2. This is the Baltic Sea

2.1. Biodiversity and the Baltic Sea

The Baltic Sea is one of the largest brackish water areas in the world, with a surface area of 420,000 square kilometres. More than one third of the Baltic Sea is shallower than 30 meters, resulting in a small total water volume in comparison to its surface area. Furthermore, the Baltic Sea has no tides and is relatively isolated from other seas. These distinctive environmental conditions form the setting for the unique biodiversity patterns that prevail in the Baltic Sea region.

The water exchange in the Baltic Sea is slow; it takes approximately thirty years for its waters to be fully exchanged (Stigebrandt 2001). Marine water masses enter the Baltic Sea from the North Sea, predominantly during winter storms, while freshwater runs in from numerous rivers. These flows contribute to the characteristic brackish water gradient of the Baltic Sea, with a gradual decrease in salinity from around 15–18 (psu) at the surface in its entrance in the Sound, to 7–8 in the Baltic Proper and 0–2 in the northern and eastern parts. Salinity also changes with depth, because high salinity water is denser than water of lower salinity. Many Baltic Sea sub-basins are stratified, with higher salinity water in a deeper layer and lower salinity water above (Meier *et al.* 2023).

The salinity conditions of today's Baltic Sea began only around 2,000 years ago (Emeis *et al.* 2003). Before then, the salinity had been decreasing over a period of a few thousands of years. The geological history of the Baltic Sea as we know it started around 12,000 years ago when the Scandinavian ice sheet retreated at the end of the Weichselian glaciation. The sea area went through different configurations characterised by either freshwater or marine/brackish water, depending on how much it was connected to outer seas (Harff *et al.* 2011). The current opening from the Baltic Sea to the North Sea was established between 7,500 and 4,000 years ago. Before this, the connection to the North Sea was wider. Land upheaval has caused the connection to narrow (Leppäranta and Myrberg 2009).

The Baltic Sea also has other distinct characteristics. It is regularly covered by ice in the winter, and even though the sea is shallow, the water at the bottom remains cold during the summer. In general, the water is more turbid than oceanic water. The photic layer, in which photosynthesis is possible, is narrower than in the oceans.

There are clear geographical patterns in biodiversity across the region. The Baltic Sea ecosystem includes both marine and freshwater species, which can tolerate the brackish conditions. In several coastal areas, marine and freshwater species may live side by side and interact within the same food web. However, the brackish water conditions limit the distribution range of many aquatic species. The low salinity limits the distribution into the Baltic Sea of many marine species, while the range of many freshwater species does not extend into waters with too high salinity for them. This creates a salinity-driven gradient in biodiversity (Figure 2.1). The overall number of species decreases from south to north. In total, the Baltic Sea has around 5,000 known species (HELCOM 2017), out of which just over 3,000 are macro-species (species that are visible to the naked eye; HELCOM 2020a). The species form a variety of populations and subpopulations which interact to create the unique ecosystem that is the Baltic Sea. While these numbers may seem high, they are low in comparison with most other sea areas. Because many Baltic Sea species live at the edge of their salinity tolerance, any further changes in their living environment can radically alter their abundance or growth. The structure of the communities could change significantly in response to even a small change in environmental conditions.

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In many cases, the species of the Baltic Sea are genetically distinct from their counterparts in other areas. Most Baltic species of marine origin likely originate from a time when this region was saltier. As the salinity has decreased over the past few thousand years, these species have faced the formidable challenge of adapting to the novel conditions or becoming locally extinct (Russell 1985). Modern methods of population structure analysis make it possible to study evolutionary adaptation processes in detail. There are several examples of marine species in the Baltic Sea undergoing genetic diversification and ecological adaptation on a very rapid timescale from an evolutionary perspective (Johannesson and André 2006, Pereyra *et al.* 2009). Two endemic species to the Baltic Sea have been identified, the narrow wrack (*Fucus radicans*; Bergström *et al.* 2005) and the Baltic flounder (*Platichthys solemdali*, Momigliano *et al.* 2018).

A highly varied geomorphology contributes further to creating a mosaic of unique habitats and biodiversity conditions across the region. The southern coasts are often characterized by sand, whereas rocky and moraine shores are a common feature in the north. Overall, these conditions make the Baltic Sea exceptional in terms of its biodiversity (Figure 2.2). There is no other sea like it in the world. The ecosystems of the Baltic Sea are simultaneously very unique and very vulnerable.

We humans are an integral part of the natural world and entirely dependent it for our survival. In the Baltic Sea region, and around the world, we depend on healthy ecosystems in our daily lives, often in ways that are not directly apparent or appreciated. As biodiversity is essential for the natural processes that support all life, biodiversity status is a key indicator of the health of an ecosystem. Maintaining a good state of biodiversity ensures the ecosystems' resilience and productivity, as well as their capacity to adapt to future environmental changes. Each unit and level of biodiversity fulfils a multitude of necessary functions in a complex network. Without healthy populations of a wide range of animals, microorganisms, plants and algae, we cannot have the healthy ecosystems that we rely on. However, despite its ecological, cultural and economic importance, biodiversity is still being degraded and lost in the Baltic Sea region, and the importance of functioning ecosystems for human well-being is too often underestimated or poorly recognized in planning and decision-making.

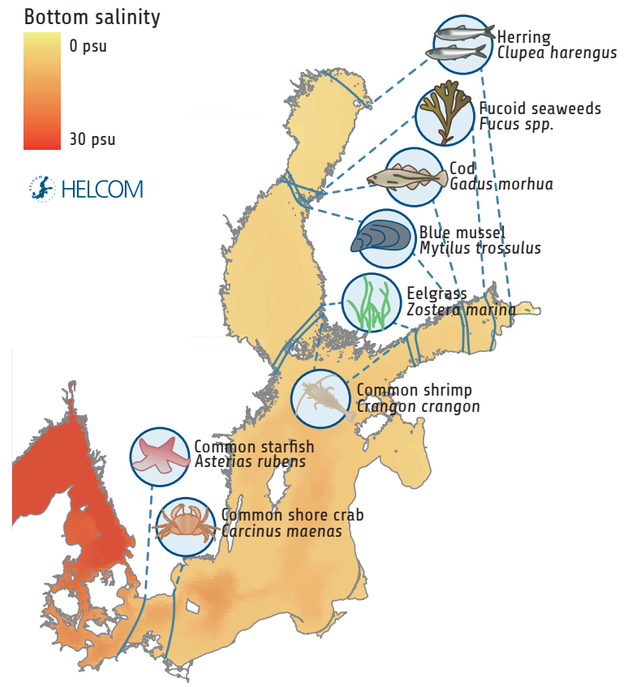

Figure 2.1. The clear majority of the macrospecies in the Baltic Sea are benthic invertebrates. The other main species groups are macrophytes (including algae, vascular plants and bryophytes), followed by fish. Phytoplankton diversity includes the currently known planktonic microalgae and cyanobacteria.