Project brief

Thünen Institute of Sea Fisheries

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PANDORA – advancing mixed fisheries simulations by taking into account climate change and economic projections

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- **Machine learning procedures were included in a novel framework to detect effects of environmental changes on the productivity of commercially-important cod-like fishes (gadoids)**
- **Temperature and salinity largely cause the current low productivity of North Sea cod, which is likely to continue to worsen due to climate change. Therefore, successful management of North Sea mixed fisheries depends on strategies to avoid unwanted bycatch of cod.**
- **Simulations with the bio-economic mixed fisheries simulation model FLBEIA highlight that fleets are impacted differently by climate change. Their future economic situation was informed by projected price and cost developments and influenced by their dependency on cod catches.**

Background and aims

The environment of the North Sea is already seriously impacted by climate change leading to productivity changes of various stocks and consequences for fisheries. Especially in the highly mixed fisheries of the North Sea, where stocks with different sensitivities to climate change are caught simultaneously, the need to take climate change effects into account becomes evident. Our overall aim in the PANDORA project (Paradigm for Novel Dynamic Oceanic Resource Assessments) was to explicitly include effects of climate change on North Sea gadoids into a bio-economic mixed fisheries simulation model, and to analyse impacts of productivity changes in terms of ecological and economic outcomes under potential future climate and socio-political projections.

Approach

Using the complex bio-economic simulation model for mixed fisheries FLBEIA, we considered effects of environmental change (temperature, salinity, currents) on the recruitment of cod, whiting and saithe and analysed the resulting impact on the economy of fishing fleets. However, pinpointing recruitment changes to environmental influences is not trivial due to effects acting on various life stages and noise in available data. In order to advance our understanding of environmental influences on stock productivity, we developed a machine learning framework allowing a semi-automatic search for meaningful covariates, originating from large spatiotemporal datasets (Figure 1). The output of this search was then used to inform future recruitment in the mixed fisheries simulations.

Future climate change scenarios were derived from a regionally-downscaled ocean-model (Max Planck Institute Ocean Model – MPIOM-REMO), which provided two warming projections under the Representative Concentration Pathways (RCP) RCP4.5 (moderate) and RCP8.5 (worst case). Additionally, economic changes in fuel and fish price development under a combination of different sociopolitical and climate change scenarios were considered in different scenarios.

Key findings

Strong negative environmental impacts on cod recruitment could be identified, whereas recruitment of whiting and saithe were less impacted by climate change projections. Under the assumption of current catch compositions and fishing patterns, climate change will likely have a negative impact on demersal mixed fisheries, although these effects are more moderate in the RCP 4.5 scenario than under RCP 8.5. Despite a short-term recovery of cod due to reduced fishing pressure as a consequence of a strict implementation of the MSY concept and the landing obligation, cod recruitment continued to decline due to climate change effects leading finally to a decline of the stock and serious fishing opportunity limitations (choking situation) for the fisheries due to low quotas for cod.

In terms of economic implications, the decrease in the cod stock mainly affected fleets relying on cod to a larger extent (>25% in their catch composition), which were less profitable under the more severe warming scenario RCP8.5 than under the "Global Sustainability" RCP4.5 scenario (Figure 2). To the contrary, fleets that were less reliant on cod showed higher profitability under the more severe RCP8.5 scenario by profiting from greater increases in fish prices under RCP8.5 ("National Enterprises" & "World markets" economic scenarios) than under the "Global Sustainability" RCP4.5 scenario. Although uncertainties around predicted values are large, and scenarios are based on a number of assumptions, this highlights that both, climate change effects and projections in economic variables need to be taken into account when making judgments on potential future developments in fisheries.

