Project brief

Thünen Institute of Sea Fisheries 2025/11a

Hotspots of change in the North Sea: cumulative pressures and their impacts

Jennifer Rehren[1], Wolfgang Nikolaus Probst[1], Casper Kraan[1], Hermann Neumann[1], Vanessa Stelzenmüller[1]

- **Fish biodiversity hotspots are mainly found in the south-western part of the southern North Sea.**
- **Core areas of distribution for many fish species are located off the English, Belgian and Dutch coasts and outside existing protected areas.**
- **Geophysical stressors contribute in particular to spatial and temporal changes in the species composition and functionality of seabed communities.**
- **The joint analysis and modelling of human pressures on key ecosystem components enables the assessment of cumulative effects on the marine environment.**

Background and objectives

Life on the seabed in the southern North Sea is exposed to increasing human activities and geophysical changes. In order to maintain the good ecological status of the North Sea, it is important to better understand the cumulative effects of these pressures.

The BMBF-funded joint project "MuSSeL - Multiple Stressors on North Sea Life" aims to assess the risks of cumulative effects on the diversity, distribution and functionality of seabed communities in the past, present and future and to identify hotspots of change.

Approach

In order to better assess and predict changes in the biotic communities on the seabed, a variety of different modelling approaches are coupled together. Qualitative information flows together with high-resolution empirical data and model data. A central approach of the project is the use of trait-based methods for the risk assessment of cumulative effects on the functionality of seafloor communities.

The cause-effect relationships identified in the project will be transferred into an operational model to provide decision-making aids for maintaining the good ecological status of seabed communities.

Results

The main drivers of cumulative human pressures on seabed communities in the southern North Sea are climate change, fisheries, offshore wind energy, sand and gravel extraction, agriculture and industry (Fig. 1). Almost all of these drivers contribute to chemical pollution and increased nutrient inputs. Habitat changes, e.g., due to turbidity plumes and sediment loss, are also caused by several drivers in the system. These pressures primarily affect biological characteristics such as size and weight, but also reproductive characteristics and the feeding behaviour of demersal (= bottom-dwelling) fish

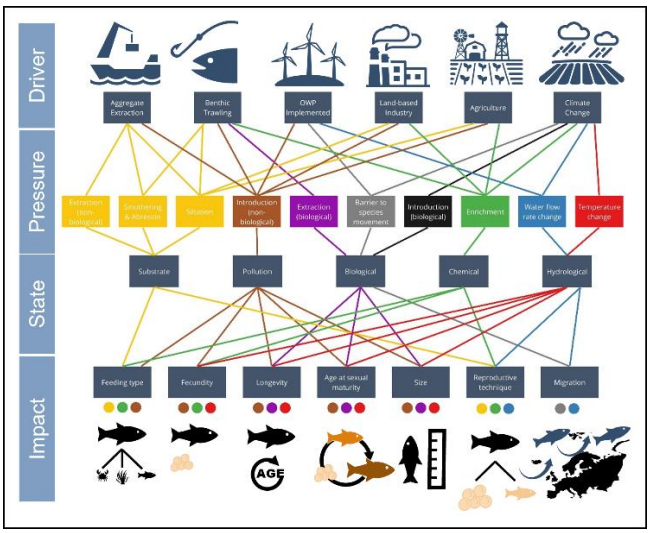

Figure 1: Cause-effect relationships between climate change and human activities (Driver), the resulting pressures and the characteristics of demersal fish communities (Impact) - (Source: Own illustration).

communities. Hotspots of communities with sensitive expressions of these characteristics are mainly located in the south-western part of the southern North Sea.

As part of an expert workshop, future scenarios for the development of some of the main drivers and pressures were considered. It was shown that bottom fishing and nutrient inputs are likely to decrease (Stelzenmüller et al., 2024). In contrast, the importance of offshore wind energy as a source of cumulative effects will increase.

The results of various statistical models show that geophysical stressors in particular have contributed to spatial and temporal changes in the species composition and functionality of seafloor communities. For demersal fish communities, these

are primarily stressors such as current turbulence on the seabed, depth and sediment grain size (Fig. 2).

