# Theme session D

## The Nordic seas and the Arctic – climatic variability and its impact on marine ecosystems, fisheries and policymaking

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Synopsis from the call

The Nordic seas and the Arctic are among the most important and fascinating oceanic systems regarding industrial activity, marine and maritime business, resources use, and climate change. Collaboration among scientific disciplines, policy-makers, and nations is needed to ensure these areas are sustainably managed in a changing climate regime.

Climatic change happens faster here than in other areas, and can affect both the distribution of fish as well as the species composition in the ocean.

Fishing activities are important in the Nordic seas and partly also in the gateways to the Arctic, while the Arctic areas are still less exploited due to ice cover. Climate change will alter the marine ecosystems and fishing opportunities will change the fishery. Fishing activities may, along with a changing biological regime, increase the vulnerability of utilized species to exploitation. This, in addition to distributional changes of marine organisms, calls for new knowledge on how ecosystems respond to climatic changes. Investigations in these vast areas are challenging, not least because of the rough physical environment. Surveys and monitoring of species are presently mainly driven by national interest and may cover only small parts of an ecosystem. The need for a broader view, considering larger regions, is more evident than ever. To obtain the dual goal of protecting the ecosystems while also utilizing their resources in a sustainable way, it is important that science does not fall behind as the industries are progressing and moving towards new areas in their search of ecosystem goods and services.

This theme session covered the following topics:

-Long-term changes in Nordic/Arctic at both ecosystem and species level

-Impact of climatic variability on trophic interactions

-Ecosystem robustness/vulnerability in light of climate change

-Management implications of climate change

-Climate change: a challenge or an opportunity in an industrial perspective

The session was well attended, speakers were well prepared ensuring that the session was on time throughout the session. All topics were covered by presentations. The presentations were selected to cover both early career scientists as well as experienced scientists, different geographical areas as well as various species and research institutes. The conveners recommend increasing capacity for posters as several interesting abstracts had to be rejected. Further, the poster presentation part at the end of the session was not so meaningful as this was on the last day of the conference and several posters were already removed.

Summary of the presentations given according to topic:

Longterm changes in the Artic and Subarctic ecosystems are observed across all trophic levels. D: 563 indicated observed and expected changes in the physical and chemical environment in relation to phytoplankton in the Barents and Nordic seas, Fram Strait, and the Nansen Basin in the Atlantic Ocean, and the Bering Sea, Bering Strait, the Chukchi and Beaufort seas in connection with the Pacific Ocean. Besides warming, increasing acidification and potential changes in circulation patterns and the reduction of sea ice will a significant effect on phytoplankton development. Comparisons of changes in the Atlantic and Pacific sectors of the Arctic show that the expected future increase in primary production is more extensive in the Barents Sea than in the Bering Strait.

D: 371 highlighted, that the reduction of sea ice cover likely changes the Arctic light regime in favor of visually hunting predators. However, contrasting trends between the Pacific and the Atlantic were indicated – with a wider range variation of sea ice in the Pacific than the Atlantic. The loss of sea-ice cover over the past 35 years has increased the visual search potential of planktivorous fish at a rate of 2.7% to 4.2% per decade.

D:23 investigated the links between zooplankton, fish foraging and environmental changes in the Norwegian Sea. Planktivorous fish such as herring expanded their foraging range far into the West Atlantic, coinciding with drops in abundance of calanoid copepods east of Iceland. Oceanographic fronts provide spawning habitat for copepods.

D: 313 provided evidence that habitat dependent feeding affects fish condition, shown for Atlantic cod in East Greenland waters. In particular, fish feeding on mesopelagics were in good condition, and consumption of these prey has increased in recent years.

Besides interactions with lower trophic levels, changes in assemblage structure become evident with climate change. D: 232 showed that diversity of the deep-water fish community along the continental slope of Greenland below 400 m depth declined over a period of 18 years coinciding with an increasing bottom temperature. D: 92 on the analysis of spatial changes in the fishery off Greenland showed that the annual variability of the coastal current systems generates a change in the position of the frontal zone and, consequently, a change in fish distribution. In the Barents Sea, significant changes in the spatial distribution of boreal and Arctic assemblages were indicated (D: 386). For more than half of 59 species represented with species distribution models (SDM), the response to climate variability in historical records is uncertain, and it is hence not possible to build models with strong predictive power. Few species however, are expected to strongly alter their geographical distribution in response to climate change.

