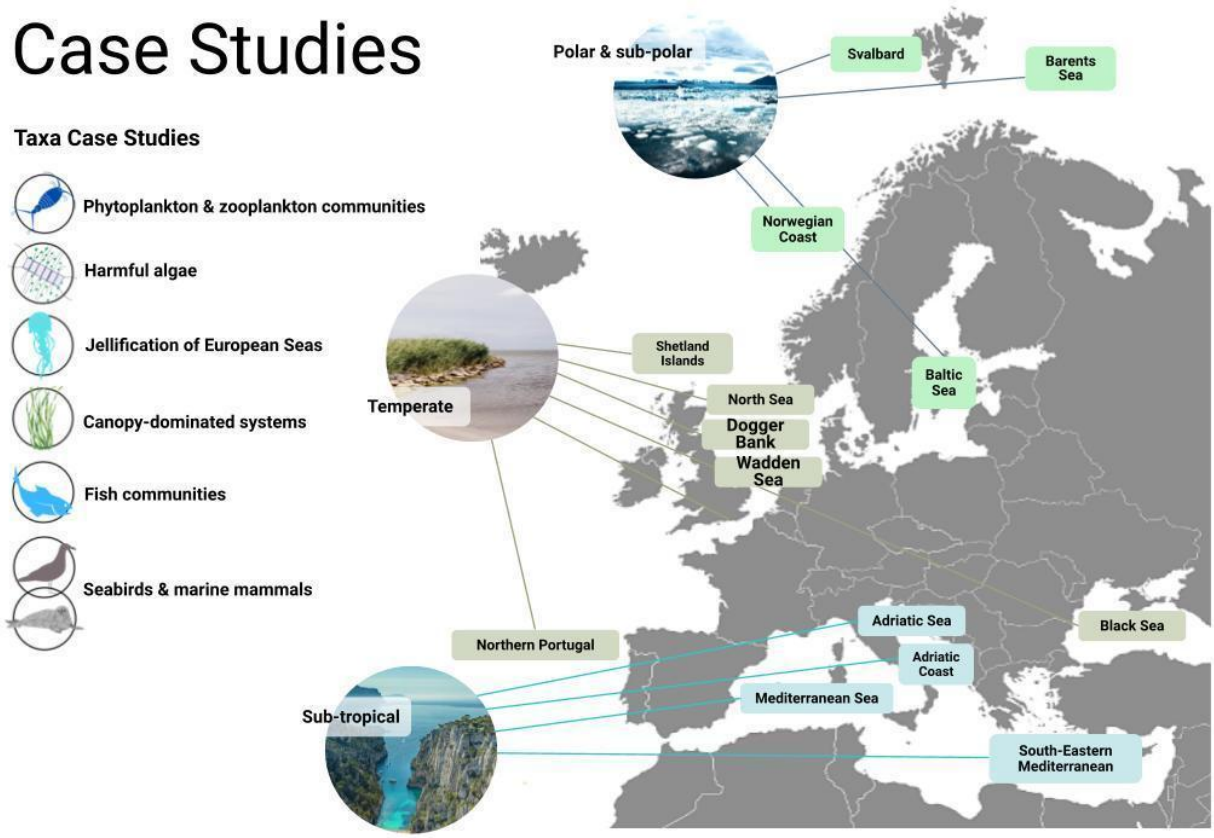
Case Study 3
Polar & Sub-Polar

Baltic Sea Food Webs



ACTNOW

ACTNOW is an EU-funded research project aimed at understanding the cumulative impacts on European marine biodiversity, ecosystem functions, and services for human wellbeing. The project equips regulators and decision-makers with essential knowledge and tools to combat biodiversity loss in coastal and marine habitats threatened by climate change and other regional drivers.

Conducted across various Case Study Regions in Europe, ACTNOW focuses on delivering scientific support for adaptation and mitigation measures, sustainable blue economy expansion, and contributions to the UNFCCC.

The project is structured into six Workpackages: WP1 (Data, Indicators and Scenarios), WP2 (Marine Organisms under Multiple Drivers), WP3 (Community, Food-Web and Ecosystem), WP4 (Cumulative Risks & Biodiversity Assessments), WP5 (Synthesis, Impacts & Solutions Options), and WP6 (Communication and Dialogue).

Objectives include developing 'what if' scenarios, understanding combined impacts on ecosystems, employing advanced biologging and molecular methods, and enhancing awareness of the links between marine biodiversity and human health.

