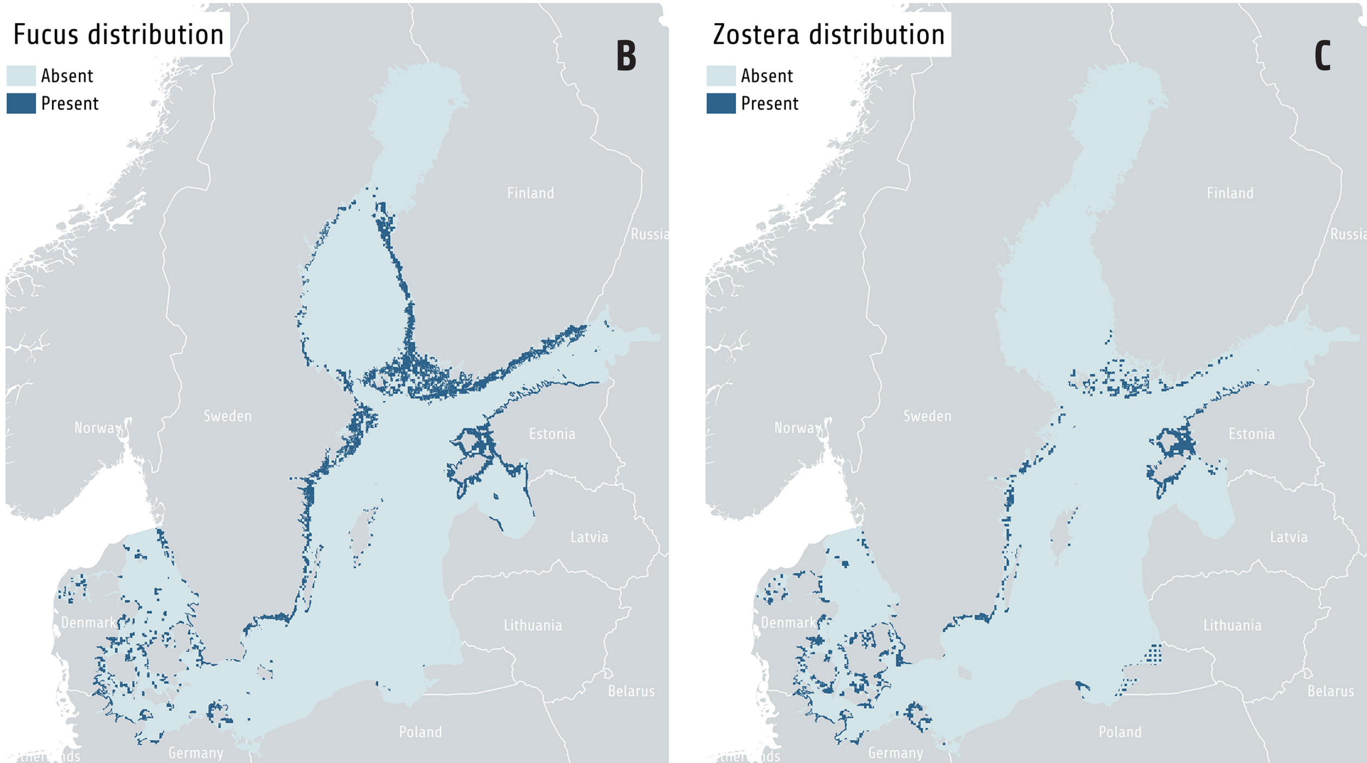


**Figure 3.7.** (Continued).Distribution of a) Potamogeton spp, an important freshwater macrophyte in the Baltic Sea, b) Fucus spp, a brown macroalga, and c) the marine macrophyte Zostera marina (eelgrass). Source: HELCOM 2023a.

