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A novel adaptive biogeochemical model, and its 3-D application for a decadal hindcast simulation of the biogeochemistry of the southern North Sea

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Adaptation and acclimation processes are often ignored in ecosystem-scale model implementations, despite the long-standing recognition of their importance. Here we present a novel adaptive phytoplankton growth model where acclimation of the community to the changes in external resource ratios is accounted for, using optimality principles and dynamic physiological traits. We show that the model can reproduce the internal stoichiometries obtained at marginal supply ratios in chemostat experiments. The model is applied in a decadal hindcast simulation of the southern North Sea, where it is coupled to a 2-D benthic model and a 3-D hydrodynamic model in an approximately 1.5km horizontal resolution at the German Bight coast. The model is shown to have good skill in capturing the steep, coastal gradients in the German Bight, suggested by the match between the estimated and observed dissolved nutrient and chlorophyll concentrations. We then analyze the differential sensitivity of the coastal and off-shore zones to major drivers of the system, such as riverine nutrient loads. We demonstrate that the relevance of phytoplankton acclimation varies across coastal gradients and can become particularly significant in terms of summer nutrient depletion.