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Projected impact of climate change in the North and Baltic Sea. Results from dynamical downscaling of global CMIP climate scenarios

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Climate models have predicted strongest climate change impact for the mid/high lattiude areas. Despite their importance, shelves seas (which are supposed to account for more than 20% of global marine primary production and for up to 50% of total marine carbon uptake) are not adequately resolved in climate models.
In this study, the global ocean general circulation and biogeochemistry model MPIOM/HAMOCC has been setup with an enhanced resolution over the NW European shelf ($\sim$10 km in the southern North Sea). For a realistic representation of atmosphere-ocean interactions the regional model REMO has been implemented. Thus, this model configuration allows a physically consistent simulation of climate signal propagation from the North Atlantic over the North Sea into the Baltic Sea since it interactively simulates mass and energy fluxes between the three basins.

The results indicate substantial changes in hydrographic and biological conditions for the end of the 21st Century. A freshening by about 0.75 psu together with a surface warming of $\sim$2.0 K and associated circulation changes in and outside the North Sea reduce biological production on the NW European shelf by $\sim$35%. This reduction is twice as strong as the reduction in the open ocean.
The underlying mechanism is a spatially well confined stratification feedback along the shelf break and the continental slope which reduces the winter mixed layer by locally more than 200 m compared to current conditions. As a consequence winter nutrient supply from the deep Atlantic declines between 40 and 50%. In addition to this, the volume transport of water and salt into the North Sea will slightly reduce ($\sim$10%) during summer. At the end of the 21st Century the North Sea appears nearly decoupled from the deep Atlantic.
The projected decline in biological productivity and subsequent decrease of phytoplankton (by averaged 25%) will probably negatively affect the local fish stock in the North Sea.

In the Baltic Sea the climate change impact is even stronger than in the North Sea. The surface temperature rises by 2.8 K and surface salinity declines by 1.3 psu. In the Gotland basin oxygen concentrations below 100m in the Baltic Sea reduce slowly and salt intrusion events from the North Sea become less frequent. This enhances the probability for extending hypoxic conditions in the Baltic Sea. The reproductive water volume for cod decreases by 25% towards the end of the simulations with main drops in the 1980'ies and 2020'ies.

Due to the reduced biological production CO_2 uptake in the North Sea is lowered by 1/3 at the end of the 21st Century compared to the end of the 20th Century implying a strong weakening of shelf carbon pumping. Contrary to previous studies, our results indicate that the North Sea acts only as a very weak carbon shelf pump. This is because most of the water exported to the open ocean remains within the mixed layer, where it is still exposed to the atmosphere. For the North Sea we estimate that currently only 20% of the absorbed carbon is stored for longer in the open ocean.