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.*

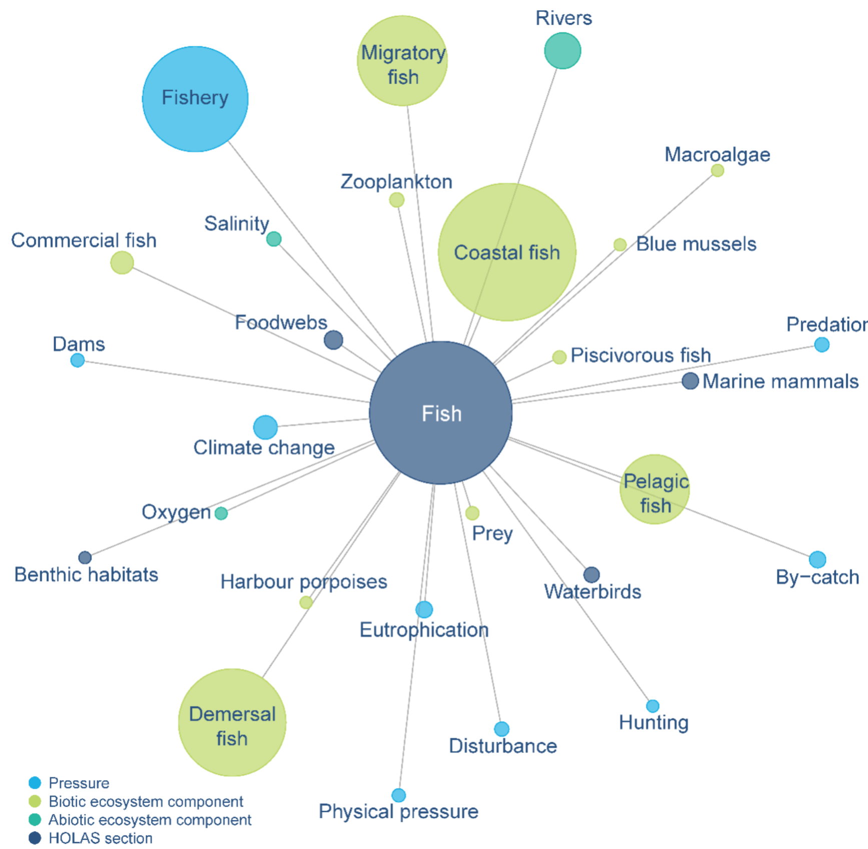


**Figure 3.8.** An overview of the ecosystem components and pressures descriptively linked to the status of fish in HOLAS 3. The figure reflects aspects highlighted in the chapter on this topic in the HOLAS 3 thematic assessment report on biodiversity (HELCOM 2023a), based on the terms used and interlinkages 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.

