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Non-Redfieldian dynamics explain seasonal pCO_2 drawdown in the Gulf of Bothnia

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High inputs of nutrients and organic matter make coastal seas places of intense air-sea CO_2 exchange. Due to their complexity, the role of coastal seas in the global air-sea CO_2 exchange is, however, still uncertain. Here we investigate the role of phytoplankton stoichiometric flexibility and extracellular DOC production for the seasonal nutrient and CO_2 partial pressure (pCO_2) dynamics in the Gulf of Bothnia, Northern Baltic Sea. A 3D ocean biogeochemical-physical model with variable phytoplankton stoichiometry is for the first time implemented in the area and validated against observations. By simulating non-Redfieldian internal phytoplankton stoichiometry, and a relatively large production of extracellular dissolved organic carbon (DOC), the model adequately reproduces observed seasonal cycles of macronutrients and pCO_2. The uptake of atmospheric CO_2 is underestimated by 50% if the Redfield ratio is instead used to determine the carbon assimilation, as in other Baltic Sea models currently in use. The model further suggests, based on the observed drawdown of pCO_2, that observational estimates of organic carbon production in the Gulf of Bothnia, derived with the 14C method, may be much too low. We conclude that stoichiometric variability and decoupling of carbon and nutrient assimilation have to be considered in order to better understand the carbon cycle in coastal seas.