NE Atlantic & North Sea - Sustainable Harvesting in the NE Atlantic & North Sea: Atlantic salmon in Hardangerfjord

Storyline 4

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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.

NBS Regional Context

Atlantic salmon (*Salmo salar*) (Figure 1) is a mainstay of the Norwegian coastal economy. Wild salmon stocks have traditionally been a source of food and tourism. Farmed salmon in Norwegian Fjords (Figure 2) has grown rapidly to be worth more than NOK 70 billion in 2020 with planned capacity more than doubling since 2018 (Kontali, 20121). Wild and most farmed salmon are susceptible to modifications in ocean climate. The focus of this study will be to characterise climate thresholds on individuals with a focus on temperature. The study will evaluate viability of present populations and farm location. For wild salmon this will include an evaluation of oceanic changes representing present distributions and for future migratory trajectories. For farmed stocks, the Storyline will focus on Hardangerfjord where climate impacts will be studied in relation to the optimum farm placements in a changing climate and also on the interplay between aquaculture activity and the carrying capacity of the fjord. Climate opportunities for farming in Northern Norway will also be evaluated. Climate challenges to the migration of wild salmon will be studied in Hardangerfjord and the coastal waters at the mouth of Hardangerfjord.

Figure 1: Atlantic salmon. © ourspecies.com

Figure 2: Salmon farm in Western Norway. © Intrafish

Projected impacts of climate change

The temperature tolerance of adult fish is high, between -0,9 - 23 °C (e.g. Figure 3) (Dalkhe et al., 2020; Calado et al., 2021). Nevertheless, wild salmon are most commonly reported in temperatures between -8 to 16 °C and Salmon from northern fjords have been shown to prefer temperatures for feeding migration between 1.6 and 8.4 °C (Strøm et al., 2019). Salmon have been shown in aquaculture systems to have a sustainability limit of 22-24 C (Barton, 1996). The temperature sensitivity of migrating smolt is much higher and optimum temperature range between 9-15 °C (Calado et al., 2021) and young salmon have a preference range of 8-12 °C (Holm et al., 2004; Sheehan et al., 2012).

Initial analysis of the climate model projections of surface temperature across the mouth of Hardangerfjord (Figure 4) indicate that there will be small to moderate temperature risk to smolt and adult salmon. However, these are monthly averaged values and do not represent shorter timescale warming events. This will be part of the future studies in this project where regional climate models will be used.