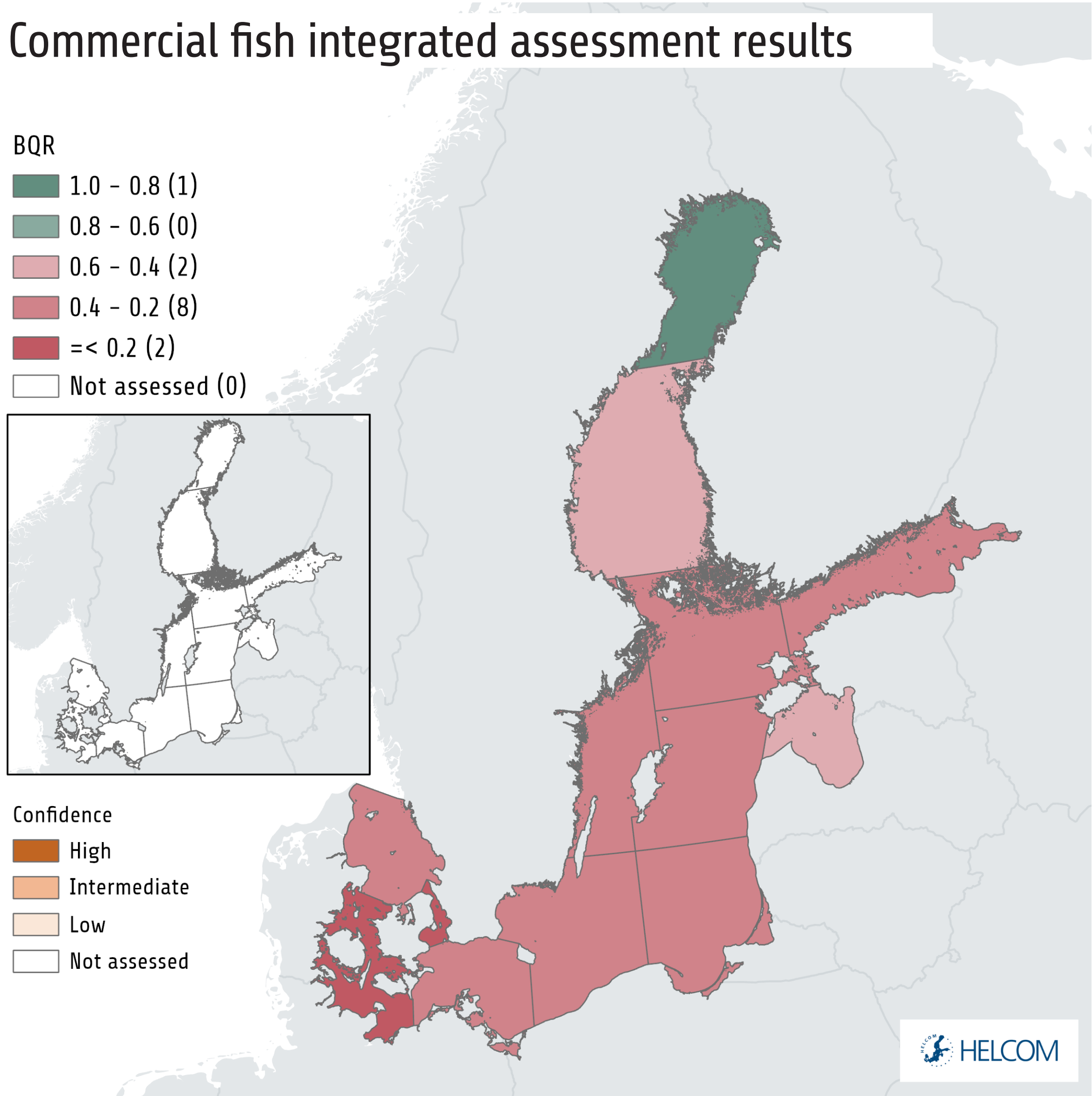


**Figure 3.9a.** Summary of results from the integrated assessment of commercial fish. Biological quality ratios (BQR) and Ecological Quality Ratio (EQR) above 0.6 correspond to good status. Assessment confidence is presented in the inserted small maps. The spatial assessment units for commercial fish are the ICES sub-divisions. Source: HELCOM 2023a.

