Document title	Baltic Sea Climate Change Fact Sheet climate change key messages related to fish, fisheries, and aquaculture
Code	3-3
Category	INF
Agenda Item	3 – Matters arising from HELCOM work of relevance for the group
Submission date	16.2.2022
Submitted by	Secretariat

Background

This document contains information on climate change impacts on fish, fisheries and aquaculture, as included in the first Baltic Sea Climate Change Fact Sheet, produced by the HELCOM-Baltic Earth Expert Network on Climate Change and published in September 2021.

Action requested

The Meeting is invited to take note of the information.

Baltic Sea Climate Change Fact Sheet – climate change key messages related to fish, fisheries, and aquaculture

This document contains concise key messages on climate change impacts on the topics 'Coastal and migratory fish', 'Pelagic and demersal fish' as well as 'Fisheries' and 'Aquaculture', as well as short summaries of all these topics. The work is a part of the first Baltic Sea Climate Change Fact Sheet which was published in September 2021 by the HELCOM-Baltic Earth Expert Network on Climate Change.

Summaries of climate change impacts of selected parameters of relevance for the Fish Group

Coastal and migratory fish

Coastal and migratory fish respond to changes in temperature, ice-cover, salinity and river-discharge. Spring and summer-spawning species (e.g. perch, cyprinids, pike) will benefit from increasing temperatures, whereas autumn-spawning (e.g. salmonids) may be disfavoured. Future actions must consider eutrophication, fishing, food-web interactions and habitat exploitation, for migratory fish also in rivers.

Pelagic and demersal fish

Fish of marine origin mainly respond to changes in temperature, salinity, water stratification and circulation influencing oxygen conditions. Actions to reduce eutrophication, anoxic conditions, and fishing, while considering food-web interactions will be important.

Fisheries

Most notable impacts to fisheries will take place in the northern Baltic Sea. Trawl fishing season will be extended, trawling areas shifted towards the south and shallower areas, target species compositions shifted towards species preferring warmer waters, and winter-time coastal fishing decreased due to diminishing ice-cover.

Aquaculture

Baltic Sea aquaculture is dominated by open-cage rainbow trout farms with low climate impact. Cultivation of blue catch-crops, including plants and invertebrates, is increasing. Warmer conditions will promote offshore locations and species diversification. Industrial scale, land-based aquaculture farms are unlikely in rural parts due to their external resource- and infrastructure dependents.

Key messages on climate change impacts on selected parameters of relevans to the Fish Group

Climate Change in the Baltic Sea Fact Sheet 2021
Indirect parameters: Ecosystem

Coastal and migratory fish

Biota and ecosystems

Linked parameters:
Water temperature, Sea ice, Salinity and saltwater inflows, River run-off, Benthic habitats, Waterbirds, Marine mammals, Marine protected areas, Ecosystem function, Fisheries

Links to main policies:
HELCOM Baltic Sea Action Plan
UN Sustainable Development Goal 14
UN Convention on Biological Diversity
EU Green Deal
EU Marine Strategy Framework Directive (MSFD)
EU Water Framework Directive (WFD)
EU Habitats Directive
EU Common Fisheries Policy (CFP)
EU Strategy for the Baltic Sea Region (EUSBSR)
EU Biodiversity Strategy

Description

Fish of freshwater origin dominate most Baltic coastal areas, some preferring warm (perch, cyprinids) and others cold waters (salmonids, burbot)[1]. These species often migrate back to their natal spawning ground for spawning, resulting in many local populations that adapt to local conditions. Small scale environmental variations, local fishing pressure, habitat availability, and food web interactions influence their reproduction, recruitment, growth, and mortality.

What is already happening?

- Higher water temperature has improved the reproduction of many spring and summer spawners[2-9].
- In contrast, the reproduction of autumn-spawners, e.g., vendace and whitefish, is disfavoured by warm winters and their distribution decreases with less ice cover and higher winter temperatures[10-13].
- Species preferring warm waters have become more common relative to winter-spawning species[14].
- Migratory anadromous species, like salmon, return earlier to rivers after warm winter/spring. However, high water temperature in autumn and winter seems to lower the survival of salmon migrating back to the sea[15-19].

What can be expected?

- Earlier spawning, faster egg, and larval development, increased larval survival of spring spawning freshwater coastal fish species[6-9,20-22] (*).
- Earlier migration from nursery habitats[5] may influence food web interactions with negative effects on piscivorous species[23] (*).
- Reproduction of autumn-spawning migratory fish is expected to decrease with increasing temperatures, and spawning areas reduced if ice cover decreases further[11-13].
- The effect of water temperature on body growth differs among species and size-classes: growth is generally expected to increase for small but not for large fish[3,10,16,17,21,22].
- Possible brownification of coastal waters may decrease body growth[24].