ACTNOW has 17 CSs, 11 are regional CSs while 6 are pan-European (group / taxon) CSs. All are designed to deliver a cause-and-effect understanding, build predictive capacity in models, and to develop indicators and tools for decision-makers charged with the stewardship of European marine biodiversity under threats from multiple drivers (stressors in call) (see fig below). In each case, drivers examined represent the local/regional priorities from regulators who co-create what-if scenarios of interacting drivers including envisioned management actions.

1. Case Study 3: Baltic Sea Food Webs

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Description

The Baltic Sea, including the Kattegat, is a large, almost non-tidal North European inland sea of 393,000 km2, with a mean depth of 54 m. Sub-polar climate conditions influence the Northern part of the Baltic Sea. The sea is divided into several basins, mostly separated by shallow sounds or sills. Surface salinity gradually declines inwards, from 18–26 in the Kattegat to 2–4 in the innermost Bothnian Bay). There is also permanent salinity stratification with depth. This causes stagnation of the bottom water and, in recent decades, has led to widespread deep-water oxygen deficiency, seasonal in Kattegat and the Danish Sounds, near-permanent in the Baltic proper, intermittent in the Gulf of Finland, but not affecting the Gulf of Bothnia. Water renewal is slow, on the order of 50 years for the whole Baltic, making it vulnerable to pollution from the surrounding catchment, with an area four times larger than the Baltic Sea, and a human population of around 85 million. The waters of the Baltic Sea are generally cold, with the northern areas freezing over every winter, but the surface waters heat up in summer, in warm years, to over 20 °C. These gradients cause large differences in ecological conditions along the sea, with biodiversity declining sharply with salinity (see Elmgren et al 2015 and references therein) .

Services

The Baltic Sea provides multiple services:

· Regulating: carbon sequestration via phytoplankton, seagrass beds of *Zostera* sp. and other shallow coastal habitats

· Provisioning: coastal fisheries, seafood (e.g. blue mussels) and relevant products from aquaculture

· Cultural: coastal and marine tourism (hiking, birdwatching, recreational boating, snorkelling and diving), culture heritage, aesthetic and educational values, including underwater archaeology

· Supporting: biodiversity, nutrient cycling, fuelling adjacent Baltic Sea habitats, and offering connectivity between marine and freshwater ecosystems.

Interacting Drivers of Biodiversity Change

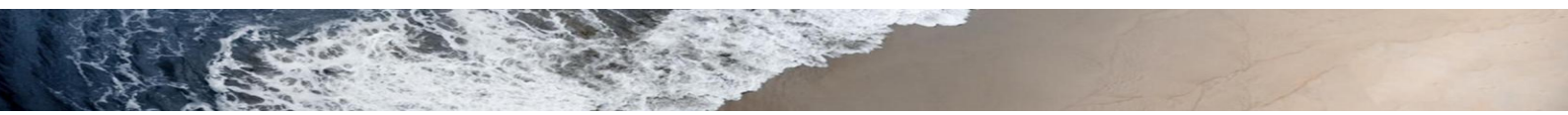
In the Baltic Sea, many drivers simultaneously affect biodiversity (species and habitats). The latest biodiversity status assessment by HELCOM (HELCOM 2023) identifies key interacting pressures, including:

3. Eutrophication: Excessive nutrient input, primarily from agricultural runoff and wastewater, intensifies algal blooms (including blooms of harmful algae and cyanobacteria) that deplete oxygen levels at the seafloor, affecting marine life and habitats.
4. Pollution: Contaminants such as heavy metals, hazardous substances, pharmaceuticals and plastic pollution, including microplastics, pose significant risks to marine species and ecosystems.
5. Climate Change: Rising temperatures and changing precipitation patterns alter the physical and chemical conditions of the Baltic Sea, impacting species distribution and ecosystem functions.
6. Land Use: Coastal development and land use changes lead to habitat loss and increased organic matter input, which affects water quality and marine ecosystem health.
7. Resource Extraction: Overfishing and activities like dredging and mining disrupt pelagic and benthic habitats, marine food webs and reduce biodiversity.

Due to the temporal and space-specific interaction of drivers, an integrated management approach that addresses these drivers simultaneously and adaptively is needed to protect further and restore biodiversity in the Baltic Sea.

Research Needs:

Due to the poor environmental status of the Baltic Sea and many species living at the extremes of their tolerable environmental conditions, the research needs are large; therefore, only a few are mentioned here. One important research need is investigating the specific effects of climate change and the other drivers mentioned above and their cumulative impact on species distribution, reproductive cycles, biodiversity (based on community metrics) and ecosystem dynamics. Also, a better understanding of the genetic diversity of key species and how this diversity contributes to the resilience of populations and ecosystems in the face of the drivers, as mentioned earlier, is urgently needed. To estimate the cumulative impacts on biodiversity, we need to develop a comprehensive biodiversity assessment that integrates different aspects of biodiversity (community, key species and habitats, and their functions). This is the challenge and the ambition of ACTNOW.



