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pH variability, CO2 induced acidification and ecological consequences in the North Sea.

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There is a strong possibility that marine pCO2 levels will double over their pre-industrial values by the mid 21st century, with resulting pH changes three times greater than those experienced during the transition from glacial to interglacial periods. Affects on marine biogeochemistry are inevitable but complex with several vectors such as the disruption of carbonate chemistry and inhibition of nitrification. Such changes have the potential to shift plankton species composition, altering both the strength of the biological pump and the economic utility of the system. By integrating 1D and 3D NW European shelf marine ecosystem models with algorithms that describe carbonate chemistry and pH, we quantify the temporal and spatial variability in pH across the southern North Sea as it relates to the biological processes affecting CO2, namely photosynthesis and respiration, riverine boundary conditions and atmospheric CO2 concentrations. This modelling capability is based on the ERSEM ecosystem model that resolves the detailed functional and community structure of the marine system, including benthic chemistry and ecology; coupled with either the high resolution GOTM (1D) or POLCOMS (3D) physical models. Annual pH ranges are found to vary from $<$0.2 in areas of lower biological activity to $>$1.0 in areas influenced by riverine signals, consistent with observations and previous studies. It is shown that benthic processes are an important driver of this variability. The acidification of the region due to the predicted increase of atmospheric CO2 fluxes into the marine system is calculated and shown to exceed, on average, 0.1 pH units by 2050 and result in a total mean acidification of 0.5 pH units below pre-industrial levels at atmospheric CO2 concentrations of 1000 ppm. The potential for measurable changes in biogeochemistry is demonstrated by simulating the observed inhibition (of the order of a 10% decrease) of pelagic nitrification with decreasing pH. We also report on the sensitivity of coccolithophore populations to the observed pH related inhibition of calcification

coupled with the prevailing physical conditions, demonstrating the necessity to consider acidification effects alongside those of global warming.