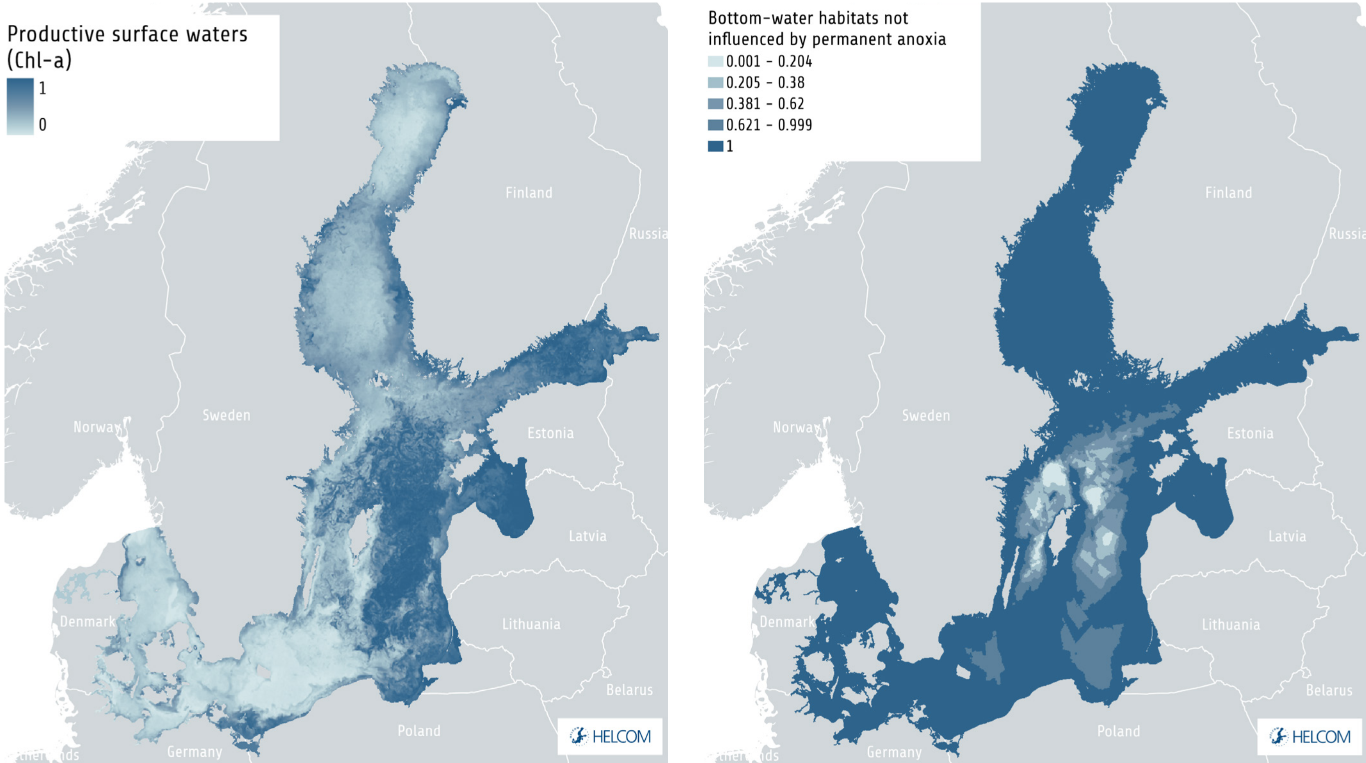

Figure 3.4. Distribution of pelagic habitat. Left: Productive surface waters are represented by the concentration of chlorophyll-a during spring. Higher values indicate areas with more chlorophyll-a in surface waters. The dataset was prepared by the Finnish Environment Institute. Right: Bottom-water habitats not influenced by permanent anoxia. Areas with low values are more influenced by anoxia. High values thus indicate suitable habitats for biota with respect to oxygen condition. The map was prepared based on the occurrence of hydrogen sulphide near the sea bottom. Importantly, the map only shows areas with permanent anoxia, and nformation on this is only available for open sea areas. Additional areas experience various degrees of temporary oxygen deficiency. For example, anoxia in coastal waters is often temporary in nature (HELCOM 2023h). Data were provided by the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) and are based on point measurements and modelling for five periods per year during 2016–2021. Source: HELCOM 2023e.

