

## Project information

### Keywords

Biodiversity, cod, predation, climate, fish communities, human impact, Barents Sea, Scotian Shelf, modelling

### Project title

How do a dominant predator and climate shape fish biodiversity over space and time in large marine ecosystems?

### Year

2016

### Project leader

Kari E. Ellingsen, Norwegian Institute for Nature Research (NINA)

### Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

We are using data from the entire Barents Sea (from the Ecosystem Surveys), and also from waters on the northern and western part of the Svalbard shelf. Svalbard Bank: ca 75°N, 20°E; Central Bank: ca 75°N, 40°E.

### Participants

- **National:** NINA (Torkild Tveraa, Per Fauchald); Institute of Marine Research, IMR (Edda Johannesen, Randi Ingvaldsen, Mette Skern-Mauritzen); UiT The Arctic University of Norway (Nigel G. Yoccoz)
- **International:** Polar Research Institute of Marine Fisheries and Oceanography (PINRO), the Russian Federation (Andrey V. Dolgov); Bedford Institute of Oceanography (BIO), Canada (Kenneth T. Frank, Nancy L. Shackell); Massey University, MU, New Zealand (Marti J. Anderson)
- For a special focus on the waters around Svalbard, included as an additional part under the Flagship Fjord and Coast (i.e. not included in the RCN-project FISHDIV), we have included some additional researchers from IMR (Odd Aksel Bergstad, Åge Høines, Vidar Lien).

### Flagship

Fjord and Coast

### Funding Source

Fram Centre (Insentivmidler and Fjord and Coast), RCN (HAVKYST), Own funding NINA, IMR, UiT, PINRO (Russia), BIO (Canada)

## Summary of Results

The scientific report covers all sources of funding (Fram Centre, RCN and own funding). In 2016 we have worked on three new papers:

**1) Habitat use by cod in the Barents Sea:** This paper is based on a presentation at a symposium in Russia in 2014 (Edda Johannesen, Randi B. Ingvaldsen, Andrey V. Dolgov, Nigel G. Yoccoz and Kari E. Ellingsen (2014). Habitat use by Barents Sea cod (*Gadus morhua*) under recent warming conditions. 49th European Marine Biology Symposium, September 8-12, 2014, St. Petersburg, Russia), but we have done a number of additional analyses (Johannesen et al. ms). The paper is focusing on cod in the Barents Sea, and specifically habitat use by cod. We are focusing on different age groups of cod (from 1-2 years to older than 11 years). We have done a number of data analyses and made figures/tables. We are currently writing the paper.

**2) Fish biodiversity in the Barents Sea and the role of drivers:** This paper is focusing on patterns of biodiversity in space and time in the Barents Sea, and the role of cod and temperature for structuring fish biodiversity (Ellingsen et al. ms). This is a comparative study where we compare the results from the Barents Sea with our results from the Scotian Shelf, Canada (Ellingsen, K.E., Anderson, M.J., Shackell, N.L., Tveraa, T., Yoccoz, N.G. & Frank, K.T. (2015) The role of a dominant predator in shaping biodiversity over space and time in a marine ecosystem. *Journal of Animal Ecology*, 84: 1242-1252). We have divided the Barents Sea into 11 sub-areas based on changes in cod distribution and abundance and sea temperature during the last decade. With this design-based approach, we account for the dynamics of these drivers, and separate between the effects of dominant predators and environmental variables on the patterns of diversity. We have done a number of new data analyses in 2016 (using advanced statistical methods). Our analyses show that the increasing cod population has resulted in changes in fish biodiversity with a more homogeneous fish community. We found that climate had a minor importance for explaining the observed changes in the fish communities during our study period. Our results from the Barents Sea are in accordance with our results from the Scotian Shelf. We are currently writing a paper, and we are aiming for a general ecological journal.

**3) Baseline study of fish communities around Svalbard:** This paper has a special focus on demersal fish communities in the Svalbard

archipelago (Bergstad et al. ms). This is a region characterised by complex bathymetry and numerous islands, as well as steep and strong environmental gradients between the warm areas of the Norwegian Sea under the influence of Atlantic Water, and the Arctic Water to the north and northeast. We have used data from the annual ecosystem surveys of the Barents Sea (2007-2014), including 967 bottom trawl stations with 59 species of demersal fish. The paper was submitted to the journal "Polar Biology" in December 2016. The title is: 'Demersal fish assemblages in the boreo-arctic shelf waters around Svalbard during the recent warm period'.

### **Highlights:**

#### **Highlight 1:**

We have found that the dominant predator cod is important for structuring fish biodiversity using data from two large marine ecosystems: the Scotian Shelf in the Northwest Atlantic and the Barents Sea. We found that climate only had minor importance for explaining the observed changes in the fish communities during our study period.

#### **Highlight 2:**

We have produced a baseline study of the fish communities in the waters surrounding Svalbard using data from the last decade. This baseline is characterizing a warm period historically.