Other drivers

- Anthropogenic pressures, such as eutrophication, fishing, and habitat exploitation, affect fish in coastal areas .
- Pharmaceutical residues and plastics might negatively affect fish locally.
- Increased cormorant and seal populations consume substantial amounts of coastal fish[25], but the impact on fish populations is disputed[26].
- Migratory anadromous fish are affected by a similar set of pressures as coastal fish, and in rivers also by altered hydrological regimes, migration barriers caused by dams, and increased sedimentation due to land-use changes in the drainage area[19].

Knowledge gaps

Indirect and interactive effects of different natural and anthropogenic pressures in combination are poorly studied. To identify causal relationships, modelling based on monitoring data in combination with experimental studies is needed.

The effects of some expected climate induced changes, e.g., shrinking ice cover and browner waters, on coastal and migratory fish stocks are poorly studied.

The importance of extreme weather events under climate change for fish population development and status is furthermore insufficiently studied. Follow-up studies after extreme weather events (like heatwaves, and ice-free winters) are of key importance for understanding the recovery and resilience of fish populations and communities.

Policy relevance

Coastal and migratory fish are key elements for Baltic Sea coastal food web structure and function, and fundamental for small scale coastal commercial and recreational fisheries. Current measures to protect and restore coastal and migratory fish populations hardly ever target and consider climate change effects. Targeted short-term actions, e.g., temporary or spatial closures, could help affected fish populations to recover from extreme weather events. Future management should include climate change effects in status assessments and management plans, targets, and measures to acknowledge and mitigate climate related effects.

*) Expected to be caused by warmer temperatures.

Climate Change in the Baltic Sea Fact Sheet 2021
Indirect parameters: Ecosystem

Biota and ecosystems

Pelagic and demersal fish

Description

Fish of marine origin, such as cod, herring, sprat, and flatfishes (flounder, plaice, turbot, and dab), dominate pelagic and demersal habitats of the Baltic Sea[1]. These species occur in large, often internationally managed, stocks.

Currently, sticklebacks make a significant part of the pelagic fish biomass.

Temperature impacts the recruitment (successful reproduction and survival of the offspring), body growth and mortality of pelagic and demersal fish, resulting in changes in spatial and seasonal distributions.

What is already happening?

Increasing temperatures and hypoxic conditions have impaired reproduction, reduced feeding areas as well as quality of food, resulting in decreasing distributions of flatfish, herring and cod, and reduced growth and body condition of cod[2-10].

Increasing temperature favours stickleback[11,12].

Periods with low salinity are connected to lower recruitment of several flatfishes, herring, and cod[13-18], and lower abundance and lipid content of zooplankton prey for herring and sprat[19-22], resulting in lower body growth, condition, and abundance[19-23].

Recruitment of sprat is higher in warmer waters after winters with low ice cover but opposite for herring[24,25].

What can be expected?

Increasing water temperature causes earlier spawning, shorter development, and increased recruitment of sprat[24,26,27],

and increasing larval growth of herring, sprat, and flatfish, and body growth of adult sticklebacks[11,26,28,29]. Herring and cod recruits may miss optimal temperature windows resulting in lowered recruitment[25,26,28,30,31].

Increasing temperature, especially if the halocline shifts upwards and nutrient loads are not reduced, may reduce oxygen in water and sea bottom. This will lead to reduced reproduction and feeding areas, increased food competition, and dependency on shallow areas for cod and flatfishes[5,32].

If salinity decreases, this may also reduce recruitment, abundance, and distribution of flatfish, sprat, and cod[2,6,8,15,28,33].

Other drivers

Impacts of multiple drivers on offshore fish communities are perceivable[34,35]. High nutrient discharges have resulted in enhanced hypoxic conditions affecting many fish species negatively[5-10], but also benefitting others[36,37].

Nutrient loads have decreased since the 1980s, but the response in nutrient concentrations is slow and also affected by runoff and climate related variables such as temperature and stratification[31].

Fishing strongly affects cod, herring, and sprat. Harmful substances, marine litter, and pharmaceutical residues might have negative impacts on individuals while effects on populations appear to be small, yet uncertain. Food-web interactions (competition/predation/food quality) among populations are evident.

Vitamin deficiency (e.g., thiamine) may impact fish species.

Knowledge gaps

Indirect and interactive effects of climate parameters and other pressures on fish need to be better studied[38-41]. To explain causal relationships, modelling of monitoring data in combination with experiments is required. Furthermore, impacts of changes related to climate, like ice cover, brownification, and acidification, are poorly studied in the Baltic Sea.

