea Action Plan for the entire catchment area is expected to result in a significantly improved environmental status of the Baltic Sea, including a reduced hypoxic area (Figure 2.8). This would also increase the resilience of the Baltic Sea against climate change (Meier *et al.* 2022).

The areal cover of sea bottoms with no oxygen or poor oxygen conditions is considerably higher today compared to when the first oxygen measurements in the Baltic Sea were taken. In 2016, the maximum extent of areas with poor oxygen conditions (hypoxia) in the Baltic Sea was about 70,000 square kilometres, whereas it was presumably very small or even absent 150 years ago (Gustafsson *et al.* 2012, Carstensen *et al.* 2014a, b, Meier *et al.* 2019). Hypoxia is mainly caused by increased nutrient inputs from the land and atmospheric deposition, leading to eutrophication (Chapter 4). Other drivers, such as warming or sea level rise, have a smaller, though still important, impact (Carstensen *et al.* 2014a, Meier *et al.* 2019). On annual to decadal timescales, variations in the halocline also have a considerable influence (Conley *et al.* 2002, Väli *et al.* 2013).

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

2.3. Human uses of the Baltic Sea

The Baltic Sea countries benefit considerably from their utilization of the Baltic Sea, both economically and socially. Nine countries share the borders of the Baltic Sea, namely Denmark, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland and Germany. Another five countries are partly located within its drainage area (Figure 2.9). In total, around 85 million people live within the drainage area of the Baltic Sea. The benefits we receive from the Baltic Sea include jobs, income and natural resources, as well as various contributions to personal well-being. We all depend on biodiversity in our daily lives in ways that are not always directly apparent or appreciated.

Figure 2.9. The Baltic Sea and its drainage area.

As one example, plants and algae take up nutrients from seawater as part of their normal growth, and they in turn serve as food for other species, supporting the production of fish, for example. But the storage of nutrients in tissues of long-lived plants and algae can also contribute to the regulation of excess nutrients stemming from human activities. The nutrients can become bound for a longer period if the organic materials are buried in soft bottom sediments. Such sequestration of nitrogen and phosphorus has an estimated worth of nearly 10.5 billion euros per year in costs saved for the countries surrounding the Baltic Sea (HELCOM 2023d). Some of the nutrients are also removed from the aquatic system by activities such as fishing. Similarly, the marine ecosystem can regulate carbon flows, as carbon is bound in plants and animals or accumulated in bottom sediments (Figure 2.10). The monetary benefits of carbon sequestration range from 622 to 1,554 million euros on average per year in the Baltic Sea region, based on an annual sequestration of 4.23 million tonnes of carbon in total.

A good biodiversity status and ecosystem functions are also essential for human well-being in several other ways. Primary producers and animals at different levels of the food web form the basis as prey for fish, birds and mammals, which could not exist without them. These structures are essential to humans, for food provision, supporting recreation, enabling cultural values, and more. Fishing is among the most traditional livelihoods and is widely distributed globally, including in the Baltic Sea region.

Figure 2.10. The variety of habitats in the Baltic Sea contribute to biodiversity and to a wide range of ecosystem services of importance for humans. © Juuso Haapaniemi

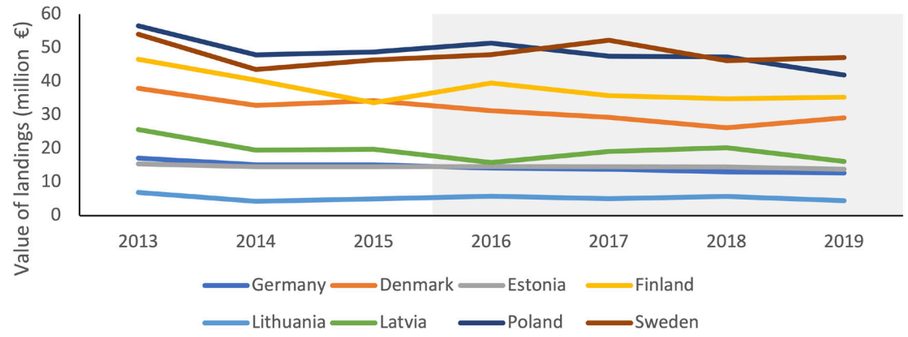

Figure 2.11. Value of landings (million €) 2013 – 2019. Shading indicates the years included in the HOLAS 3 assessment period. Source: STECF 2021b. All monetary values have been adjusted for inflation; constant prices (2015) using Eurostat (2022i). STECF does not report on Russia.