Research Planned in ACTNOW

● T1.1 Provide the current used biodiversity indicator data.

● T2.3 Assessing the impacts of multiple stressors common for the Baltic Sea coastal areas (warming, hypoxia, pollution) on performance and fitness of keystone benthic species.

● T3.1 Testing the community responses and resilience using Baltic Sea data

Some notes from DTU: Joint-species distribution models for Baltic Sea fish and benthic invertebrate communities are being set up and parameterized by DTU using the HMSC framework (which is adopted as the principal statistical modelling tool within this task). DTU expects to have a set of converged and validated models by early 2025. The models will provide improved process understanding of the drivers and assembly processes determining patterns and changes in species distribution and composition, as well as a means to forecast future changes in responses to climate change scenarios.

● T3.2 Testing the food web responses to multiple drivers using Baltic Sea data

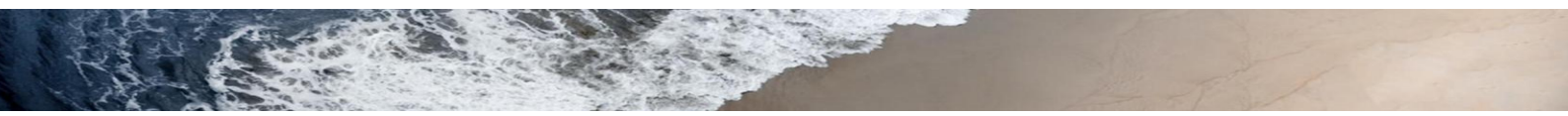
● T4.1 Using literature from the Baltic Sea for the comprehensive literature review

● T4.2 Testing the risk tool on Baltic Sea data.

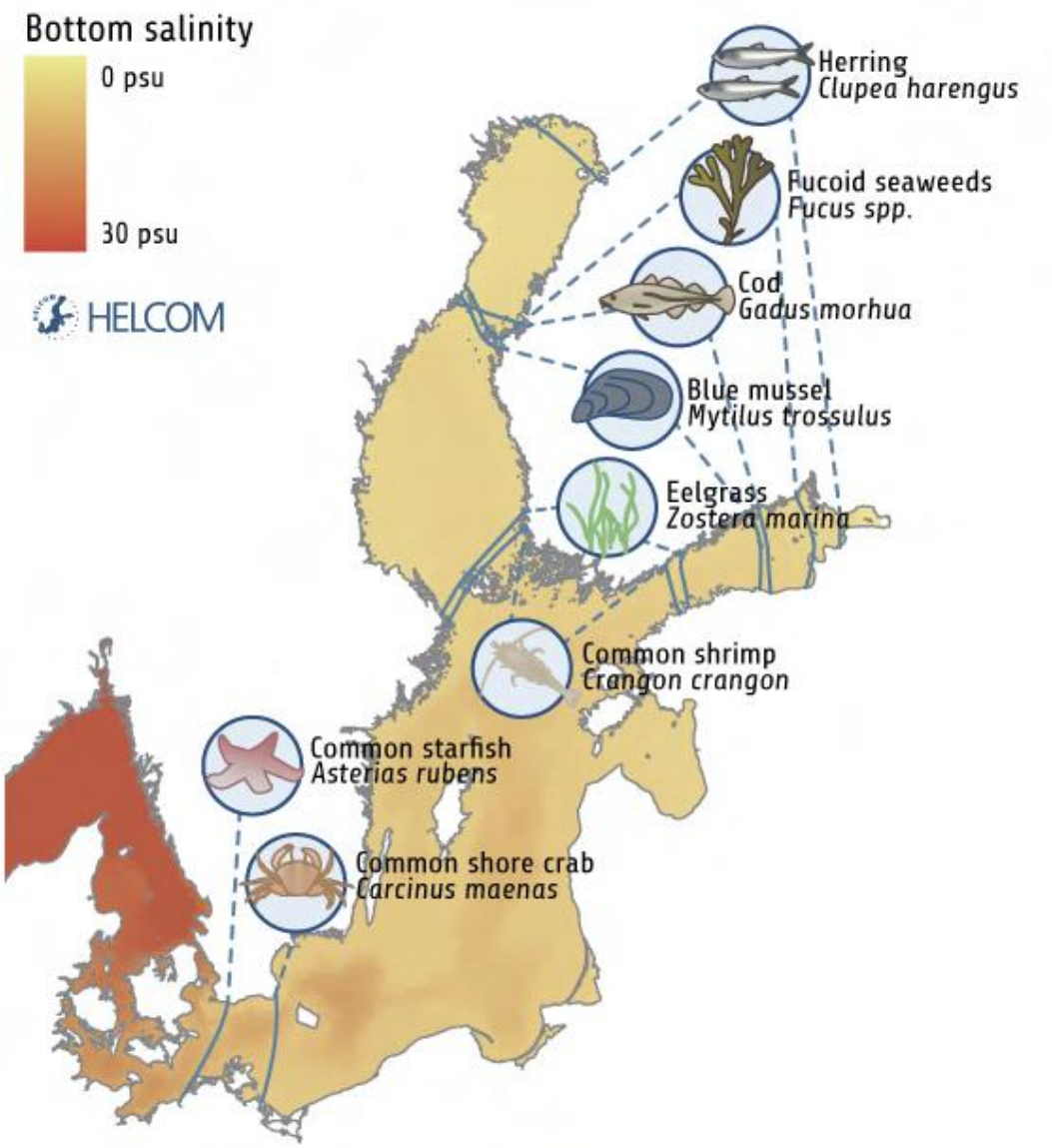
● T4.3 Developing and testing the biodiversity assessment tool at the Baltic Sea