Effects of climate change on pelagic habitats

Various changes in the species composition and seasonality of pelagic communities are expected in a future climate (HELCOM/Baltic Earth 2021). For example, dinoflagellate blooms are assumed to increase, and diatom blooms decrease with increasing temperatures, although the associated processes are not yet fully understood. Worldwide, climate change is a significant driver of changes in zooplankton communities. However, what impacts this will have in the Baltic Sea is still uncertain.

Changes in the timing of spring blooms can occur due to changes in ice cover, cloudiness or wind condition (Kahru *et al.* 2014, 2016). This could have consequences for zooplankton and could also affect benthic productivity and fish if there is a mismatch between the time when food is available and the important recruitment periods.

The effects of climate change can also interact with other pressures. For example, increased pelagic primary productivity is mainly attributed to eutrophication (Saraiva *et al.* 2019), but warmer water may increase pelagic and benthic primary production (Kahru *et al.* 2016, Karlson *et al.* 2015, Lindegren *et al.* 2012, Hjerne *et al.* 2019, Suikkanen *et al.* 2013).

3.2.2 The status of benthic habitats

The status of benthic habitats (Figure 3.5) is assessed based on the status of soft-bottom macrofauna, shallow-water oxygen conditions, oxygen debt and the cumulative impact of physical pressures. Large parts of the benthic habitats in the southern Baltic Sea do not have a good integrated status, while the status is good in most of the open sea areas in the northern parts of the region (Figure 3.6). The vast majority of the coastal area, irrespective of its location, exhibits not good status (HELCOM 2023a). Of particular concern is the increasing extant of areas with poor or low oxygen in deep waters of the central Baltic Sea, which limits the populations of benthic fauna and impacts on overall ecosystem processes. The oxygen debt below the halocline has increased in all sub-basins since the early 1900s, especially in the Baltic Proper. The increase has been very steep between the previous and current assessment periods.

Why is this important?

Benthic habitats are widely distributed and contribute to various ecosystem services, including the assimilation, storage and sequestration of carbon and nutrients.

Many benthic animals have important regulatory roles by decomposing organic matter that sinks to the seabed or as grazers in shallow areas.

Benthic species are a fundamental food source for fish and birds and are therefore an important link between food web processes in benthic and pelagic habitats.

Seaweeds and plants in shallow areas are an important environment for many fish species.

