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Ammonium regeneration rates in the oligotrophic oceans – consequences for estimates of new production

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The biogeochemical cycling of carbon and nitrogen in the oceans is intrinsically linked. Marine primary productivity in the oligotrophic ocean is limited by the availability of dissolved nutrients - usually inorganic nitrogen. Our understanding of biological sequestration of atmospheric CO_2 in the ocean depends on estimates of 'new production' – the amount of primary production that results from nitrate assimilation. Phytoplankton cells assimilate other nitrogen compounds, principally ammonium. Microbially mediated degradation of organic molecules releases ammonium, thus supporting 'regenerated production'. New and regenerated production are related in the f-ratio, which is widely used in model formulations of exportable production. Fratios are derived experimentally from estimations of N-assimilation rates using ^{15}N tracer techniques. These techniques assume that the isotopic enrichment of the Nsource (NO_3^- or NH_4^+) is constant for the duration of incubations. However, this assumption is not correct if significant rates of ammonium regeneration or nitrification take place during incubations. The consequent isotope dilution leads to an underestimate of Nassimilation rates and hence errors in the fratio.

This paper presents data generated from a new Gas Chromatography / Mass Spectrometry technique developed for the determination of ammonium regeneration rates in severely oligotrophic oceans. The method was applied on a transect of the Atlantic Ocean between the UK and the Falkland islands on a cruise of the Atlantic Meridional Transect project (AMT13); the cruise track included the West African upwelling region. Measurements were made on samples taken from two depths (equivalent to 1% and 55% surface Photosynthetically Active Radiation) at 16 stations along the transect. The lowest rates of ammonium regeneration were measured in the olig-

otrophic gyres of the North and South Atlantic Ocean, with values in the region of 1.06 nmol·L^{-1}·hr^{-1} (1% sPAR) and 2.25 nmol·L^{-1}·hr^{-1} (at 55% sPAR). In the upwelling region off the West African Coast, ammonium regeneration rates increased to 2.52 nmol·L^{-1}·hr^{-1} (1%) and 6.22 nmol·L^{-1}·hr^{-1} (55%).

These rates of ammonium regeneration have a significant impact on estimates of fratio and new production. In the North Atlantic, at depths equivalent to 55 % sPAR, f-ratio values decrease by 10 to 13 % when corrected for isotope dilution due to ammonium regeneration. This is a non-trivial difference in fratio and demonstrates that significant errors will result in experiments to estimate new production if ammonium regeneration is ignored. These findings have important implications for global estimates of new production and the role of microbial interactions in the sequestration of atmospheric CO_2.