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Using stable isotopes to unravel sources and cycling of nitrogen in shelf seas

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Shelf seas are highly productive and economically important regions of our oceans, and therefore play a significant role in the global ocean carbon cycle. Their productivity is thought to be sustained through dynamic physical mixing processes combined with the supply of both terrestrial and oceanic nutrients and internal regeneration of nutrients; however the relative importance of these different nutrient pools is currently not clear. In the present study, we use the nitrogen stable isotope composition (δ15N) of particles (δ15N-PN) and the δ15N and stable oxygen isotope (δ18O) composition of dissolved nitrate to quantitatively assess the relative magnitude and importance of a terrestrial and oceanic source of nitrate versus on-shelf regeneration of nitrate in sustaining the on-shelf nitrate pool that supports high primary productivity in temperate shelf seas.

Samples were collected from 2014 to 2015 in the Celtic Sea, part of the Northwest European shelf sea. Dissolved inorganic nutrient and oxygen concentrations were highest in spring, and decreased through the stratified productive season until the breakdown of stratification in the autumn. During this time, we observed a 1:1 increase in surface δ15N-NO_3 and δ18O-NO_3 reflecting the assimilation of the nitrate pool by phytoplankton to fuel production. Between spring and autumn, the N:P of the bottom layer dissolved inorganic pool increased from 12 to 15, while oxygen saturation decreased from super-saturation in spring to less than 90% in autumn. There was a concomitant decoupling of the δ15N and δ18O of nitrate in bottom water with the introduction of isotopically light δ18O-NO_3 , indicating that $\sim$30 % of the nitrate pool was sustained by local regeneration of nitrogen on the shelf.

Previous studies have assumed that diapycnal nitrate fluxes to the euphotic layer in shelf seas support "new production", our results suggest that up to 30% of this nitrate may be locally regenerated in the central region with areas further on-shelf sustained increasingly by regenerated nutrients. Therefore, our findings have significant implications for our understanding of the efficiency of the shelf sea carbon pump and subsequent potential carbon export from shelf seas.