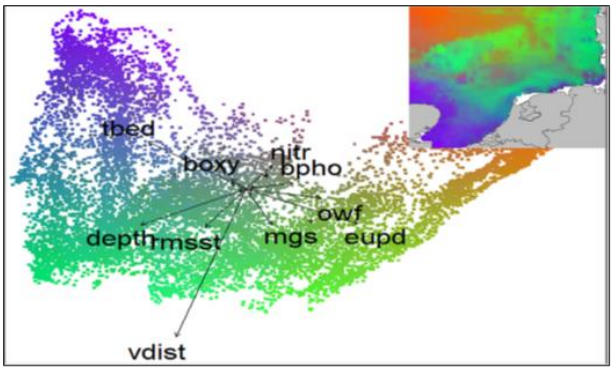

Figure 2: Predicted changes in the species composition of demersal fish communities for the ten most important drivers such as current turbulence (vdist), depth and sediment grain size (mgs). These changes were mapped to the first two dimensions of a biologically transformed space of explanatory variables, taking into account their respective influence on species composition patterns. The colour scale shows the explanatory variables most strongly associated with these changes in species composition, with the arrows indicating the direction and strength of the explanatory variables (Source: Kraan et al., 2024).

The distribution maps of fish species statistically determined with the help of survey data and environmental data can be used both for individual species and for species communities to identify relevant core areas.
If the distributions of all demersal fish species are superimposed, a hotspot map is created (Fig. 3). In the southern North Sea, there are areas that are core areas of distribution for more than 30 fish species. However, these areas are mainly located off the English, Belgian and Dutch coasts. In Germany's exclusive economic zone, the density of species with core areas is significantly lower and areas with an increased number of species are located outside existing protected areas. One factor that may influence the distribution of fish species in the future is climate change. For example, a distribution model for the thornback ray Raja clavata predicts an increase in this species, which is threatened by fishing bycatch, with warmer temperatures.

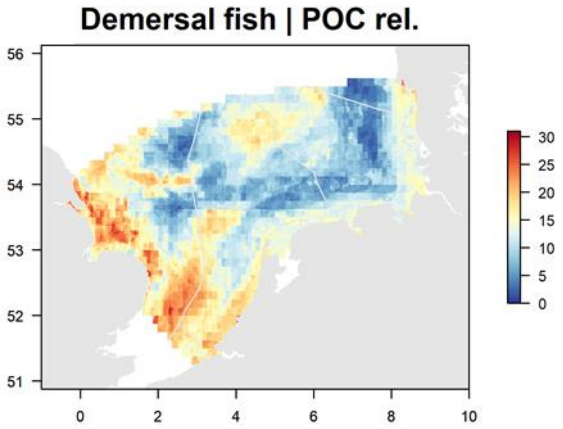

Figure 3: Distribution of diversity hotspots of demersal fish in the southern North Sea. The number of species-specific relative core areas (POC rel.) is given for each grid cell. Relative core areas describe areas where a species is most likely to be found.
(Source: https://zenodo.org/records/11261320)

Conclusion

The southern North Sea is subject to multiple uses and pressures that have already affected and will increasingly affect the occurrence and distribution of marine organisms. The analysis and modelling of human-induced pressures on key ecosystem components allows an assessment of the cumulative effects of human activities in a changing marine environment.

Further information

Contact

[1]Thünen Institute of Sea Fisheries

jennifer.rehren@thuenen.de
www.thuenen.de/sf
www.mussel-project.de

Partner

Helmholtz-Zentrum Hereon
Universität Hamburg
Bundesamt für Seeschifffahrt und Hydrographie
Hochschule Bremerhaven

Runtime

11.2020-10.2023

Project-ID

2348

DOI: 10.3220/253-2025-8

Publications

Stelzenmüller, et al. (2024). Framing future trajectories of human activities in the German North Sea to inform cumulative effects assessments and marine spatial planning. J Environ Manage 349, 119507.

Kraan et al. (2024). Thresholds of seascape fauna composition along gradients of human pressures and natural conditions to inform marine spatial planning. Sci Total Environ 914, 169940.

Rehren et al. (2022). Fact sheet on key policies & development components of sand and gravel extraction in the German North Sea. https://hub.hereon.de/portal/sharing/rest/content/items/8457e3c1204940cc86749149d05e06b4/data

Probst N. 2024. https://zenodo.org/records/11261320

Funding

Federal Ministry of Education and Research

FONA
Forschung für Nachhaltigkeit