The importance of average changes relative to extreme weather events (e.g., heatwaves vs. average temperature) are poorly studied. There is a need to analyse monitoring data before, during, and after extreme events, supplemented with experiments and long-term data to understand the recovery and resilience of fish species and communities after extreme weather events.

Policy relevance

Demersal and pelagic fish are key elements for Baltic Sea offshore food web structure and function, and offshore fisheries. Management of demersal and pelagic fish, e.g., quotas, fishing closures and protected areas, takes historic changes in stock productivity into account but does not consider predicted climate change effects. Furthermore, management of these stocks needs to be adaptive to react to long-term effects of climate change. Targeted short-term actions, e.g., temporary, or spatial closures, could help affected fish populations to recover from extreme weather events. Targets and measures in future management plans need to consider long-term impact of climate change on fish populations and communities.

Aquaculture

Human activities

HELCOM Baltic Sea Action Plan
UN Sustainable Development Goals
UN Convention on Biological Diversity
EU Green Deal
EU Water Framework Directive (WFD)
EU Maritime Spatial Planning Directive (MSP)
EU Habitats Directive
EU Strategy for the Baltic Sea Region (EUSBSR)
EU Biodiversity Strategy

Linked parameters:
Water temperature, Sea ice, Salinity and saltwater inflows, Waves, Oxygen, Pelagic and demersal fish, Coastal and migratory fish, Waterbirds, Marine mammals, Non-indigenous species, Marine protected areas, Nutrient concentrations and eutrophication, Fisheries, Blue carbon storage capacity, Marine and coastal ecosystem services

Description

Baltic aquaculture is currently dominated by open cage rainbow trout farms and contributes <0.5% of the total nutrient load to the Baltic Sea[1]. Farms are located throughout the Baltic at Åland and Åbo Archipelago (Finland), the Danish straits, and a few other scattered locations.

In both Finland and Sweden, farm closure and relocations have significantly reduced local-scale farm impacts on the marine environment. Finland and Estonia are evaluating offshore locations with a first pilot farm in the Bothnian and Tagalaht bays. Extractive farming where blue mussels and macro-algae are harvested as a way to recover excessive marine nutrients for terrestrial use, is also being explored.

What is already happening?

Summer surface-water temperatures periodically exceed the optimal for rainbow trout in the whole Baltic and especially in the northern areas[2] reducing physical fitness, impairing growth, and increasing mortality[3]. Fish species presently farmed are unlikely to be affected by changing salinity, but any increase in terrestrial nutrient loading could be negative for aquaculture. Warmer water could promote farming of more temperature resilient species, such as perch and pikeperch.

Farming of blue mussels and macro algae is negatively affected by both warmer water and lower salinity. Increased waves and more heatwaves, as well as increased predation by fish and birds would increase mussel losses[4,5].

What can be expected?

Any temperature increase, especially in combination with high algae concentrations, will further stress currently farmed organisms. A possible salinity decrease will limit mussel farming and force a shift to cultivation of freshwater tolerant plants and invertebrates. Increasing policies promoting farming in more exposed locations will raise production costs. Offshore aquaculture, especially for mussels, but also for fish, could be co-located with offshore wind farms, offering moorings at locations with high water exchange, without risk of interference with shipping and recreation[6].

Other drivers

Policies promoting circular production and rural development will be positive drivers for aquaculture, however, industrial sized land-based systems are not likely to be implemented in remote locations within the archipelago, due to infrastructure dependencies. Marine spatial planning priorities, consumer acceptance of farmed fish, as a complement to wild fish, as well as governmental acceptance of blue catch crops, are all important for future Baltic Sea aquaculture. Synergies between renewable energy and food production based on co-location of aquaculture with offshore energy should especially promote extractive aquaculture. Demands for resilient, resistant, local food production and the possibility of local and circular-based feed sources, should further promote all types of aquaculture.

Knowledge gaps

There are multiple knowledge gaps related to climate change effects on Baltic Sea aquaculture. Regional differences are incompletely understood. Reliable, local-scale projections of future water temperatures, salinity, occurrence and toxicity of algae blooms, and ice cover are needed for siting new farms. Use of native species tolerant of possible future conditions requires knowledge of techniques and ecosystem effects, including use of sterilized fish. New farming technologies offering an economically feasible solution for particle recapture and deep-water siting must also be developed and evaluated. Credible environmental assessment of both sediment and total nutrient budgets of offshore farms using Baltic feed sources are also needed. Furthermore, alternative, and new species, especially those on lower trophic levels, and their acceptance by consumers is not well investigated.

