Baltic Sea - Basin-scale management & MPAs in the Baltic Sea

Storyline 8

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Introduction

The EU Horizon project FutureMARES (2020-2024) was designed to develop science-based advice on viable actions and strategies to safeguard biodiversity and ecosystem functions to maximise natural capital and its delivery of services from marine and transitional ecosystems in a future climate. The program investigates effective habitat restoration, conservation strategies and sustainable harvesting at locations across a broad range of European and other marine and transitional systems. The restoration of habitat-forming species (plants or animals) and habitat conservation (e.g. marine protected areas, MPAs) represent two nature-based solutions (NBS) defined by the EU as "resource efficient actions inspired or supported by nature to simultaneously provide environmental, social and economic benefits that help to build resilience to change". A third action that will interact with these two NBS and have positive effects on marine biodiversity is nature-inclusive harvesting (NIH) such as the sustainable farming of plants and animals at the base of marine food webs and ecosystem-based management practices for traditional (artisanal) and commercial fisheries. FutureMARES will advance the state-of-the-art forecasting capability for species of high conservation value, explore new and less carbon intensive aquaculture production methods, perform modelling analyses geared towards informing the development of climate-smart marine spatial planning approaches, and provide an assessment of ecosystem services based on scenarios of climate change and the implementation of NBS and NIH.

This document provides a multi-disciplinary summary of activities conducted in FutureMARES in a specific area on specific NBS and/or NIH. The activities include work across various disciplines including marine ecology (analyses of historical time series and experiments performed in the field and laboratory), climate change projection modelling (future physical, biogeochemical and ecological changes), economic analyses, social-ecological risk assessments. Many of these components and analyses, including NBS / NIH scenarios tested, were co-developed with local and regional stakeholders through regular engagement activities. The work presented in these Storylines represent activities conducted by a large number of FutureMARES project partners. Broader comparisons and syntheses (across regions and/or topics) are provided in the FutureMARES deliverable reports (www.futuremares.eu) submitted to the European Commission.

Introduction & NBS regional context

The Baltic Sea is one of the largest brackish water bodies in the world (1), covering 420,000 km^2. Its eutrophicated water basin is characterised by strong temperature and salinity gradients, from relatively warmer and saline waters in the southwestern part to cold and almost freshwater in the northernmost parts (2) and by vertical stratification. Salty, well-oxygenated water from the North Sea occasionally enters the Baltic Sea and propagates into the deeper areas. Due to its hydrological characteristics, the basin has a limited diversity of fish species, dominated by marine species in the southwestern areas and a combination of marine and freshwater species in the northeastern areas.

Fisheries in the Baltic Sea are focused on a few major species (cod, herring, sprat, flatfishes). The pelagic fisheries, which account for the majority of catches (by weight) in the region, are mid-water trawl fisheries for sprat and herring. The most important demersal fisheries are bottom-trawl fisheries for cod and flatfish. The demersal fisheries are concentrated in the south and west of the Baltic Sea, while the pelagic fisheries are more widespread. A recent northward shift in the distribution of pelagic stocks caused a lack of spatial overlap between predator (cod) and prey (clupeids).

Basin-wide, commercial fishing effort has declined in recent years. Overall fishing effort fell by approximately 50% from 2004 to 2012. Multispecies analysis indicates that there is a trade-off between fishing on cod or on herring and sprat in the central Baltic Sea. Many species and habitats of the Baltic Sea are not in good condition, according to recent assessments (2). This affects food web functionality, reduces the resilience and resistance against further environmental changes, and diminishes prospects for socioeconomic benefits, including fishing opportunities.

Key signals are (2):

- The overall loading of nutrients has decreased due to improved management, but annual nutrient inputs still exceed regionally-agreed goals
- The extent of deep-water areas with poor or no oxygen caused by a combination of eutrophication and fluctuating inflows of saline and oxygen-rich water from the North Sea remains high.
- Sprat, herring and cod stocks are overfished (fished at greater than FMSY).
- Cod size structure and condition factor have deteriorated markedly without signs of improvement.
- Structural shifts in the open-sea food web of the central Baltic Sea occurred in the late 1980s and early 1990s.
- Grey seal populations have grown over the past few decades following the cessation of hunting in the 1980s, but this has levelled off in recent years.

The HELCOM MPA database contains 55 MPAs, covering almost 24,000 km^2, which is 11% of the sea area in the Baltic proper. However, a recent evaluation of the ecological coherence of the MPA network shows a number of weaknesses. First, a large majority of the MPAs is situated in the coastal zone, while open sea areas and deep bottoms have relatively low levels of protection. Second, a number of MPAs lack management plans, which means that it is highly unclear if they pose any restriction on use or activities in the MPA area. It has also been pointed out that, as is the case for all European sea areas, fishing is rarely restricted in MPAs and no-take zones are almost non-existing in the Baltic proper.