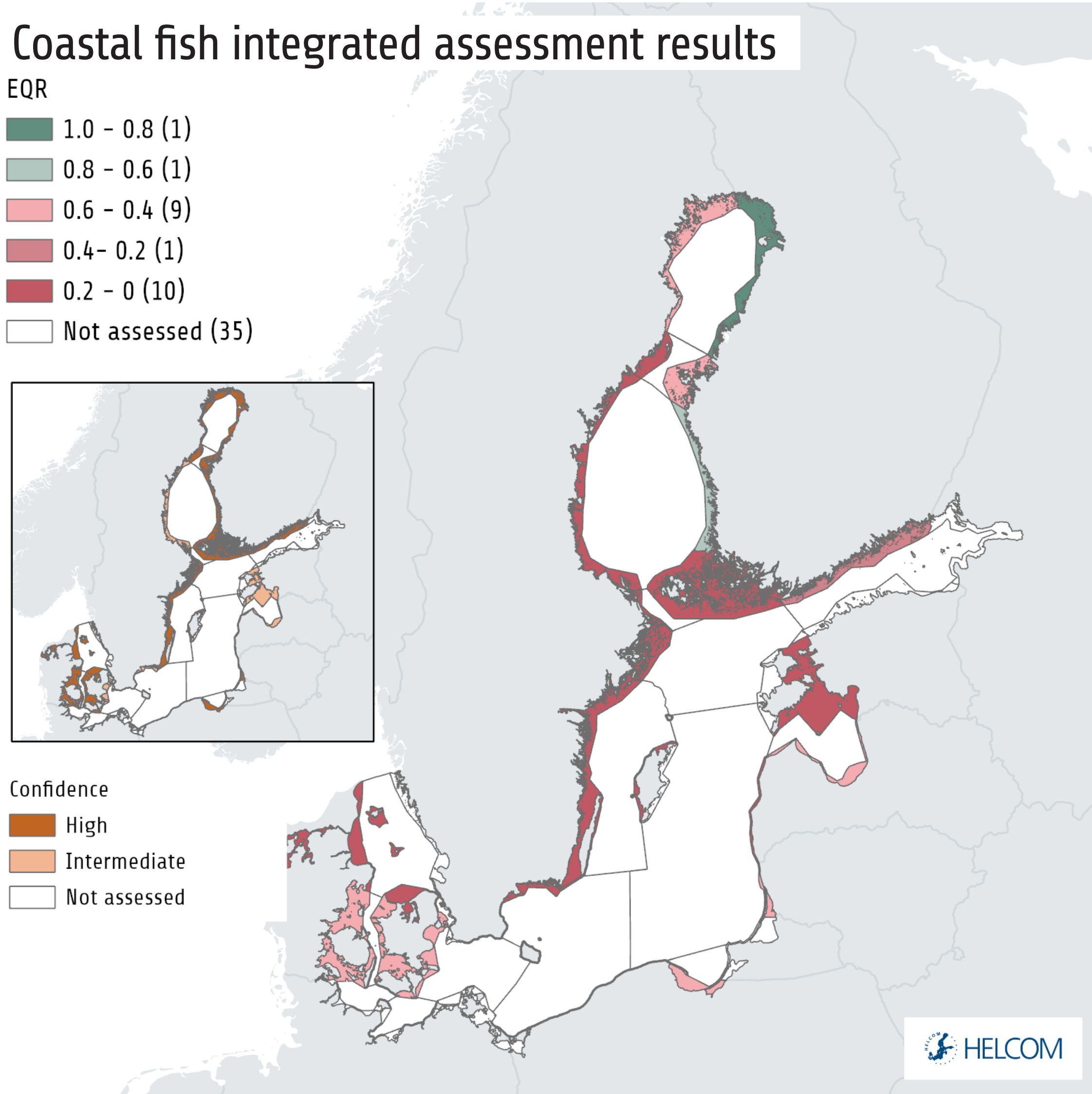


**Figure 3.9b.** Summary of results from the integrated assessment of coastal fish. Biological quality ratios (BQR) and Ecological Quality Ratio (EQR) above 0.6 correspond to good status. Assessment confidence is presented in the inserted small maps. Source: HELCOM 2023a.

### What can we do – what is affecting the status of fish in the Baltic Sea?

Overfishing has had a wide impact on fish stocks in the Baltic Sea. During the current assessment period, fishing mortality was too high for about half of the assessed stocks (HELCOM 2023a, section 4.3.1). Fish are also affected by eutrophication via its effects on habitat quality, prey abundance and feeding behavior.

Several cumulative pressures affect fish in coastal areas, including impacts on spawning areas, feeding and fish populations (Bergström *et al.* 2016, 2018, Moyano *et al.* 2022, Olsson *et al.* 2012, Olsson 2019, Snickars *et al.* 2015). The gradual reduction in the availability of important spawning and recruitment areas is a growing concern, as sheltered coastal areas and river mouths are often preferred areas for development and coastal construction (Seitz *et al.* 2014, Sundblad and Bergström 2014).

In the open sea, the currently most important spawning area for Eastern Baltic cod in the Bornholm Basin is now only a fraction of its historical area, because of oxygen deficiency. The Gdansk Basin and the Gotland Basin have had very limited contribution to cod recruitment since the 1990s (Köster *et al.* 2017).

### Effects of climate change on fish

It is very likely that climate change is already affecting fish in the Baltic Sea, and that such effects will increase in the future. Climate change can affect fish directly, through effects on recruitment success and growth (Huss *et al.* 2019, 2021, Lindmark *et al.* 2022, Polte *et al.* 2021, van Dorst *et al.* 2019), or it may influence the distribution range of species, prey availability or the strength of other ecological interactions, for example (MacKenzie *et al.* 2007). Changes in temperature and seasonality may affect the length or onset of the reproductive season of fish, or alter the availability of zooplankton during critical life stages when fish are dependent on these for food (Polte *et al.* 2021). Decreases in surface water salinity could have a strong effect on fish community composition, if marine species in the Baltic Sea are disadvantaged and habitats suitable for freshwater species expand (Olsson *et al.* 2012, Koehler *et al.* 2022). Like any other organism, fish populations are more likely to tolerate external pressures when they are in a good status (Sumaila and Tai 2020). Reaching healthy fish populations in the Baltic Sea in the near future is crucial to build the ecosystem's resilience to future negative impacts of climate.





