Project information

Keywords
integrated ecosystem assessment fisheries benthos fish
Project title
Ecosystem Vulnerability Assessment of Resources in the Barents Sea (VULRES)
Year
2015-2017
Project leader
Raul Primicerio
Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
66 °N, 5 °E, 80 °N, 60 °E
Participants

Institute of Marine Research: Elena Eriksen, Maria Fossheim, Edda Johannessen, Lis L Jørgensen, Padmini Dalpadado

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University of Santa Barbara, California: Kevin Lafferty

Flagship
MIKON
Funding Source

FRAM MIKON. Activities relating to ICES working group WGIBAR are funded by IMR (FKD).

Summary of Results

In 2017, the project VULRES has further developed the vulnerability analysis of the benthos, demersal fish and pelagic fish of the Barents Sea ecosystem, has expanded and further integrated work on zooplankton functional traits and on their food web roles and included sea mammals in the vulnerability analyses. The compiled databases, developed approaches and output will contribute to the Integrated Ecosystem Assessment activities for the Barents Sea within ICES. The output of the analyses is being summarized in maps suitable for synthesis and communication to areal management.

Three prominent properties of Barents Sea demersal fish communities influencing ecosystem vulnerability to trawling all displayed substantial spatial variability with clear geographical patterns (Fig 1). Through time (2004-2012), the spatial patterns changed displaying trends associated with increasing water temperatures and decreasing sea ice coverage. Fish sensitivity to trawling, assessed on the basis of life history characteristics of fish that affect demographic growth rates, showed a sharp gradient, with average fish sensitivity (averaged ranks) at stations falling rapidly in a North-East direction (Fig 1). Fish functional diversity, estimated on the basis of a functional traits dendrogram, displayed a clear gradient with diversity dropping towards the East (Fig 1). Finally, the average number of fish feeding links (degree centrality) showed a strong reduction towards the North indicating that there is a lower food web connectivity in the Arctic reaches of the Barents Sea (Fig 1).

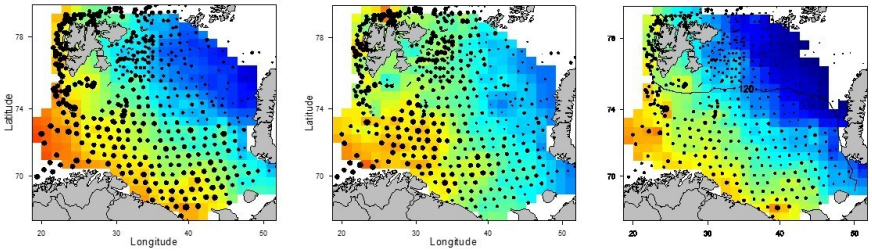

Figure 1. Barents Sea demersal fish community in 2004. Fish sensitivity to trawling (left panel), functional diversity (mid panel) and food-web degree centrality (right panel). Highest values in red, lowest values in blue (circle size is proportional to measured value at a station).

The temporal trends showed a systematic increase in sensitivity, functional diversity and degree centrality towards the North, with the Arctic reaches of the Barents Sea experiencing the most rapid and extensive changes in ecosystem vulnerability (Fig 2).

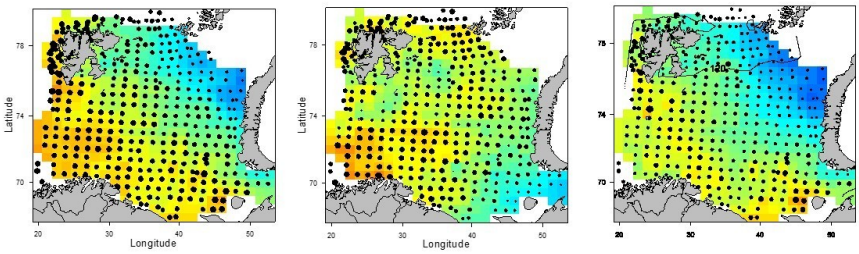

Figure 2. Barents Sea demersal fish community in 2012. Fish sensitivity to trawling (left panel), functional diversity (mid panel) and foodweb degree centrality (right panel). Highest values in red, lowest values in blue (circle size is proportional to measured value at a station).

The pelagic fish community (pelagic trawl catches) also displayed extensive spatial variation with regard to the above three properties, with patterns partly resembling those observed for demersal fish (Fig 3). The temporal changes in spatial patterns were also substantial, and apparently related to the climatic variability and to the fluctuating abundances of some of the dominant pelagic fish species.

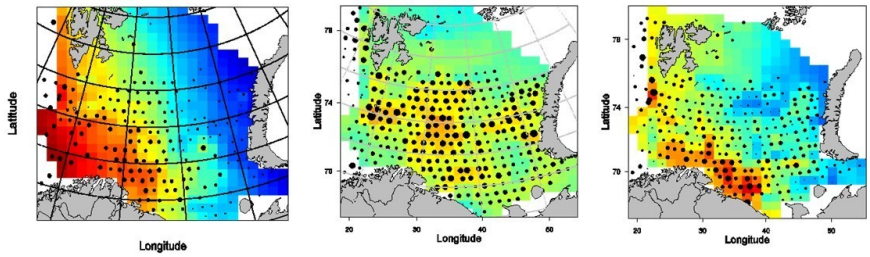

Figure 3. Barents Sea pelagic fish community in 2004. Fish sensitivity to trawling (left panel), functional diversity (mid panel) and foodweb degree centrality (right panel). Highest values in red, lowest values in blue (circle size is proportional to measured value at a station).