### For the Management

Over-exploitation and collapse of top predators in marine ecosystems are well recognized, but its impact on biodiversity at the ecosystem level is only poorly understood. On the Scotian Shelf in the Northwest Atlantic the cod population has been dramatically reduced, with a collapse on the eastern shelf in the early 1990s. Our analyses show that this has resulted in large changes in the fish biodiversity with increased variability in the bottom fish community. This means that the fish communities were more homogeneous when cod was more prevalent in the system. In the Barents Sea the cod population has increased substantially both in numbers and distribution over large spatial scales, i.e. a rather unique situation for marine ecosystems. The Barents Sea cod population is currently the largest in the world. At the same time, the climate in the Barents Sea has changed during the last decades, with increased sea temperature and declining sea ice. We have evaluated the role of the dominant predator cod and climate in shaping fish biodiversity over space and time in the Barents Sea and our results corresponds to our results from the Scotian Shelf. Through these studies, we have used a new methodological approach that is expected to give an earlier warning on changes in ecosystems than more traditional statistical methods. Obviously, such early warnings are important for the management authorities. In addition, we have produced a baseline study of fish communities in the waters surrounding Svalbard. This baseline is characterizing a warm period historically and it can be used for comparison with future studies in light of climate change and the increasing human activity in northern marine areas.

### Published Results/Planned Publications

We have published one popular article in *Ottar* in 2016 where the whole project is presented, but with a special focus on the result from the paper by Ellingsen et al. (2015):

ü Ellingsen, K.E., Tveraa, T. & Yoccoz, N. (2016). Overfiske og klimaendringer i marine økosystemer. *Ottar*, 309: 42-47.

#### Planned publications:

1. Johannesen et al. ms: Focusing on habitat use by cod in the Barents Sea.
2. Ellingsen et al. ms: Focusing on fish biodiversity in the Barents Sea and the role of drivers.
3. Odd Aksel Bergstad, Edda Johannesen, Åge Høines, Kari E. Ellingsen, Vidar S. Lien, Ingvar Byrkjedal, Nigel G. Yoccoz, Torkild Tveraa, Rupert Wienerroither, Gunnar Langhelle, Thomas de Lange, Wenneck. Demersal fish assemblages in the boreo-arctic shelf waters around Svalbard during the recent warm period (submitted to *Polar Biology* in December 2016).

### Communicated Results

We had a workshop in Halifax, Canada in January 2016 with participants from NINA, UiT and Canada. We also had a workshop in Tromsø in April 2016 with participants from NINA, UiT, IMR and Canada. In addition, we had a workshop in Bergen in June 2016 with participants from NINA, UiT and IMR, with a special focus on the Svalbard-paper.

Ellingsen and co-authors presented the project and the findings by Ellingsen et al. (2015), i.e. the fish biodiversity study from the Scotian Shelf, in a popular article in Ottar in 2016 (Ellingsen, K.E., Tveraa, T. & Yoccoz, N. (2016). Overfiske og klimaendringer i marine økosystemer. Ottar, 309: 42-47).

Ellingsen presented the project and main results at “NINA-dagene” in Trondheim in October 2016 for more than 200 participants, including a number of representatives from The Environment Agency and researchers from NTNU.

#### Interdisciplinary Cooperation

The participants have an interdisciplinary composition and the project brings together the disciplines of biodiversity, ecology, fishery biology, statistics/modelling and climate/physical oceanography. Indeed, our project benefit in a positive way from this inter-disciplinary cooperation. In addition, the high-level international competence increase the impact of the project at an international scale.

#### Budget in accordance to results

The funding from the Fram Centre has been important in several ways. The funding from 2013 (incentive money) made it possible to write the research project proposal to the RCN (HAVKYST). The funding for 2014-2016 (Fjord and Coast) has given us the opportunity to have a special focus on the shelf waters around Svalbard, including the western and northern parts. This special focus was not originally included in the RCN-project, and therefore not included in the RCN-budget. This funding has also made it possible for some additional fishery people and a physical oceanographer at IMR to work more closely with some core project participants in the RCN-project, with regard to the special focus on the waters around Svalbard. Funding from the Fjord and Coast Flagship has also contributed to strengthening of the core activity in the RCN-project. The funding for 2016 has also been used for the popular article in 2016 in Ottar (Ellingsen m. fl. 2016). These expenses were not included in the RCN-budget. The budget for travelling/accommodation with regard to the meeting in Bergen at IMR in June 2016 with participants from NINA, UiT and IMR, for a special focus on the Svalbard-paper, was also covered by the Fjord and Coast flagship.

Could results from the project be subject for any commercial utilization

No

#### Conclusions

- a) a) The project has given an important contribution to the understanding of dominant predators in shaping biodiversity in marine ecosystems. Currently, there are few studies focusing on the role of apex predators in shaping biodiversity in terrestrial and marine ecosystems.
- b) b) During the last decades, there has been a big focus on the impacts of climate change on different biological parts of ecosystems. In our study, we found that the role of the apex predator cod was more important than climate in explaining changes in fish biodiversity during our study period.
- c) c) Our results show that multivariate measures capture changes in ecosystems at an early stage and give additional information compared to more traditional methods.
- d) d) We have produced a baseline study of fish communities in the waters surrounding Svalbard. This baseline is characterizing a warm period historically and it can be used for comparison with future studies in light of climate change and the increasing human activity in northern marine areas.