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Physical preconditioning of oxygen depletion in shelf seas

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The global ocean dissolved oxygen (DO) inventory is decreasing and the areal extent of DO deficiency is increasing. In the shelf sea BML, net DO removal can occur as a result of restricted ventilation due to seasonal thermal stratification, oxygen consumption via pelagic and benthic respiration of organic matter, and nitrification. DO decline is becoming evident in several shelf seas, with recent model studies estimating that large regions of the Northwest European continental shelf seas (325,000 to 400,000 km^2) have the potential to become seasonally deficient in DO in late summer. It is therefore of vital importance that DO is monitored accurately and effectively in shelf seas.

Here we present results from AlterECO project, which aimed to provide an alternative, novel framework for the monitoring of shelf sea ecosystem health indicators, including DO, via the deployment of 20 gliders in the North Sea (NW European shelf). Between November 2017 and May 2019 the gliders provided 18 month continuous measurements of T, S, chlorophyll fluorescence, and DO in the seasonally stratified study area, capturing the onset and breakdown of two spring blooms. In both years the gliders captured a weakly stratified, deep (>60m) thermocline in late autumn which was responsible for oxygen deplete (75%) 'pools' in the North Sea. Our results show that preconditioning of pre-bloom transitional periods as well as episodic mixing events drive inter-annual differences in BML DO concentrations. Large inter-annual variability between pre-bloom physical conditions was observed, with the occurrence of anticyclone Hartmut in February 2018 resulting in a much colder water column (and therefore higher solubility of DO) in spring 2018 than 2019. Additionally we will demonstrate that the erosion of mini-blooms during the onset of stratification results in mixing of supersaturated DO surface water into the BML, helping to prevent DO deficiency in the BML in late summer. Comparisons of our high resolution glider data with the latest state of the art biogeochemical models (AMM15-ERSEM) will also be presented. We postulate that understanding the drivers of inter-annual variability in pre-bloom physical conditions is crucial in terms of understanding and predicting DO depletion in shelf seas.