There were two presentations dealing with food web and trophic interactions, numbers D: 204 and D: 235. While the first one mainly dealt with changes in functional traits, as attributed to the ongoing borelisation of the Barents Sea, and changes in the food web structure caused by this, the second paper discussed how to use 13C and 15N stable isotopes in present and past otoliths to monitor the effects of climate change and fishing activities on the marine food web of Faroe Islands. The ongoing borealisation of the Barents Sea is mainly driven by temperature and sea ice reduction. It affects food web structure and thereby flow of energy. Functional diversity for boreal and Arctic areas converges during 2004-2012. The Arctic region had low diversity from 2004-2007, but diversity increased since 2008. The increase in functional diversity in the Arctic has clear consequences for ecosystem functioning, including energy flow patterns and biomass accrual. This result is alarming and indicative of a change at an unprecedented rate. Assessments of species and functional composition are needed to underpin sustainable economic policies, to adjust current harvesting practices, and to conserve areas of special interest. The take home message is that functional diversity is increasing in the Arctic and there is ongoing borealisation in the Arctic ecosystem. The results give an early warning signal of changes in the Arctic. The use δ 13C and δ 15N of present and past otoliths to monitor the effects of climate change and fishing activities on the marine food web represents a new method to study food web structures and functions. Otoliths were taken from three co-occurring gadoids saithe, cod and haddock experiencing different degrees of fishing pressure and belonging to different trophic niches. For each species, the authors assessed the annual δ 13C and δ 15N of otoliths from individuals caught in Faroe Islands between 1955 and 2014, and modeled the temporal variations of these signatures according to fishing pressures, environmental parameters, and climate indices. The results of this study, the first one investigating the long-term changes in marine trophic functioning, will allow for a better understanding and better predictions of the impacts of climate change and fishing activities on marine ecosystems.

A number of papers addressed management in the context of climate change (D: 112, 242, 277, 405, 490, 570). The distributional shifts in fish species will mean that ecosystems will change over time, with new species entering new areas. The climate induced changes in fish stock distributions illustrate a potential future problem for joint management. Along with climate change-induced changes in fish migrations and stock distributions, fisheries management must adapt to continue to meet the objectives of optimum utilization of the fishery resources and safeguarding of marine ecosystems. So far decision-making processes do not facilitate TAC allocation changes or new members. Invasion of new species will call for discussions on who should have the right to profit from utilizing them. The climatic change also influences the social dimension with the Arctic areas developing new industries, tourism, settlement, influencing how humans can cope with climate change.

The theme “robustness” or “vulnerability” was discussed in at least three presentations. First, there was a presentation about the future of Northeast Arctic cod under ocean acidification and warming (D: 253), the direct and indirect effects of acidification on cod and herring (D: 403) and a poster on the effects of stressors on deep-sea fish communities on the eastern slope of the Norwegian Sea (D: 272). The Arctic waters are predicted to be the most affected by climate change globally. While the impact of rising temperature on Arctic fish has been thoroughly investigated, understanding of the effects of ocean acidification is hampered by the lack of experimental data. The combined effects of ocean warming and acidification on the cod population given 1) different shapes of the C02 response function to climate change and 2) different temperature optima of recruitment production was studied. Temperature enhanced productivity (recruitment and growth) can offset ocean acidification effects, but only in the short term and when recruitment has not reached a temperature optimum. It was concluded that if recruitment remains as strongly temperature dependent as today, and the temperature optimum is not reached within the next 50 years, losses through ocean acidification are compensated for.

Deep-sea fish species inhabiting the continental slope in the eastern Norwegian Sea show great variability in distribution and abundance. Based on bottom trawl surveys along the eastern continental slope and deeper shelf areas from approximately 62°N - 80°N the study identified major fish communities, or species assemblages, and described their compositions in terms of species based and size-based community indicators. Species assemblages were identified and related to season, spatial gradients and depth using multivariate analyses. The vulnerability of individual assemblages to direct and indirect exploitation is assessed based on life history traits of the component species. Spatial and temporal variation in deep-sea fish communities is partly related to climatic variation, which may be different at greater rather than shallower depths. There was clear depth related community structure while species richness appeared to be noticeably constant along this long south – north gradient.

The last topic addressed climate change as a challenge or an opportunity from an industrial perspective. The effect of climate change was addressed by a poster as well reflected in the discussion after the presentations. The fact that climatic variability may be challenging to fishing communities as fish find new distribution areas and migration routes may also represent new opportunities to the industry finding new species to harvest in new areas.

Among the messages to take home from this session are:

-Considering the large changes that take place in the Arctic, and their wide range of effects, it is important to combine various fields of science when studying this area.

-We observe that species are moving in response to climate but our models are not able to give good projections into the future. We need to find better tools when modelling the future.

-It is a challenge to disentangle the effects of the fishery and other anthropogenic effects from species interactions etc.

-We compile lots of data from the northern areas, but how can we put these into a management context?

-We, as natural scientists, see what changes are taking place in the Arctic. We are responsible for letting the public know about these changes, since they may structure and shape the future for people.

-Scientists have lost credibility since our attempts to give prognoses for fish stock development have not always succeeded.

-The Barents Sea is so variable that we should probably not try to dive into details and try to explain everything. Rather we should take a more holistic view of the area and the changes going on there, and try to figure out how we could best deal with the large-scale challenges that we are faced with as climate changes.

-Take a holistic approach in order to find trends and shifts at a larger scale

-Study how climate change shapes fisheries and fishing communities in the polar region

-Reveal what are the observed and expected social-economic consequences of climate change

-Study the potential national and international conflicts raising from changing oceans

-Address the management challenges of mobile fish stocks entering new areas

-Reveal potential strategies and management that are available to help communities to adapt to the impacts of climate change.

-The session benefitted much from the multidisciplinary approach, attracting people from various fields of science. Industrial participants would be welcomed in the future.