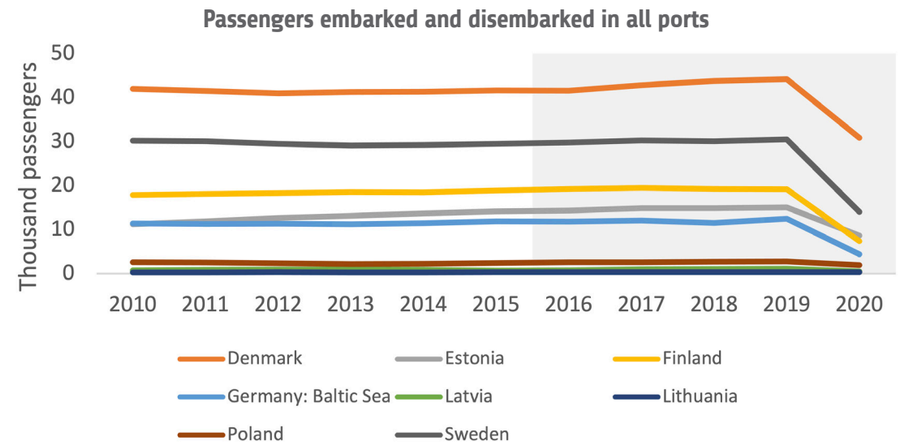

Figure 2.12. Passengers embarked and disembarked at all ports (thousand persons) 2011 – 2019. Shading indicates the years included in the HOLAS 3 assessment period. Source: Eurostat 2022e. Eurostat does not report on Russia.

However, humans use marine waters in a wide variety of ways with different characters. While some activities, such as fishing and most recreational activities, depend on the state of the marine environment, others do not, such as maritime transport and construction (Bryhn *et al.* 2020). Furthermore, activities can rely on the extraction of tangible resources, the use of space, or on intangible resources connected with how we, as humans, experience the sea.

The fishing sector depends on healthy fish stocks of a harvestable size for its well-being and long-term sustainability. Many Baltic fish stocks are currently in an especially bad state and, moreover, have a negative forecast, which affects the profitability of the fishing sector (STECF 2022). The total value of landings in Baltic Sea countries has been unchanged or has slowly declined during the current assessment period (Figure 2.11). Sweden and Poland have

had the largest values of landings. Around 4,000 full-time equivalent jobs remain in the Baltic Sea fisheries, of which more than half are in Poland. Overall, the Baltic region's small-scale coastal fishing fleets have negative gross and net profit margins, which differs from other marine regions within the EU (STECF 2022).

Marine transport encompasses both marine transport infrastructure and the shipping sector. The infrastructure sector includes ports and the activities to maintain ports and their services, such as dredging and cargo handling, while shipping includes the transportation of freight or passengers by sea. The gross weight of goods handled by ports in the Baltic Sea countries has been relatively constant over the past decade, with the exception of a notable increase in Poland. Passenger volumes were also relatively unchanged overall, aside from a clear drop in 2020 reflecting the impact of the COVID-19 pandemic (Figure 2.12). Employment in shipping has been relatively stable over the past decade, with only minor fluctuations, while the added value has shown larger changes (HELCOM 2023d).

