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Modelling marine ecosystem response to climate change and trawling in the North Sea

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One-dimensional water column models of the coupled physical-biogeochemical model GOTM-ERSEM were applied to three contrasting sites in the North Sea, forced with Hadley Centre regional atmospheric circulation model predictions for the period 1958-2099 to investigate the predicted response of the lower trophic levels of the ecosystem to climate change. Also, the combined effects of climate change and sea-bed impact of bottom trawling (mortality of benthic organisms and enhanced pore water nutrient exchange with the pelagic system) were simulated. The three sites were the Sean Gas Field in the southern Bight (depth 30 m, well-mixed throughout the year, sandy bottom), the Oyster Grounds (depth 45 m, seasonally stratified, muddy sand), and a site north of the Dogger Bank (depth 80 m, seasonally stratified, muddy sand). Improvements were made to the benthic-pelagic coupling of the model. Model results were compared with an extensive data set collected at the three sites in 2008 using moored buoys, sea-bed landers, mid-water tethers, ship-based CTD casts, sea-bed grab samples and SPI camera sea-bed sections. Results for climate change showed increased primary production and pelagic carbon cycling, and reduced benthic biomass. These changes were induced partly by the increase in air temperature, and partly by changes in the seasonality of the wind climate, which resulted in more quiet spring weather. The model response was quite complex, and different for each of the three sites. Overall, the model trended towards a more pelagically oriented ecosystem. Bottom trawling had the largest effect on benthic biomass, mainly through increased mortality of benthic organisms, as such enhancing the climate-change response. These results can provide guidance for marine management under the EU Marine Strategy Framework Directive and the UK Climate Change Act.