### 3.2.4 Status of waterbirds

The overall status of waterbirds (Figure 3.10) is assessed as not good, although there is variability between groups with different feeding behaviour (Figure 3.11). Benthic feeders and waders do not have good status in any part of the region, while surface feeders have good status only in the Gulf of Bothnia. Grazing feeders do not have good status in the Kattegat, the Northern Baltic Proper, or the Åland Sea. Pelagic feeders have good status in several sub-basins. Many bird species characteristic of the Baltic Sea have decreased in abundance over the past decades, such as the pelagic-feeding great black-backed gull (*Larus marinus*) and the velvet scoter (*Melanitta fusca*), while a smaller number of species have increased, such as the greylag goose (*Anser anser*).

### Why is this important?

*Waterbirds are an integral part of the Baltic marine ecosystem, and their feeding behaviour also plays an important role in linking different parts of the ecosystem.*

*Waterbirds are a diverse group with various ecosystem functions. For example, they are predators of fish and macroinvertebrates, scavengers and herbivores*

*Waterbirds are unique in that they connect aquatic ecosystems with terrestrial ecosystems. Their long-distance migrations link the Baltic Sea with other marine regions.*

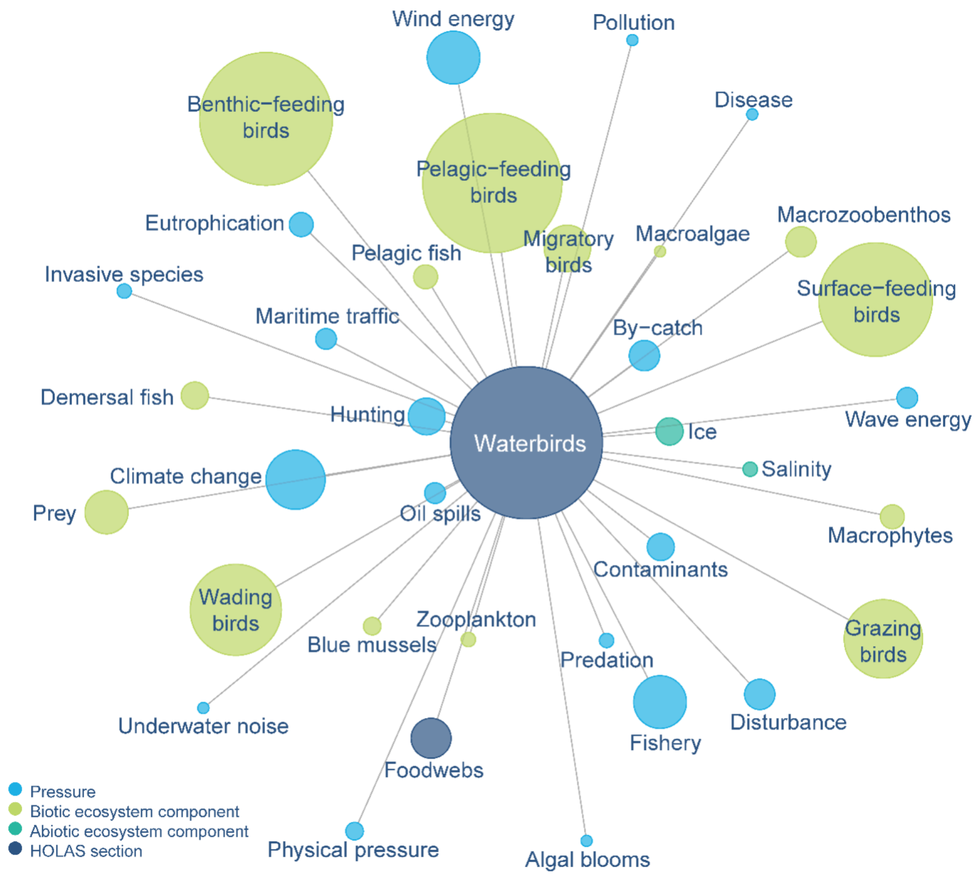


**Figure 3.10.** An overview of the ecosystem components and pressures descriptively linked to the status of waterbirds in HOLAS 3. The figure reflects aspects highlighted in the chapter on this topic in the HOLAS 3 thematic assessment report on biodiversity (HELCOM 2023a), based on the terms used and 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.