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Importance of nitrification for nitrogen cycling in the Southern Benguela Upwelling system.

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Nitrification is the oxidation of ammonium to nitrate through biological processes. It is a a two step process where ammonium is converted to nitrite and then oxidised to nitrate. Nitrification in the euphotic zone has, in the past, been considered negligible. Recent studies have found that quantifying this process correctly is important when linking export to nitrate uptake by phytoplankton. However there are very few studies showing nitrate uptake and nitrification rate together in surface waters. This study presents the first such data for the Benguela upwelling system, which is one of the most productive marine ecosystems.

This paper presents a comparison of nitrogen uptake and regeneration rates from St-Helena Bay, located in the Southern Benguela upwelling system, during three studies in November 2011, March 2012 and March 2013. During each survey, samples were collected within 5 metres of the surface at a single station for three consecutive days. Two of the experiments investigated both night time as well as day time rates. The samples were enriched with 15-N tracers and incubated *in-situ* for 6, 12 or 24 hours to estimate ammonium and nitrite oxidation and nitrate and ammonium uptake rates. Nitrate uptake, ρNO_3 , ranged from 7 to 753 nmolL^{-1} h^{-1} during the day. At night, the minimum ρNO_3 was 5 nmolL^{-1} h^{-1} and the maximum 23 nmolL^{-1} h^{-1} . Ammonium uptake, ρNH4 , ranged 7 to 440 nmolL^{-1} h^{-1} . Ammonium oxidation rates were between 0.20 $\pm$0.54 and 17.8 $\pm$0.4 nmolL^{-1} h^{-1} and nitrite oxidation rates between 18.6$\pm$9.7 to 88.20$\pm$17.78 nmolL^{-1} h^{-1}.

Depending on the timing of sampling within an upwelling cycle, the proportion of nitrate used by phytoplankton from the regenerated pool rather than a “new” (i.e upwelled) source varied. Equating nitrate uptake to carbon export traditionally relies on the assumption that all nitrate present in the surface is “new” and originates from below the euphotic zone. In this study, the nitrite oxidation (nitrate regeneration) rates ranged from 3.5% to more than 100% of the nitrate uptake rate. This shows that the application of uniform carbon export models,which consider nitrification within the surface layers to be negligible at all times, should be revised. The results are put in the context of the ecosystem and biogeochemical framework of the experiment relating nitrate uptake to, *viz.* nutrient and chlorophyll concentrations, pH, pCO_2 and the taxonomy and size distribution of the phytoplankton community.