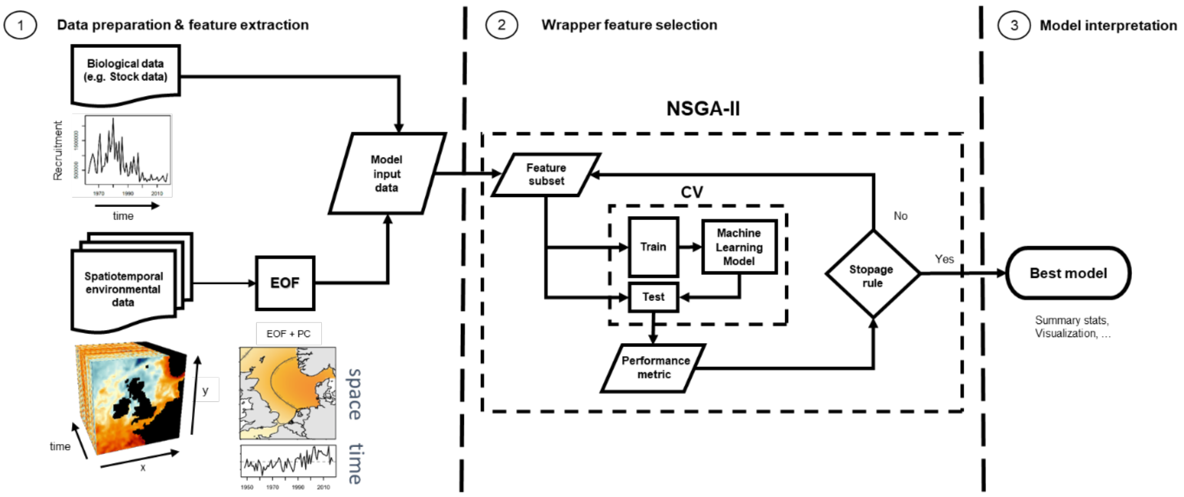

Figure 1: Overview of the workflow in the proposed framework: (1) unsupervised feature extraction of spatiotemporal environmental data via empirical orthogonal functions (EOFs) (2) a robust cross-validated (CV) wrapper-based feature selection via a non-dominated sorting genetic algorithm (NSGA-II), to predict biological processes (e.g. recruitment) with a supervised machine learning model, and (3) tools for further model interpretation. Source: Adapted from Kühn et al. (2021).

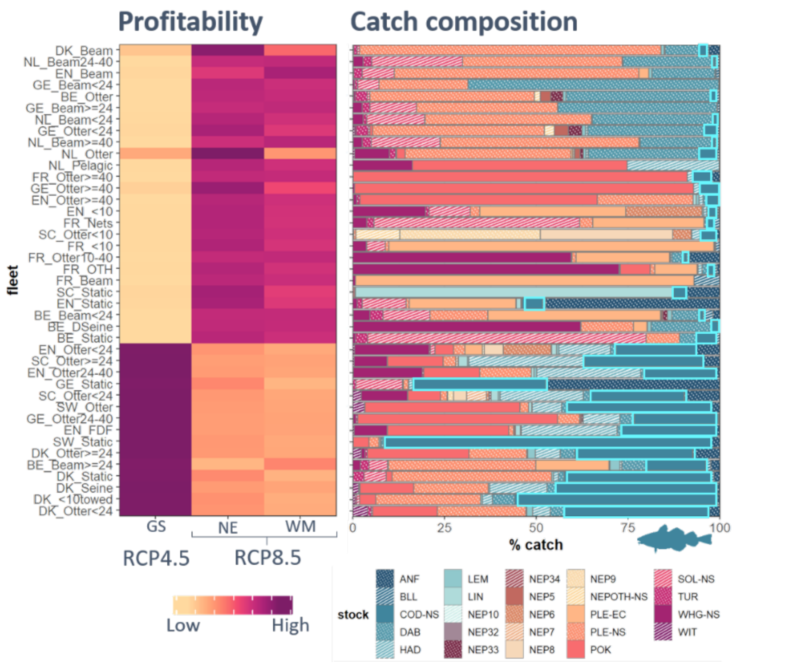

Figure 2: Profitability (scaled heatmap, left) and catch composition (stacked barplot, right) in percentage per fleet, linking the economic effect of climate change projections RCP4.5 (Global sustainability – GS) and RCP8.5 (National Enterprises – NE, World Markets – WM) with the catch of the fleets. Percentages of cod in the catch are additionally highlighted (blue with turquoise border) to show the effect on profitability under the different socio-political & warming scenarios (Source: Thünen Institute of Sea Fisheries (2021)).

Further Information

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