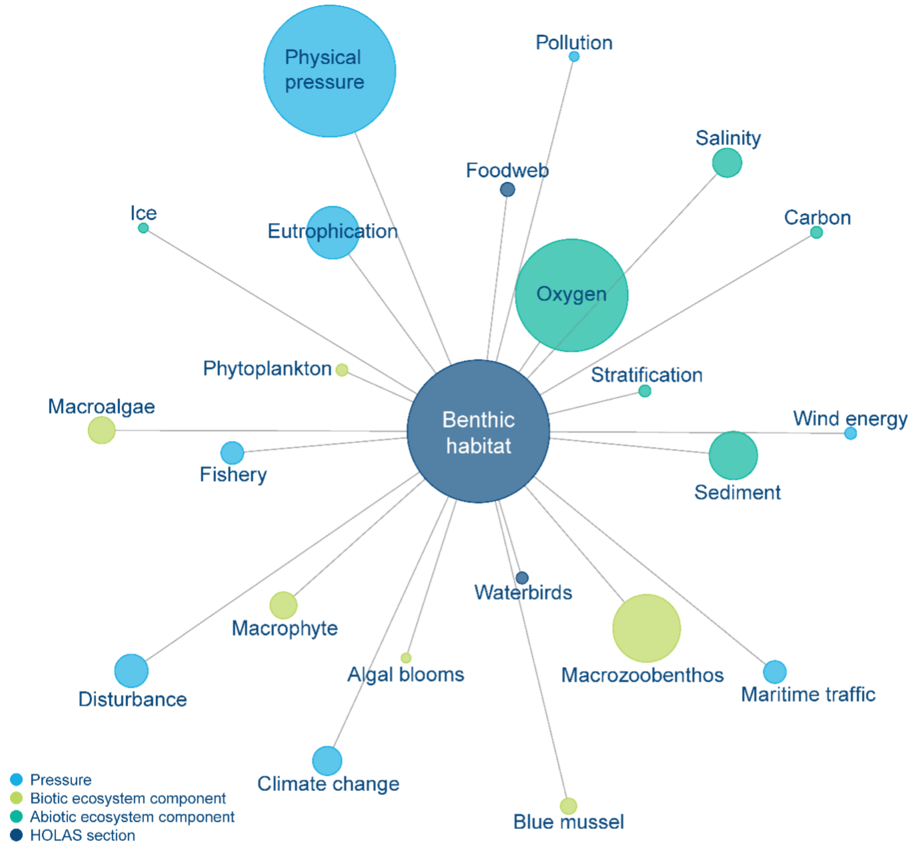

Figure 3.5. An overview of the ecosystem components and pressures descriptively linked to the status of benthic habitats in HOLAS 3. The figure reflects aspects highlighted in the chapter on this topic in the HOLAS 3 thematic assessment report on biodiversity (HELCOM 2023a), based on the terms used and interlinkages made. The chapter itself is symbolised by the dark blue circle in the centre, and the other circles represent the key elements (terms) used in the chapter. The size of each circle is based on how often the term is mentioned in the chapter and should only be interpreted in this way. The terms are aggregated, so each circle includes both the term itself and all terms deemed to be synonymous (e.g. “eutrophication” includes “eutrophication” and associated terms such as “nutrient input” or “concentrations”). The width and length of the lines and the placement of the items is arbitrary. The image gives a simple visual representation of the topics covered in the evaluation, while simultaneously providing a gap analysis of where more information may be required in the future to increase the holistic nature of the evaluation (e.g. if an interaction between a certain pressure and an ecosystem component has not been well addressed). The overview was made using igraph.

