Simulating the carbon cycle in a high latitude shelf sea (North Sea) — evidence for decoupled carbon and nutrient cycles

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For the first time, the carbon budget of the North Sea, a Northwest European shelf sea, has been assessed using a three–dimensional coupled biogeochemical model resolving the carbon cycle. Simulations for the years 2001/2002 are thoroughly validated against high resolution field data sets from the same period. The results indicate that the North Sea acts as a significant sink for atmospheric CO_2. The uptake of CO_2 is balanced by an export of carbon into the deep waters of the North Atlantic, confirming observations suggesting the efficient removal of CO_2 from the atmosphere via the continental shelf pump mechanism. The simulated net community production (NCP) and net primary production (NPP) reveal the biological controls of this transport: despite the higher NPP in the southern North Sea, NCP, i.e. net carbon fixation, and the NCP/NPP ratio are small because of high remineralization of organic matter in the continuously mixed water column. In contrast, in the surface layers of the northern North Sea, NCP, net carbon fixation and the NCP/NPP ratio are high because of the high export of organic matter into the deeper layer of the seasonally stratified system, preventing organic matter remineralization in the surface layer. The implementation of overflow production releasing semi–labile dissolved organic carbon under nutrient limited conditions enables the model to reproduce the observed pCO_2 and DIC drawdown during summer. This decoupling of carbon fixation from the control of nutrient

uptake via a fixed C/N ratio is essential for a realistic simulation of the magnitude of the air–sea flux of CO_2, and thus the carbon cycle of the North Sea.