● T5.1 Model input from joint-species distributions to biodiversity projections

● T6.2 Contributing to the development of the serious game "*Playing for change: Using experiential learning for bridging science and policy making to drive holistic understanding "*

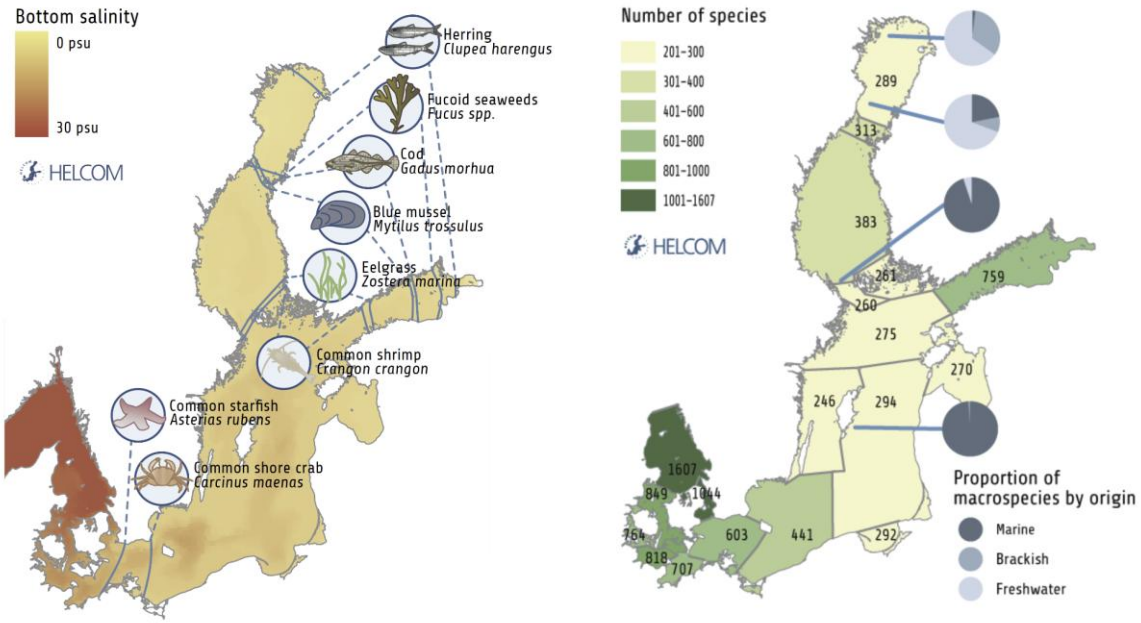


Pictures, graphs and maps



The Baltic Sea is characterised by a gradient in salinity, which also affects the biodiversity and number of species and their spatial distribution. Source: Helcom 2023

A possible alternative figure showing the number of species, also from HELCOM (HELCOM State-of-the-Baltic-Sea Second-HELCOM-holistic-assessment-2011-2016, Published in December 2018):



References

HELCOM 2023. Thematic assessment of biodiversity 2016-2021. Baltic Sea Environment Proceedings No.191." https://helcom.fi/post_type_publ/holas3_bio/