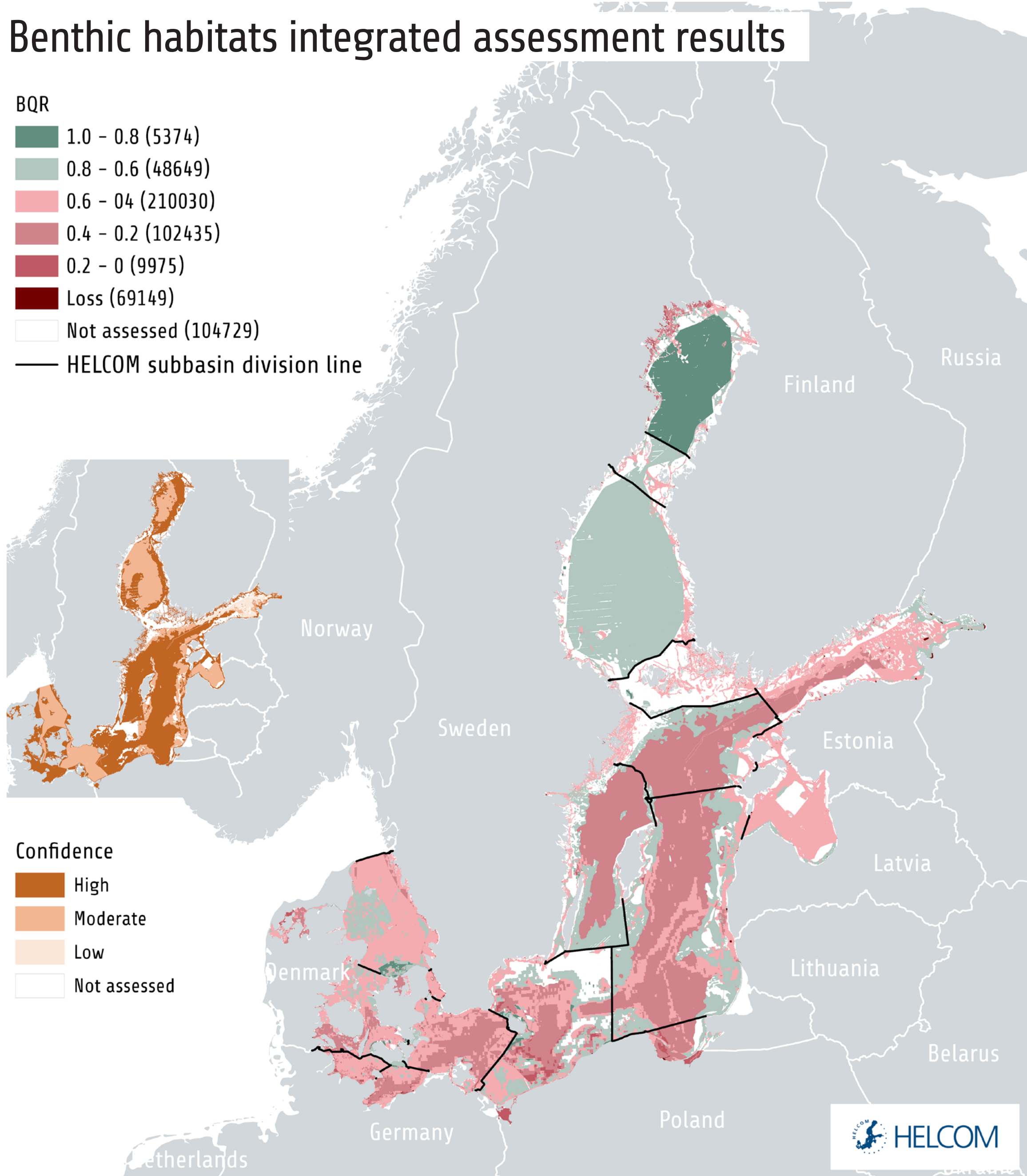

Figure 3.6. Summary of results from the integrated assessment of benthic habitats. Biological quality ratios (BQR) above 0.6 correspond to good status. Assessment confidence is presented in the inset map on the left. Source: HELCOM 2023a.

What can we do – what is affecting the status of benthic habitats?

Benthic habitats are often under impact from several simultaneous pressures, particularly in coastal areas. Typical pressures affecting benthic habitats are eutrophication, alteration of the physical habitat, habitat loss and pollutants.

Oxygen depletion in benthic habitats is influenced by the eutrophication status of the Baltic Sea, as increased productivity in pelagic habitats leads to increased sedimentation of organic matter to the seabed, where oxygen is consumed as the material decomposes (Figure 3.4).

Several human activities also cause physical disturbance to the deeper parts of the seafloor, including bottom trawling fishery, extraction and disposal of sediments, and construction. The cumulative impact-risk from physical pressures is generally highest in the southern Baltic Sea and in the Kattegat, where pressures with a wide spatial extent commonly occur, such as bottom trawling. To improve the status of benthic habitats, nutrient runoff and physical disturbance from human activities such as bottom trawling must be reduced.

Effects of climate change on benthic habitats

In the Baltic Sea, many benthic species live at their distributional limit with regards to high or low salinity (Figure 3.7), and even small fluctuations in climate-related factors can affect their abundance, biomass or spatial distribution (HELCOM/Baltic Earth, 2021).