Figure 1: Baltic bottom trawl Survey catch (Photo by Tycjan Wodzinowski)

Figure 2: Fishing vessel near Swedish coast. Photo by Maciej T. Tomczak

Projected impacts of climate change

Climate change is projected to cause an increase in average water temperature between 1.6°C (RCP4.5) and 2.7°C in (RCP8.5) by the end of the century (Saraiva et al. 2019). The extent of sea ice, which covers the northern parts of the Baltic Sea in winter, is predicted to decline by 53-63% (RCP4.5) and by 85% (RCP8.5), making the Bothnian Sea (RCP4.5 & RCP8.5) and even most of the Bothnian Bay (RCP8.5) ice free in March-April (Höglund et al. 2017). Baltic Sea salinity is determined by freshwater inputs and the inflows of saline water from the North Sea. Previous CC modelling projected a decline in salinity (Meier 2012, Meier et al. 2014, Vuorinen et al. 2015) while more recent projections are less clear due to the large uncertainties in runoff, wind conditions and global sea level rise (HELCOM ENCLIME factsheet in press, Höglund et al. 2017).

Eutrophication is an ongoing challenge in the Baltic Sea, with a Baltic Sea Action plan (BSAP, HELCOM 2007) in place to reduce nitrogen and phosphorus inputs. Climate change is expected to exacerbate eutrophication effects by accelerating nutrient fluxes (Carstensen et al. 2007, Meier et al. 2012, Neumann et al. 2012, Meier et al. 2018), and by increasing thermal stratification, which make coastal waters more susceptible to hypoxic events (Carstensen & Conley 2019). Nevertheless, nutrient load reductions as envisaged in the BSAP, are expected to affect nutrient concentrations, primary production and oxygen conditions more than climate change (Meier et al. 2012, 2018), with moderate uncertainty on the response of the Baltic Sea to load changes in a warming climate (HELCOM ENCLIME fact sheet in press).

Climate-driven changes in water temperature, salinity and eutrophication have an influence at all trophic levels and on the structure and function of the ecosystem (Leppäranta & Myrberg 2009). Rising temperature and lowered salinity is expected to affect species physiology (i.e. body growth) and reproduction capacity (i.e. cod and sprat) in positive (sprat) and negative (cod) ways. Climate change, especially rising temperature, impacts spatial and seasonal distributions of stocks. Impacts on bird communities are expected due to shifts in prey resources causing changes in migration patterns as well as foraging and food quality (HELCOM ENCLIME factsheet in press).

Reduction of ice-cover, sea level rise and increase of temperature may result in decreasing abundance and shifts in the distribution of seals (HELCOM ENCLIME factsheet in press). Occurrence of new, unobserved conditions (Ammar et al. 2021) may result in increases in the abundance of non-native invasive species already existing in the Baltic Sea (HELCOM ENCLIME factsheet in press). Due to indirect changes of fish abundance and distribution, fisheries strategies and fishing grounds may change (Bauer et al. 2018, 2019).

Figure 3: Cyanobacterial bloom in the Baltic Sea July 11, 2005. Satellite image from NASA' s Terra satellite, MODIS instrument. Credit: www.su.se/deep/english/publications/cyanobacterial-summer-blooms-progressively-earlier-in-the-baltic-sea-1.197802