Policy relevance

Aquaculture has the potential to provide sustainable, climate-smart local food while counteracting marine eutrophication. Political obstacles and public perceptions are probably more difficult challenges to Baltic Sea aquaculture than the changing climate. Aquaculture using sterile fish, which express neither phenotypic nor behavioural spawning characteristics, is needed to protect Baltic Sea biodiversity. Policy support for science-based solutions incorporating technological innovation and best practices is needed, as are marine spatial planning processes that avoid environmentally sensitive sites but still allow aquaculture to develop to meet European and regional policy targets, such as the EU Blue Growth Strategy.

Fisheries

Authors
Meri Kallasvuo, Sanna Kuningas, Antti Lappalainen, Natural Resources Institute Finland (Luke), Finland
Örjan Östman, Jens Olsson, Rahmat Naddafi, Lena Bergström, Swedish University of Agricultural Sciences (SLU), Sweden
Oksana Glibko, St. Petersburg State Geological Unitary Enterprise "Specialized Firm Mineral", Russia
Antanas Kontautas, Marine research institute, Klaipėda University, Lithuania

Human activities

Linked parameters:
Sea ice, Sea level, Wind, Waves, Pelagic and demersal fish, Coastal and migratory fish, Marine mammals, Marine protected areas, Offshore wind farms, Ecosystem function, Shipping, Aquaculture, Marine and coastal ecosystem services

Links to main policies:
HELCOM Baltic Sea Action Plan (BSAP)
UN Sustainable Development Goals 2 and 14
UN Convention on Biological Diversity (CBD)
EU Maritime Spatial Planning Directive (MSP)
EU Common Fisheries Policy (CFP)
EU Biodiversity Strategy

Description

The commercial fishery in the Baltic Sea includes pelagic offshore and demersal fleets that contribute to 95% of total landings, and a variety of small-scale coastal fisheries. The main species targeted are Baltic herring, sprat, cod, and flatfishes. In addition, a variety of coastal freshwater and anadromous fish species are targeted. Mid-water and bottom trawls, gillnets, and trap-nets are the main gears used[1]. Recreational fishing is common in coastal areas[2]. For certain coastal species, the recreational catch is comparable or even higher than the commercial catch[3,4].

What is already happening?

In the northern Baltic Sea, trawl fishing has already seen an earlier seasonal start in some years, with better operating conditions due to a shorter period of ice cover[5]. Coastal recreational ice fishing opportunities have been reduced[2]. In much of the Baltic Sea, small-scale wintertime coastal fishing has also suffered from competition with seals that find ice-free fishing sites easier to access[5]. The species composition targeted especially by the coastal and demersal fisheries is changing due to eutrophication and climate change[6,7]. Also, increased effort is needed for fishing-gear maintenance, due to accumulating biofilm and filamentous algae[5].

What can be expected?

The potential trawling season in the northern Baltic Sea will likely be extended due to a shorter ice-covered period. The main trawling areas for pelagic species are likely to shift towards more southern, shallower areas[8,9]. The coastal and recreational fisheries will increasingly target species that prefer warmer and more nutrient-rich waters[10]. Some winter-time fishing will suffer from a shortage of ice and increased conflicts with seals. The recreational fisheries may become more popular with longer seasons for boat-trips and rod-fishing.

Other drivers

Other drivers, such as changes in society, fish stocks, fishing regulations and fish markets, are likely to have as profound effects on the fisheries sector as climate change. For example, changes in consumer demand or changes of subsidies might affect the profitability of fisheries. Other environmental issues, partly interacting with climate change, such as increasing eutrophication if nutrient reductions according to the Baltic Sea Action Plan are not achieved, changes in the regulation of harmful substances, parasite infection-rates in fish, and the dispersal of non-indigenous species, will also affect the quantity and quality of fish, and the demand for the catch.

Knowledge gaps

Scientific evidence for alteration in Baltic Sea fisheries driven by climate change is still sparse. Complicated interacting and potentially additive effects in the environment, ecosystem and society make it very challenging to predict the potential consequences of climate change on different fisheries. Therefore, conclusions are confined to the currently observed trends.

Policy relevance

Fisheries have an important role in marine economy, providing work and healthy food. Fisheries activities are regulated by the EU Common Fisheries Policy and on national level. Fish stocks' monitoring and management plans should be adaptive and adjustable to mitigate climate change effects and ensure resilience[11]. To acknowledge the potentially negative effect on fish stocks and other factors affecting the prospects of fisheries under climate change, a precautionary approach has to be applied. Climate change is only one of many challenges facing the fisheries sector: competition with apex predators and other fisheries sectors, low profitability, conflicts over shared resources, decreasing stocks of targeted species, and harmful substances are major concerns.