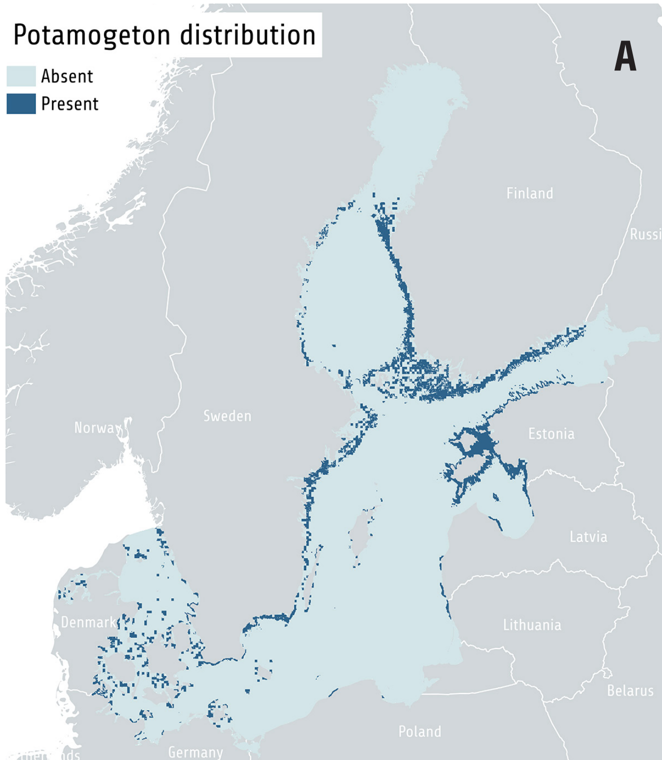

Figure 3.7. Distribution of a) Potamogeton spp, an important freshwater macrophyte in the Baltic Sea, b) Fucus spp, a brown macroalga, and c) the marine macrophyte Zostera marina (eelgrass). Source: HELCOM 2023a.

