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A long term glider study of shelf sea oxygen dynamics

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Oxygen is involved in most biogeochemical processes in the ocean, and dissolved oxygen (DO) is a well-established indicator for biological activity via the estimate of apparent oxygen utilisation (AOU). In the deep waters of the open ocean, the AOU provides a valuable insight into the ocean's biological carbon pump. However, in the physically dynamic and highly productive shallow shelf seas, interpretation of the oxygen distribution and the magnitude of AOU is complex. Physical processes, such as diapycnal mixing, entrainment and horizontal advection act to ventilate waters below the thermocline and thus increase oxygen and decrease AOU. In contrast, biological remineralisation of organic material below the thermocline will consume oxygen and increase AOU. We aim to address the following: 1. Does AOU change seasonally in a shelf sea in response to seasonal changes in productivity? 2. How important is turbulence in redistributing oxygen in a shelf sea?

Using 9 months of high-resolution data from >20 glider deployments in the seasonally stratified NW European Shelf Sea we identify and quantify the physical and biological processes that control the DO distribution and magnitude of AOU in shelf seas. A 200km transect between the shelf edge and the central Celtic Sea (CCS) was repeated between November 2014 and August 2015, thus capturing key periods in the seasonal cycling in shelf seas, specifically the onset of stratification, the spring bloom, stratified summer period and breakdown of stratification. The gliders collected data for DO, temperature, salinity, chlorophyll fluorescence, CDOM, backscatter and turbulence. In addition, direct measurements of turbulent dissipation from the Ocean Microstructure Glider deployed during the campaign provided estimates of mixing at CCS and the shelf break, allowing accurate quantification of the vertical fluxes of oxygen. We find that oxygen decreases ubiquitously across the shelf as soon as stratification takes hold, though BML oxygen decreases at a slower rate during summer compared to spring at the shelf break and also across the inner shelf. This appears to be due to a stronger oxycline and potentially more efficient, sporadic mixing of oxygen across the thermocline during summer. Biological oxygen consumption is greater at the shelf break than on shelf even when accounting for enhanced oxygen diapycnal fluxes at the shelf break. Gliders prove to be a good tool in monitoring long term oxygen changes in shelf seas and we find that accurate estimation of AOU in the shelf sea requires inclusion of mixing processes.