The benthos community displayed ample spatial variation in sensitivities to trawling, snow crab invasion, climate variability and acidification (Fig 4). Functional diversity and degree centrality also varied extensively in space, with discernible geographical patterns.

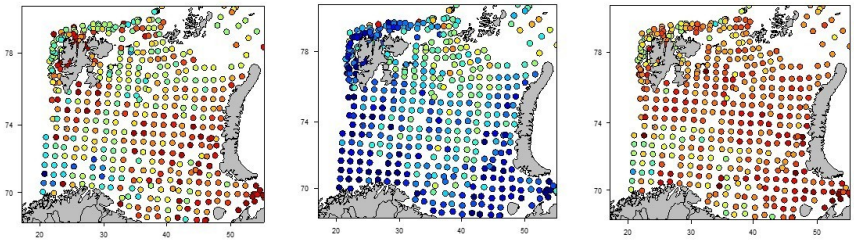

Figure 4. Barents Sea benthos community in 2013. Benthos sensitivity to snow crab invasion (left panel), climate variability (mid panel) and acidification (right panel). Circle colour codes for proportion of taxa at a station characterized by response traits that increase sensitivity to an environmental pressure. Highest values in red, lowest values in blue.

Master and PhD-students involved in the project

Master student Amalia Keck and PhD Aslak Smalås have been involved in VULRES, helping to compile the traits and food web

databases.

For the Management

In an areal management perspective, our findings on Barents Sea ecosystem vulnerability have immediate relevance given the substantial spatial variability and patterns detected. To illustrate an application of our integrated Ecosystem Vulnerability Assessment, we can focus on the South-East Barents Sea where high average sensitivity, low functional diversity and high degree centrality concur to characterize this as a highly vulnerable area. In this area, fish populations are expected to display strong responses to trawling, leading to further reduction in functional diversity (ecosystem adaptability) and widespread implications for other species in the food web that are linked with these highly connected fish species.

Published Results/Planned Publications

Kortsch S, Primicerio R, Fossheim M, Dolgov A, Aschan M (2015) Climate change alters the structure of arctic marine foodwebs due to poleward shifts of boreal generalists. *Proceedings of the Royal Society B* doi: 10.1098/rspb.2015.1546 (the paper is reviewed by the journal *Nature* in the news article by Blanchard 2015 Climate change: a rewired foodweb doi:10.1038/nature16311)

Fossheim M, Primicerio R, Johannesen E, Ingvaldsen RB, Aschan M, Dolgov A (2016) Climate change is pushing boreal fish northwards to the Arctic: the case of the Barents Sea. In State of the Climate in 2015. *Bull. Amer. Meteor. Soc*. 97(8): S139-140.

Johannesen E, Fossheim M, Primicerio R, Greenacre M, Ljubin P, Dolgov A, Ingvaldsen RB, Anisimova N, Manushin I (2016) Large scale patterns in community structure of benthos and fish in the Barents Sea. *Polar Biology* doi: 10.1007/s00300-016-1946-6.

Frainer A, Primicerio R, Kortsch S, Aune M, Dolgov AV, Fossheim M, Aschan M. (2017) Climate-driven changes in functional biogeography of Arctic fish communities. *Proceedings of the National Academy of Sciences* 114: 12202-12207.

Aune MA, Aschan M, Fossheim M, Greenacre M, Dolgov A, Primicerio R. Functional redundancy in Barents Sea fish: ecological implications of environmental change. (submitted to PLOS ONE)

Jørgensen LL, Primicerio R, Fossheim M, Ljubin P, Dolgov A, Ingvaldsen RB, Anisimova N, Manushin I. Impact of multiple stressors on Barents Sea benthos. (submitted to *MEPS*)

Kortsch S, Primicerio R, Aschan M, Lind S, Dolgov A, Planque B. Biogeographic patterns in marine food-web structure at high latitudes. (submitted to *Ecography* - under revision)

Primicerio R, Aschan M, Aune M, Eriksen E, Fossheim M, Frainer A, Jørgensen LL, Johannessen E, Kortsch S, Dolgov A. Ecosystem vulnerability assessment for fishery management. (in prep *ICES J.Mar.Sci.*)

Primicerio R, Aschan M, Aune M, Eriksen E, Fossheim M, Frainer A, Jørgensen LL, Johannessen E, Kortsch S, Dolgov A, Mauritzen M. Climate driven change in Barents Sea ecosystem state, functioning and vulnerability. (in prep)

Communicated Results

VULRES findings and approaches were presented at seminars, project meetings and workshops, conferences, and in the context of outreach and educational activities (UNIS and UiT).

Eriksen E (2015) Barents Sea ecosystem vulnerability assessment. Presentation *TIBIA* NRC SIP-project meeting.