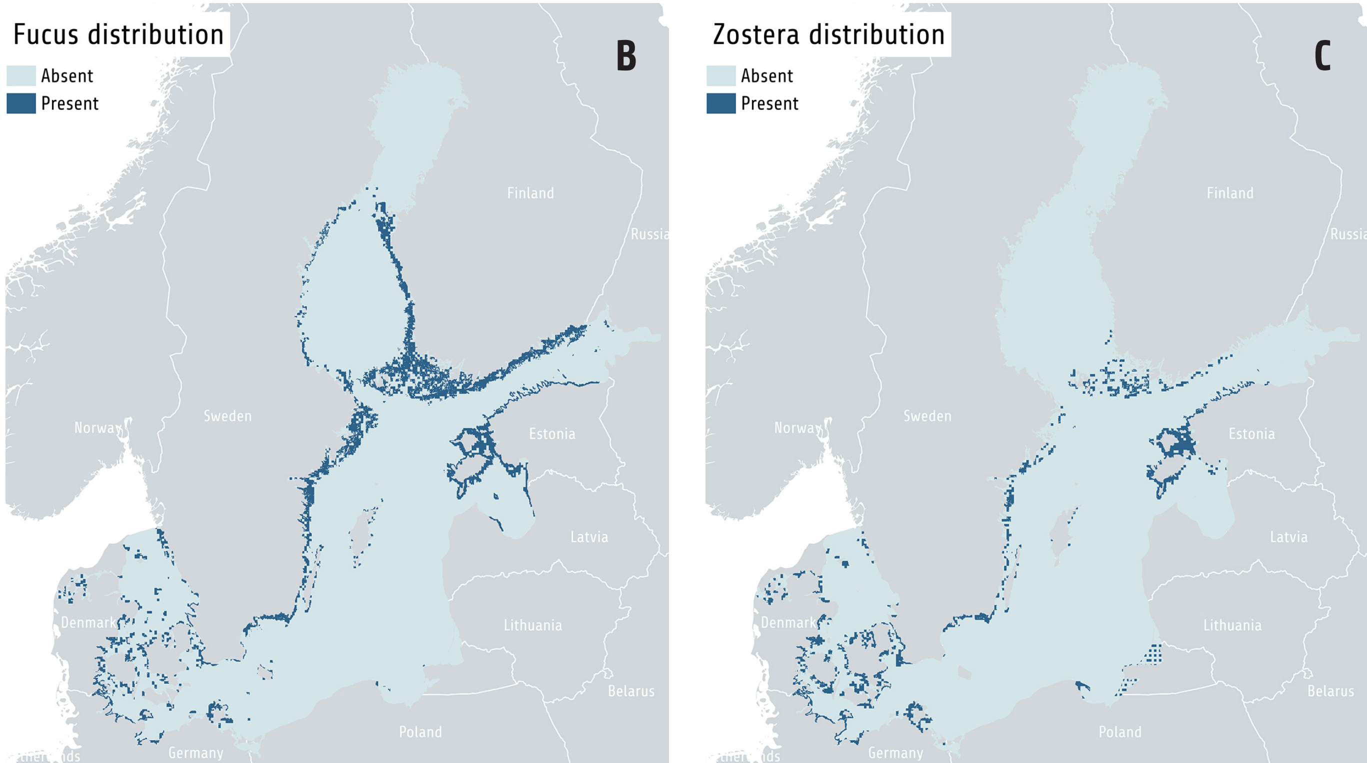

Figure 3.7. (Continued).Distribution of a) Potamogeton spp, an important freshwater macrophyte in the Baltic Sea, b) Fucus spp, a brown macroalga, and c) the marine macrophyte Zostera marina (eelgrass). Source: HELCOM 2023a.

The potential effects of climate change on benthic habitats are closely linked with processes in the pelagic system and on land. If climate change leads to increased freshwater inflows, this could bring more dissolved organic carbon to the sea. This would first affect pelagic primary production, which could either decrease or increase, depending on which species are favoured, and affect benthic habitats via changes in the amounts of organic material that eventually sinks down and reaches the seafloor. Such a scenario could mainly be expected in the northern Baltic Sea (Gulf of Bothnia). In the Baltic Proper, the combined effects of warming and planned nutrient reductions could lead to reduced amounts of carbon reaching the seafloor in the future (HELCOM/Baltic Earth, 2021). However, algal blooms have been observed more frequently during warmer years in recent decades (HELCOM/Baltic Earth 2021). Increased algal blooms may cause increased decomposition and the depletion of oxygen in bottom sediments (Carstensen *et al.* 2014). Warmer seawater in the winter may also increase the energy expenditure of certain species, such as mussels (Waldeck & Larsson 2013).

If climate change leads to lowered production of benthic animals or reduces their quality as prey, this would also have negative effects on the feeding conditions for fish, marine mammals and waterbirds (Hjerne *et al.* 2019, Kahru *et al.* 2014, 2016, 2020, Lindegren *et al.* 2012, Saraiva *et al.* 2019, Waldeck & Larsson 2013).

3.2.3 The status of fish

For fish (Figure 3.8), only four out of fifteen commercial stocks in the Baltic Sea have good status on average during 2016-2021. Compared with the previous assessment period (HELCOM 2018), the status has declined for three stocks, improved for one stock, and remained unchanged for eight stocks assessed in both periods (Figure 3.9a). The integrated status of coastal fish is good in two out of twenty-two assessed coastal areas (Figure 3.9b). For migrating species, salmon (*Salmo salar*) stocks in the northern Baltic rivers have improved, but their status is far from good in many rivers further south. The European eel (*Anguilla anguilla*) remains critically endangered, and efforts to re-introduce the regionally extinct sturgeon (*Acipenser oxyrinchus*) are ongoing.

For the first time, the HOLAS assessment includes evaluation of changes in fish age/size structure (HELCOM 2023a). Regional work should continue to develop these assessments in relation to definitions of good environmental status, to ensure the overall assessment has sufficient confidence (see also section 4.3.1).

Why is this important?