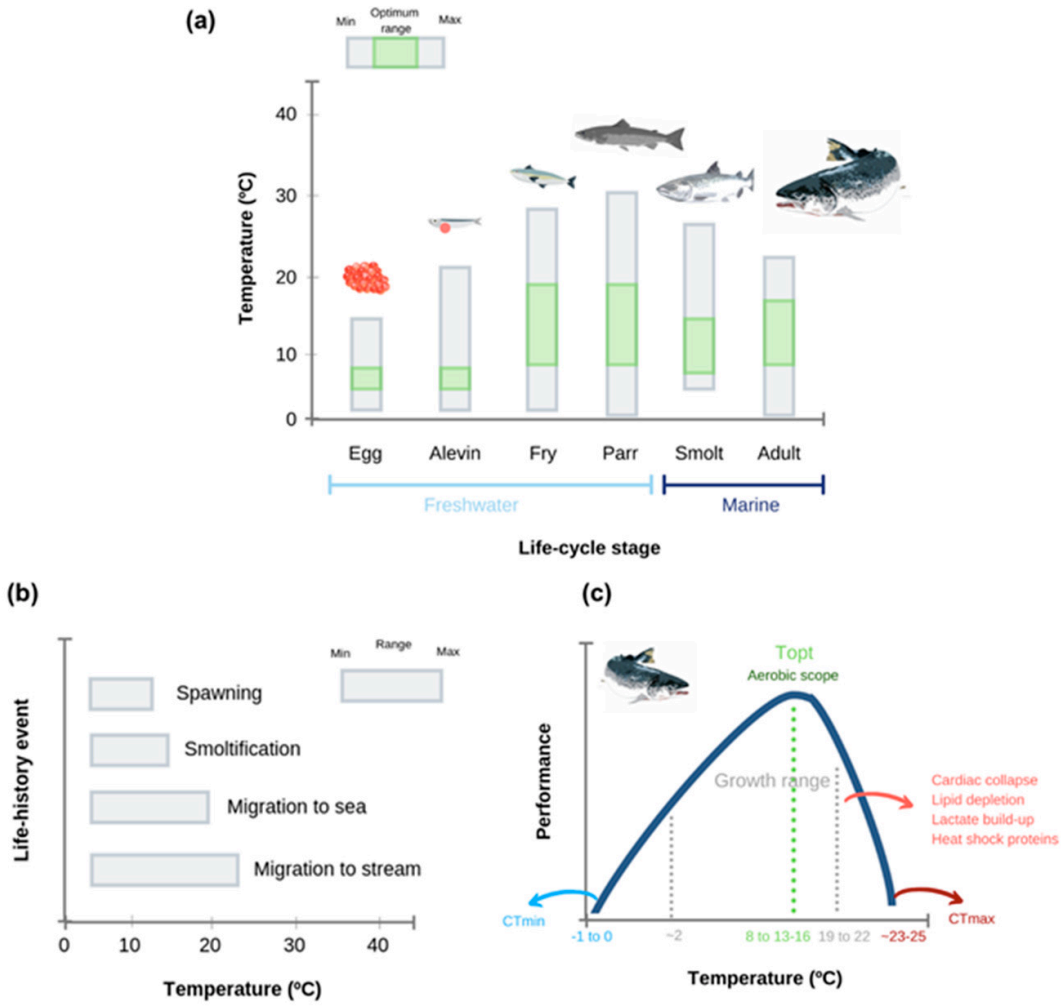

Figure 3: Thermal biology of Atlantic salmon ((a) Thermal windows estimated along different life stages; (b) thermal windows for life-history events; and (c) hypothetical thermal performance curve for adult Atlantic salmon. (Calado et al., 2021)

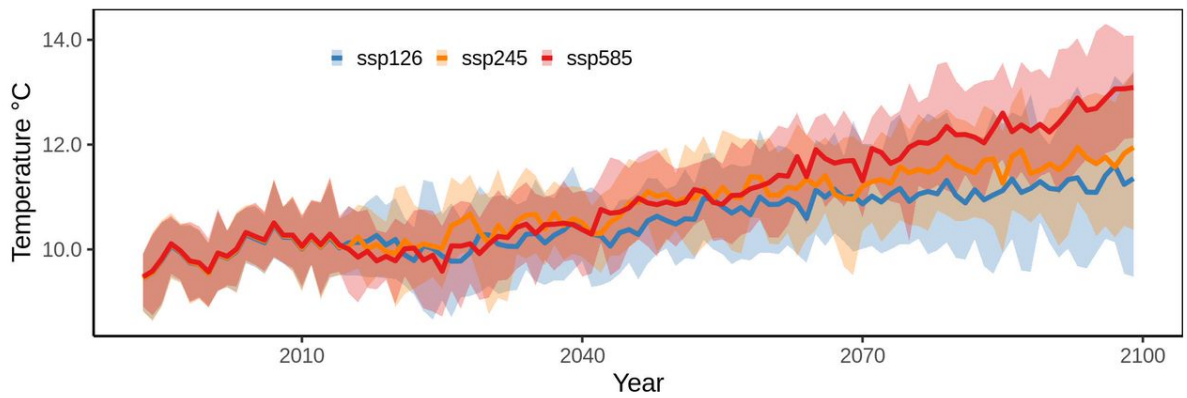

Figure 4: Surface ocean warming projections at the mouth of the Hardangerfjord, Western Norway

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. The implementation of NBS is embraced as part of climate mitigation and adaptation actions.

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. The implementation of cross-national NBS is hampered due to a lack of cooperation and agreements among countries.

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 such as air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary. The implementation of NBS is guided by economic incentives.

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

It is imperative to understand how current investment strategies in salmon farming are consistent with projections of climate change and sustainable ecosystem management. It is also crucial for the planning of sustainable production to identify future opportunities for industrial migration under climate change. Similarly, climate change will affect the migration routes and feeding areas of wild salmon and there is need to provide early warning of potential barriers to migration due to ocean warming.

FutureMARES research

- T1.1 Collect distribution data of salmon aquaculture activity in coastal Norway and assemble environmental data
- T2.3 Identify climate change challenges and opportunities in relation to salmon farming in Norway. Analyses barriers for migration of wild salmon.
- T5.1 Perform climate risk assessments based on the biological traits of Atlantic salmon based also on expert knowledge of the species and farming conditions.

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