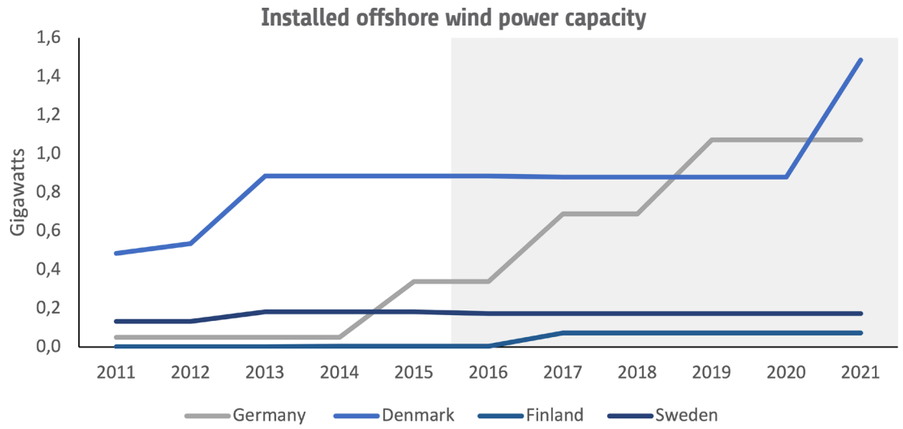

Figure 2.13. Installed offshore wind power capacity 2011 – 2021. Shading indicates the years included in the HOLAS 3 assessment period. Source: Eurostat 2022g, EMODnet 2022a. Eurostat does not report on Russia. See also Figure 5.6.

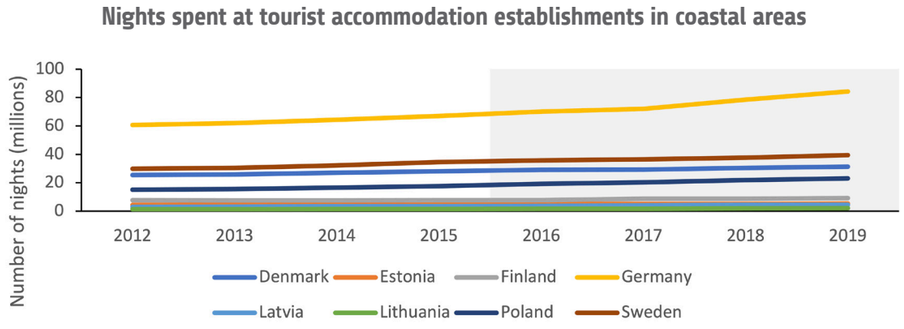

Figure 2.14. Number of nights spent at tourist accommodation establishments in coastal areas (million nights) 2012 – 2019. Shading indicates the years included in the HOLAS 3 assessment period.

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

Figure 2.15. The importance of healthy and functioning ecosystems for human well-being is too often underestimated or poorly recognized in planning and decision-making. To realize the sustainable use of marine ecosystems, we must find a balance between the values we extract from the environment and the negative impact we cause.

The Baltic Sea is a growing source of renewable energy from offshore wind farms. During the HOLAS 3 period, Germany joined Denmark as a major producer of electricity from offshore wind in the Baltic Sea (Figure 2.13). Increased renewable energy is included in the maritime spatial plans of most Baltic Sea countries, with additional capacity currently approved or under construction. At the European level, the EU strategy on offshore renewable energy recognises that Europe is in a unique position to develop offshore renewable energy because of its large maritime space and the variety and complementarity of its sea basins, and the strategy proposes ways forward to support the long-term sustainable development of the wind energy sector (EC 2020a).

Tourism and recreation are important sectors in the Baltic Sea region, although they are not always easy to quantify. For example, the coastal and marine tourism sector includes accommodation, food and drink, but also services, such as boating, water sports, recreational fishing, nature watching and beachside recreation. Though most coastal and marine tourism activities depend at least partly on the quality of the marine environment, the level of dependence varies. Altogether, the value of the recreational benefits for the Baltic Sea countries amounts to at least 33.7 billion euros on average per year, conservatively estimated (HELCOM 2023d, based on Ahtiainen *et al.* 2022). Germany and Poland have the largest total benefit, while the benefit per person is largest in Denmark, Sweden and Finland. The number of

nights spent at tourist accommodations in coastal areas is used as a proxy for developments in tourism and recreation over time (Figure 2.14). Over the past decade, the number of accommodation nights has increased in the Baltic Sea countries, increasing by more than 50% in for example Latvia, Lithuania and Poland. The annual value added and the level of employment in the tourism industry also increased during this period.

