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Biogeographic changes in fish diversity driven by changes in climate and exploitation

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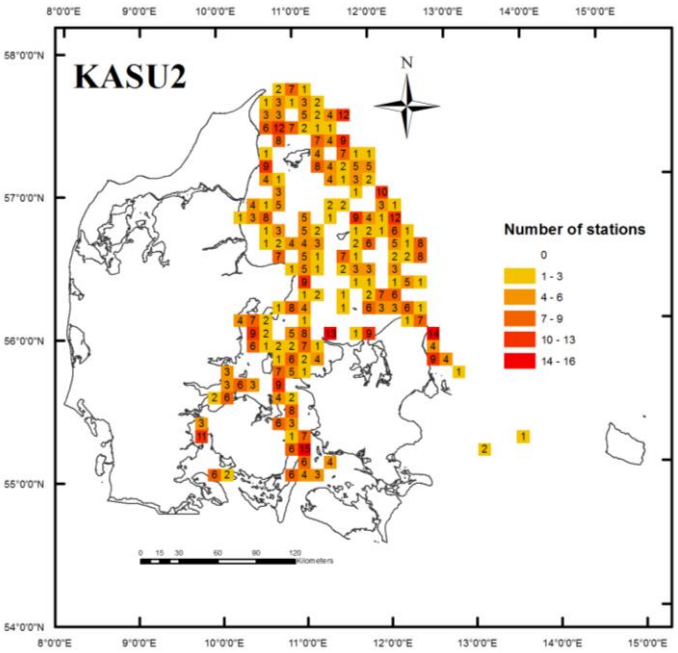
Fish communities are influenced both by climate-hydrographic impacts and by exploitation of selected species within foodwebs. The response of fish communities to these impacts can be difficult to distinguish, and in many situations, both factors interact to affect fish communities. The Kattegat-Belt Sea, which is located between the North and Baltic Sea, and has been exposed to several major perturbations in the past few decades, including overexploitation of some fish species, eutrophication and most recently an increase in temperature.

In this study, we investigate using demersal survey data how climate variability and exploitation have influenced the dynamics of the fish community in the Kattegat, Belt Sea and Øresund during 1994-2013. During this time period, temperatures have increased (e. g. MacKenzie and Schiedek 2007; Lindegren et al. 2012) and overall demersal exploitation levels in most of the region have declined (ICES 2014).



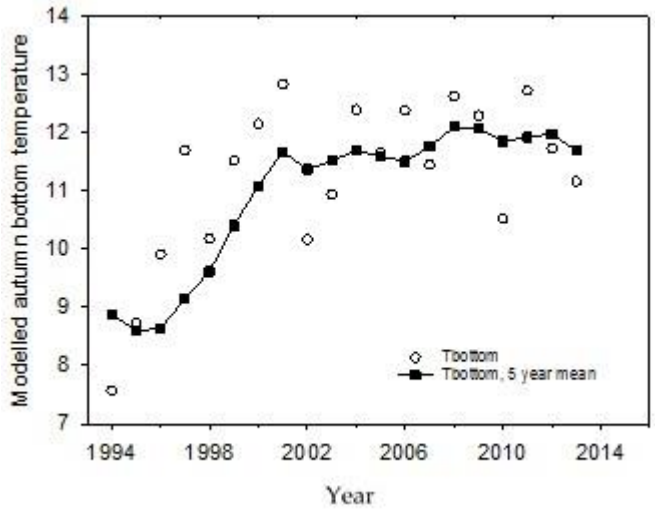
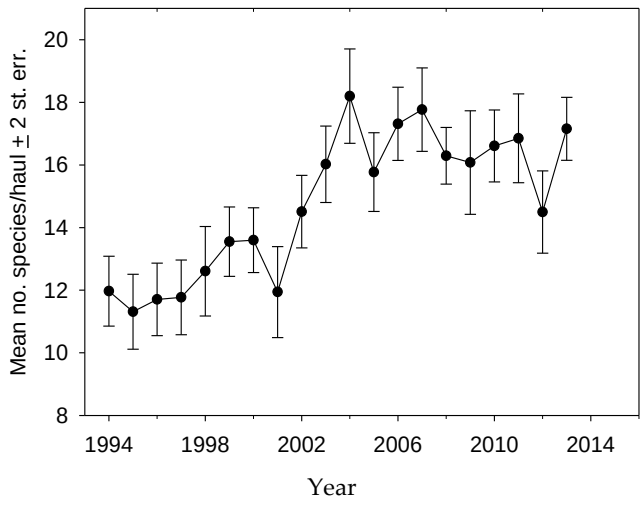