Fish are a key food source for humans, waterbirds, marine mammals, and other fish. Deterioration of fish populations affects fishing opportunities for people as well as food provisioning for many Baltic Sea species. Effects can also be seen in the long term, since depleted stocks are less productive than healthy stocks.

Healthy fish populations contribute to several ecosystem services. The role of piscivores in regulating food webs and maintaining trophic structure is increasingly recognized, in connection to worrying declines in several key piscivores in the Baltic Sea, such as cod and pike.

Deteriorated stocks are more vulnerable to environmental changes. Because of the central role of fish in the food web, this also lowers the overall resilience of the ecosystem.

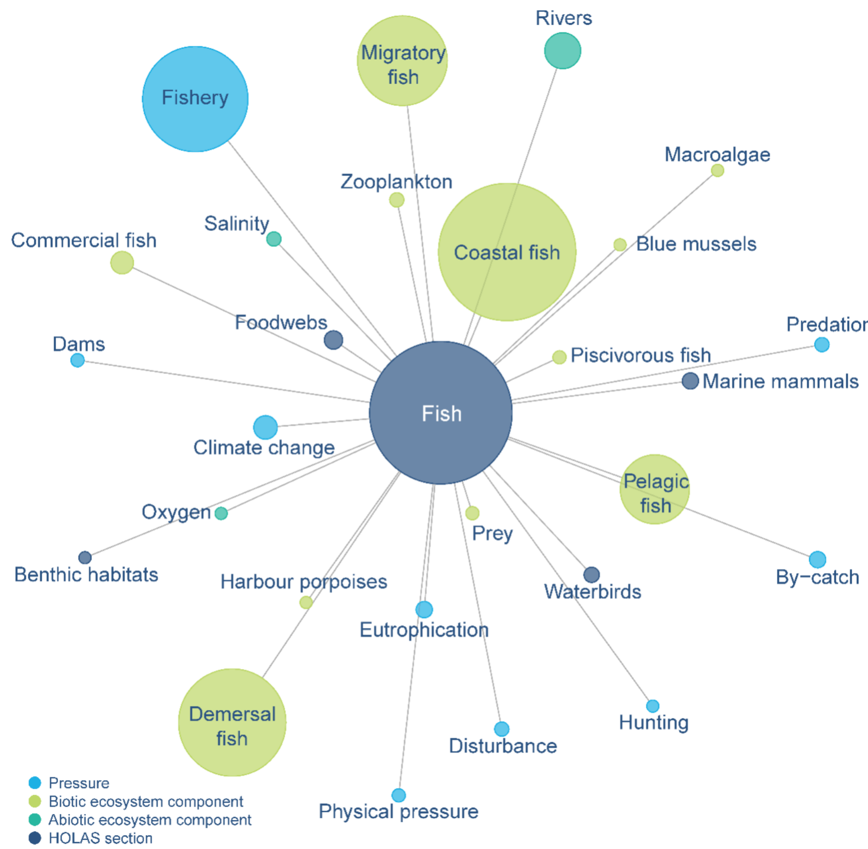

Figure 3.8. An overview of the ecosystem components and pressures descriptively linked to the status of fish in HOLAS 3. The figure reflects aspects highlighted in the chapter on this topic in the HOLAS 3 thematic assessment report on biodiversity (HELCOM 2023a), based on the terms used and interlinkages made. The chapter itself is symbolised by the dark blue circle in the centre, and the other circles represent the key elements (terms) used in the chapter. The size of each circle is based on how often the term is mentioned in the chapter and should only be interpreted in this way. The terms are aggregated, so each circle includes both the term itself and all terms deemed to be synonymous (e.g. "eutrophication" includes "eutrophication" and associated terms such as "nutrient input" or "concentrations"). The width and length of the lines and the placement of the items is arbitrary. The image gives a simple visual representation of the topics covered in the evaluation, while simultaneously providing a gap analysis of where more information may be required in the future to increase the holistic nature of the evaluation (e.g. if the interaction between a pressure and an ecosystem component has not been well addressed). The overview was made using igraph.