However, our use of the sea also puts pressure on the marine environment. This can cause environmental degradation which, in turn, reduces human well-being. Pressure on marine ecosystems from human activities can deteriorate their status, affecting biological communities and entire socioeconomic systems locally or at wider geographical scales (Österblom *et al.* 2017). The degradation of environmental conditions reduces the ability of marine ecosystems and food webs to maintain important ecological functions. This also impairs the capacity of these ecosystems to produce services that support human well-being (Beaumont *et al.* 2007, Micheli *et al.* 2013, Bryhn *et al.* 2020). Economic and social analyses linked to the status of the marine environment provide several valuable perspectives on the close relationships between society and ecosystems (Box 2.2).

Ecosystem services is the collective name for the variety of contributions that ecosystems make which could benefit human society (Potschin & Haines-Young 2016b). Functions and processes in ecosystems provide a wide range of goods that are appreciated by humans, such as wild fish and algae for nutrition, along with benefits that are necessary for our well-being, such as carbon sequestration. We also gain considerable non-material benefits from interacting with the ecosystem, like recreation. The concept of ecosystem services supports environmental policy and management by helping us understand and conceptualize the full range of connections between ecosystems and human well-being.

Cost of degradation is a term that refers to benefits that are lost to society because of a failure to achieve good environmental status. The term includes losses related to both the direct use of marine resources and non-use values, which are values people gain from the marine environment even if they do not use it directly, for example value from the existence of marine biodiversity (Figure 2.15). Reaching good environmental status in national marine waters by 2040 is estimated to be collectively worth 5.6 billion euros per year to people around Baltic Sea, based on individuals' stated willingness to pay for improved environmental conditions (HELCOM 2023d). As another example, degraded environmental conditions are estimated to cost the region's population 9 billion euros annually in terms of forgone recreational benefits. In the first example, benefit transfer was required to generate estimates for five of the nine Baltic Sea countries, and in the second example for six of the countries, which increases the estimates' uncertainty. These estimates give overlapping perspectives on the cost of environmental degradation in the Baltic Sea and should therefore not be summed.

BOX 2.2.

Social and economic analyses

The relationship of humans to nature is multifaceted. On the one hand, our well-being and prosperity depend on a healthy and thriving environment that supports our health, our economies and our overall quality of life. At the same time, our activities to derive these benefits often have negative impacts on our environment. This creates a dynamic tension between the desire to preserve the natural world and the need to use it for our own benefit.

Economic and social analyses help navigate this tension by accounting for the environmental and societal impacts and values of different courses of action. The analyses strive to clarify both the ways our society benefits from using the sea and the negative impacts our activities have on the ecosystem. Although there are typically no absolute answers, the analyses support decision-making by clarifying how our actions affect us in the short- and long-term through their impacts on ecosystems.

Developing economic and social analyses at the international scale involves continuous effort to improve the available data and methodologies. Promising tools currently in use and under development for regional work in HELCOM are ecosystem accounting, ecosystem services and cost-benefit analyses (HELCOM 2023d). Together, these can provide a transparent and sound framework for charting a course towards a more sustainable future.

The HELCOM Baltic Sea Action Plan (HELCOM 2021) includes eight actions targeted towards improving the quality and integration of economic and social analyses in decision-making. The broad objective of the UN Sustainable Development Goals is the improvement of economic and social equity, and nearly all EU environmental directives require addressing economic, social and cultural aspects. For instance, the EU Marine Strategy Framework Directive requires Member States to carry out economic and social analyses of the use of marine waters and the cost of degradation, and to consider the social and economic impacts of planned measures for protecting the marine environment (EC 2008). Hence, economic and social analysis plays a crucial role in the practical implementation of environmental protection, and in several policies related to management of the marine environment.