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Controls on oxygen response to climate change on the Northwest European Continental Shelf

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Dissolved oxygen in the ocean is an indicator of water quality and low concentrations can threaten ecosystem health. The main sources of marine oxygen are diffusion from the atmosphere and phytoplankton photosynthesis. Biological respiration and decomposition act to reduce oxygen concentrations. Under conditions of vertical stratification, the water column below the pycnocline is isolated from oxygen exchange with the atmosphere, photosynthesis may be limited by light availability and oxygen concentrations decrease. Climate change influences the oxygen cycle in two ways: 1) changing the hydrodynamic climate and 2) affecting rates of biogeochemical processes. The hydrodynamic climate affects the nutrient supply and so controls phytoplankton production while changes to water column stratification affects vertical mixing. Gas solubility decreases with increasing temperature so that oxygen uptake from the atmosphere is expected to decrease under increasing oceanic temperatures. Biological cycling rates increase with increasing temperature affecting photosynthesis, respiration and bacterial decomposition. It is not obvious whether changes in oxygen concentrations due to changing ecosystem processes will mitigate or reinforce the projected reduction from solubility changes.

The Northwest European Continental shelf (NWES) is a region of the northeast Atlantic that experiences seasonal stratification. We use the physics-biogeochemical model NEMO-ERSEM to study near-bed oxygen concentrations on the NWES under a high greenhouse gas emissions scenario (Representative Concentration Pathway (RCP) 8.5). We show that much of the NWES could experience low oxygen concentrations by 2100 and assess the relative impacts of changing temperature and ecosystem processes. Until about 2040 the impact of solubility dominates the oxygen change. The mean near-bed oxygen concentration is projected to decrease by 6.3% by 2100, of which 73% is due to solubility changes and the remainder to changes in the ecosystem. In the oxygen-depleted region in the eastern North Sea, 77% of the near-bed oxygen reduction is due to ecosystem processes.