Figure 1 (left). Map showing spatial distributions and sampling intensity of demersal hauls in the Kattegat-Belt Sea region during autumn surveys 1994-2013.
Figure 2 (right). Time series of annual (open dots) and 5-year running mean (black squares with line) modelled bottom temperature in the Kattegat-Belt Sea as derived from a 3D oceanographic model (She et al. 2007).

We found that biodiversity (species richness) of the fish community has increased both in spring and fall (figure 3), and that these increases were partly explained by local bottom temperatures as estimated by a regional oceanographic model (She et al. 2007) (figure 4). Bottom temperature also significantly increased in the region during the survey period (figure 2), which is in accordance with other studies in the region (Brander et al. 2003; MacKenzie and Schiedek 2007). We also observed that species richness increased as indicators of fishing effort declined. When investigating the increase in species richness we found that the

increase is mainly due to an increase in the number and presence of species from southern regions, as detected by examining interannual changes in the biogeographic origins of all species in the fish assemblage.

These results show that climate variability and fishing interact to affect the assemblage of fish species, probably by altering the number and strength of interactions among species during a period when environmental conditions were becoming warmer.



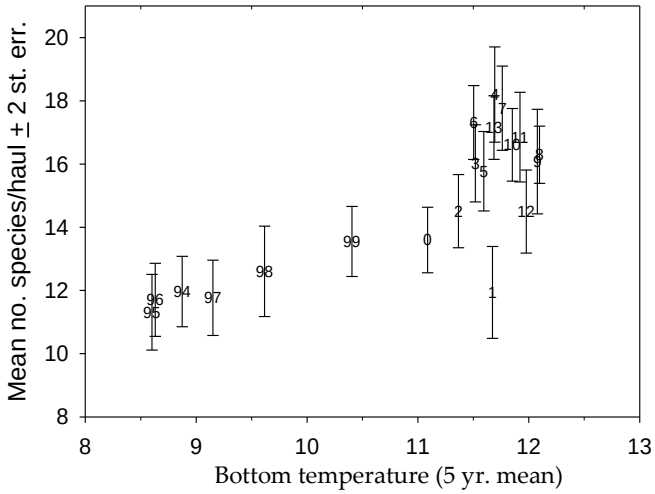


Figure 3 (left). Interannual variability in fish species richness in the Kattegat-Belt Sea during autumn surveys in 1994-2013. Richness is expressed as the mean number of species per 30 minute haul, with 2 standard errors. The mean number of hauls per year was 37. A linear regression line linking the two variables is statistically significant ($R^2 = 0.65$; $p < 0.01$).
Figure 4 (right). Covariation of fish species richness and autumn temperature (5-year running mean, based on current year and four previous years, as derived from an oceanographic model; She et al. 2007; $R^2 = 0.64$; $p < 0.01$. Species richness is presented as means with 2 standard errors. Symbols represent year when survey was conducted.

References

Brander, K., Blom, G., Borges, M.F., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Ribeiro, J., Santos, A. M. P., Toresen, R. 2003: Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Marine Science Symposia, 219: 261–270.

ICES 2014. Report of the Baltic Fisheries Assessment Working Group. ICES CM 2014/ACOM: 10. Copenhagen, Denmark.; 932 pp.

Lindegren, M., Blenckner, T., Stenseth, N. C. 2012. M., Nutrient reduction and climate change cause a potential hift from pelagic to benthic pathways in a eutrophic marine ecosystem. Global Change Biology (2012) 18, 3491–3503.

MacKenzie, B.R. and Schiedek, D. 2007: Daily ocean monitoring since the 1860s shows record warming of northern European seas. Global Change Biology 13, 1335–1347.

She, J., Berg, P., Berg, J. 2007. Bathymetry impacts on water exchange modelling through the Danish Straits. Journal of Marine Systems 65 (2007) 450–459.