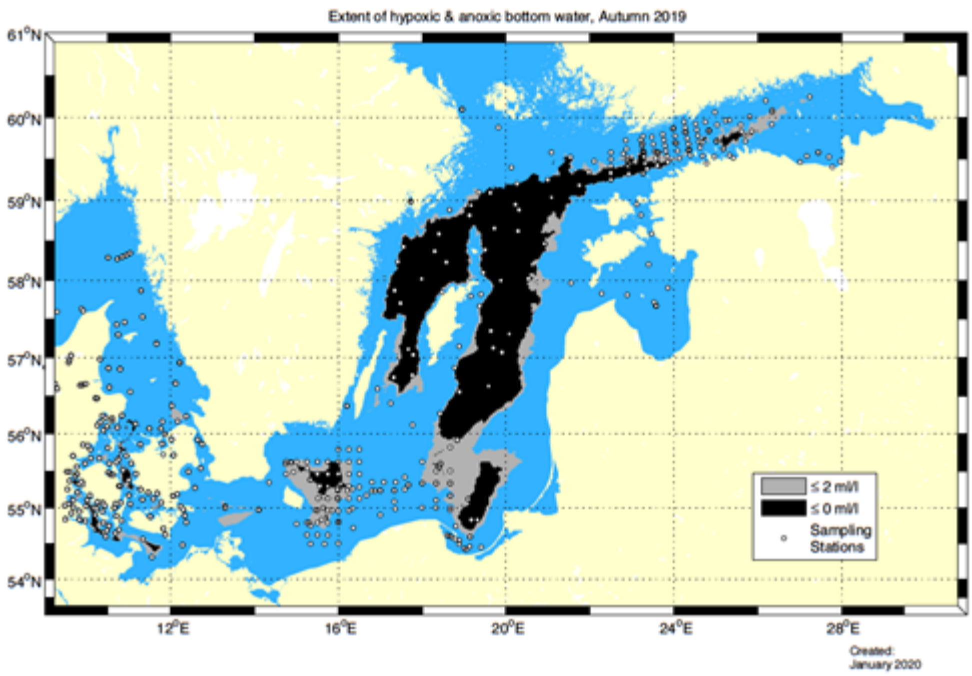

Figure 4: Oxygen Survey in the Baltic Sea 2019 - Extent of Anoxia and Hypoxia, 1960-2019 (Hypoxic and Anoxic area at grey and black). Credit: SMHI 2019. REPORT OCEANOGRAPHY No. 67, 2019 Martin Hansson, Lena Viktorsson & Lars Andersson Swedish Meteorological and Hydrological Institute, Göteborg, Sweden

Scenarios describing future society and economy

FutureMARES will develop policy-relevant scenarios based on commonly used IPCC frameworks including SSPs and RCPs. These broad scenarios are regionalised based on stakeholder perspectives to guide activities such as model simulations in specific Storylines. Each of these scenarios has implications for the three NBS examined in this program (effective restoration, effective conservation, sustainable seafood harvesting):

Global Sustainability (SSP126) - Low challenges to mitigation and adaptation

The world shifts gradually but pervasively to a more sustainable path, emphasising inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, investments in educational and health accelerate lower birth and death rates, and the emphasis on economic growth shifts to an emphasis on human well-being. Societies increasingly commit to achieving development goals and this reduces inequality across and within countries. Consumption is oriented toward lower material growth, resource and energy intensity.

National Enterprise (SSP385) - High challenges to mitigation and adaptation

A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to focus on domestic or regional issues. Policies shift over time to be oriented more on national and regional security. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialised countries and high in developing ones. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.

World Markets (SSP585) - High challenges to mitigation, low challenges to adaptation

The world increasingly believes in competitive markets, innovation and participatory societies to produce rapid technological progress and train and educate people for sustainable development. Global markets become more integrated and strong investments in health, education, and institutions are made to enhance human and social capital. The push for economic and social development is coupled with exploiting abundant fossil fuel resources and adopting resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

Figure 5: Representation of three, broad scenarios to be regionalised to guide activities such as model simulations in FutureMARES project. Credit: FutureMARES

FutureMARES research needs

Research is needed to understand how scenarios of climate change, nutrient inputs and fisheries management options impact the natural capital and ecosystem functioning including sustainable harvesting in the central Baltic Sea ecosystem. It is important to understand how fisheries management may have significantly different outcomes under different environmental conditions. Particularly relevant is gaining knowledge on the sustainable use of ecosystem resources and the trade-offs of different spatial fisheries management plans in relation to environmentally-driven changes in stock distribution under different scenarios of MPA's.

FutureMARES research (T = Task – see program structure at futuremares.eu)

Key research in this storyline includes:

- **T1.4** Refine regional narratives for the central Baltic Sea based on previous stakeholder engagement conducted as part of the Baltic Sea Action plan;
- **T2.3** CMIP6 downscaled projections along with eutrophication scenarios will be used to provide updated biogeochemical changes (temperature, salinity, oxygen) for the central Baltic Sea;
- **T4.4** Redesign an ecosystem model for the central Baltic Sea (Ecopath with Ecosysm and Ecospace) and conduct scenario tests examining the effectiveness of NBS2 (MPAs) and NBS3 (sustainable harvesting – fisheries management plans) in reference to the indicators defined in the regional and Eu Legislation (i.e Marine Stategy Framework, Common Fischeies Pollices, Baltic Sea Action Plan etc).
- **T7.1** Communicate projection results to key national (i.e HaV) and regional groups (e.g. HELCOM, ICES, BRAC) for broader distribution to regional stakeholders.

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