Fossheim M, Primicerio R, Johannessen E, Ingvaldsen R, Aschan M, Dolgov A (2015) Recent warming leads to a rapid borealization of fish communities in the western Arctic. Oral presentation at the *Arctic Frontiers* Conference, Tromsø, Norway.

Fossheim M (2015) Barents Sea ecosystem in a changing environment. Oral presentation *Transatlantic Science Week 2015*, Boston, US.

Fossheim M, Kortsch S, Johannesen E, Ingvaldsen RB, Aschan M, Dolgov A, Primicerio R (2016) Climate change is pushing boreal fish northwards. *Fram Forum* 64-67 pp.

Johannessen E (2015) Barents Sea ecosystem vulnerability assessment. Presentation at ICES working group WGIBAR

meeting.

Jørgensen LL (2015) Barents sea benthos vulnerability. Oral presentation *CAFF* meeting, Norway.

Jørgensen LL (2015) Multiple impacts on Arctic benthic communities: order in chaos, or chaos in order. Oral presentation *FRAM Science Days*.

Jørgensen LL (2016) Barents sea benthos vulnerability. UNIS course AB335 'Ecosystem Based Management of Arctic Marine Systems'.

Primicerio R (2015) Climate warming impact on Barents Sea ecosystem vulnerability. Oral presentation *FRAM Science Days*.

Primicerio R, Kortsch S, Wiedmann M, Aschan M, Fossheim M, Johannessen E, Jørgensen LL, Dolgov A (2015) Climate driven changes in Barents Sea ecosystem state, vulnerability and functioning. Oral presentation at the *Arctic Frontiers* Conference, Tromsø, Norway.

Primicerio R (2016) Climate warming impact on Barents Sea Ecosystem Vulnerability to climate warming. Meeting ERC project 'ClimeFish' University of Venice, Mestre, Italy.

Primicerio R (2016) Barents Sea Ecosystem responses to climate warming. Kickoff meeting UD project 'CLIMA', Ålesund, Norway.

Primicerio R (2016) Barents Sea Ecosystem Vulnerability Assessment. Oral presentation at meeting *ICES WGCOMEDA*, Bilbao, Spain.

Primicerio R (2016) Barents Sea Ecosystem Vulnerability and climate warming. Meeting UD project 'CoArc', Fram Centre, Tromsø, Norway.

Primicerio R (2016) Barents Sea Ecosystem Vulnerability Assessment. UNIS course AB335 'Ecosystem Based Management of Arctic Marine Systems'.

Primicerio R, Fossheim M, Jørgensen LL, Aune M, Eriksen E, Johannessen E, Dolgov A (2016) Ecosystem Vulnerability Analysis of resources in the Barents Sea (VULRES). Poster at *Fram dagen*, Tromsø, Norway.

Primicerio R (2017) Barents Sea ecosystem functioning and vulnerability. ICES WGIBAR meeting, Murmansk, Russia.

Primicerio R, Aune M, Aschan M, Dalpadado P, Eriksen E, Fossheim M, Frainer A, Jørgensen LL, Johannessen E, Dolgov A (2017) Climate driven change in Barents Sea ecosystem functioning and vulnerability. Oral presentation *ESSAS*, Tromsø, Norway.

Wiedmann MA, Aschan M, Greenacre M, Dolgov A, Primicerio R (2015) Functional redundancy in Barents Sea fish – Winners and losers in a changing Arctic. Poster presented at the *Arctic Frontiers* Conference, Tromsø, Norway.

Interdisciplinary Cooperation

The project VULRES develops the Barents Sea ecosystem vulnerability assessment in a broader context of national and international project collaborations on ecosystem approaches to management. In particular, the EU projects MAREFRAME and the newly funded CLIMEFISH, presented in the VULRES project description, integrate socio-economic aspects of resource exploitation. For the Barents Sea, the dialogue between the investigations on socio-economic sources of multiple environmental stressors and the research activities on integrated ecosystem assessment sets the stage for interdisciplinary collaboration aimed to inform management guidelines and regulation.

Budget in accordance to results

Funding from the FRAM centre has been crucial to compile, extend, integrate and harmonize the databases on response and functional traits for demersal fish, pelagic fish and benthos, and the database on the Barents Sea foodweb. Further, FRAM funding has promoted method development (vulnerability indicators based on species and whole ecosystem properties) and synergy between involved institutions in the interpretation of results (with dedicated VULRES workshops being an invaluable catalyzing activity) and their communication (VULRES papers meetings). The methods, databases and findings emanating from the project have been decisive in helping to attract further funding, both nationally (ICE-EVA, FRAM Polhavet; BSECO, KLD) and internationally (CLIMEFISH, ERC).

Could results from the project be subject for any commercial utilization

No

Conclusions

The VULRES findings on Barents Sea ecosystem vulnerability highlight strong spatial heterogeneity in vulnerability of all functional groups presently included in the analyses. Further, the temporal trends show a strong influence of climate variability resulting in systematic change in spatial patterns of vulnerability. The findings have clear implications for an ecosystem approach to areal management of the Barents Sea.