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Biogeosciences Discussions

Interactive comment on "Nitrogen uptake by phytoplankton in the Atlantic sector of the Southern Ocean during late austral summer" *by* W. R. Joubert et al.

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1) Ammonium and urea concentrations were generally high (up to 3 umoles.l-1) indicating very active processes of regeneration. These processes certainly lead to significant isotopic dilution during incubation. Then, urea and ammonium uptake rates have been certainly largely underestimated. Response: Isotopic dilution was not measured and considered in the calculation of uptake rates of regenerated substrates. The authors recognise the importance of these processes particularly considering the high ambient concentrations of ammonium and urea, which could result in underestimation of the regenerated uptake rate. Given the already high regenerated uptake rates, particularly

in northern sector, higher regenerated uptake rates would certainly result in smaller f-ratios highlighting the strong regenerated production observed in the northern sector of this cruise. In the regions further south, a smaller f-ratios will result which could indicate diminished 'exportable' new production. The text of the manuscript was modified to consider this.

2) Estimates of carbon export were derived from nitrate uptake rates. But the part of nitrate issued from nitrification in unknown. Considering the significant regeneration activity revealed by high concentrations of ammonium, nitrification cannot be ignored, especially at depth. Consequently, carbon export estimates from nitrate uptake have been overestimated, probably. Some additional information on nitrification could be given by nitrite concentrations, if available. Response: The use of nitrogen uptake as a proxy for carbon export through the f-ratio (Eppley and Peterson, 1979) remains contentious due to its underlying assumptions. These include the uptake of new nitrogen (NO3) approximately balance the upward flux of NO3 into the surface, no storage of nitrogen in the surface water, excluding the release of DON through heterotrophic activity (Bronk et al., 1994), ignoring nitrification in the euphotic layer (Yool et al., 2007). Furthermore, assumptions of stoichiometric ratios ie Redfield et al., (1969) to calculate carbon production adds further complication as phytoplankton growth often follow non-Redfield ratios due to environmental stress (Brzezinski et al., 1997, Arrigo, 2005, Moore et al., 2007). Uncoupling of carbon production and carbon export (Buesseler, 1998) is also observed where diatom-dominated new production may result in lower than expected POC fluxes (Tremblay et al., 2002). These assumptions make the f-ratio flawed as a proxy for carbon export, and needs to be considered when looking at uptake rate of nitrogen, and can provide useful information to characterise ecosystem functioning, particularly when used in conjunction with other export proxies. Furthermore, when considering that new production is an order of magnitude greater than 234Th export data, it is clear that the new production estimates are potentially severely overestimated since new production is calculated solely from NO3 uptake data. Nitrification is thought to account for half of global nitrate consumption by phytoplankton

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(Yool et al., 2007). Also given the high regenerated (NH4 and Urea) nutrients, it is difficult to ignore active nitrification. However, given the high NO3 concentrations, the contribution of nitrification to the available NO3, is assumed to be small.

3) Nitrogen uptake rates and especially nitrate uptake rates show very high values at 10 and 1% incident light, often higher than those measured at surface (see stations L1, L2, S2, L3, L4, L5,L6, L76, S5). How the authors can explain these vertical profiles of nitrate uptake? I suppose that depths indicated in table 1 correspond to the 5 irradiance levels. Please improve. Response: Table 1 is updated to include the % irradiance levels, and the caption is updated accordingly. The reviewer correctly highlights the often high nitrate uptake rates observed at the 10% light level. These rates are often similar to the rates observed 25% light level. Nitrate uptake at the 1% light level, in most cases (except L3) are lower than rates observed at higher irradiances. A decrease in nitrate uptake is expected with depth due to the higher light requirements of nitrate uptake relative to ammonium uptake (Cochlan et al., 1991). This would result in decreasing f-ratios with depth. Conversely, higher nitrate uptake would result in higher f-ratios with increasing depth. From Table 1, f-ratios remain fairly constant down the depth of the water column.

4) More, considering the high values of nitrogen uptake observed under 1% light, integrated rates have been probably underestimated at several stations. Response: No measurement of uptake rates was conducted below the 1% light level. We acknowledge the reviewers concern, but have no way of extrapolating to deeper light depths without inferring a light attenuation model, which adds further uncertainty to the nitrogen uptake. It is possible that our data is underestimated, at stations with high uptake at 1% light level.

5) Urea is an organic substrate assimilated easily by heterotrophic bacteria. Then, how to be sure that urea uptake was only regenerated production, i.e. nitrogen uptake associated with photosynthetic carbon fixation? Heterotrophic urea uptake can lead to underestimation of f-ratio. I have some reservations on the use of uptake rates for the

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f-ratio estimates. Please discuss. Response: It is unlikely that urea uptake is mainly regenerated production, as urea is easily assimilated by heterotrophic bacteria (Kirchman, 2000) which can contribute up to 25% of nitrogen uptake (Fouilland et al., 2007). The low f-ratios are probably underestimated, due to the non-inclusion of heterotrophic bacterial activity, which does not escape the glass fibre filters (0.7 microns), however, an decreased autotrophic urea uptake would still contribute significantly to the nitrogen uptake in this region. The discussion section is modified accordingly.

6) Comparison between the two estimates of vertical carbon fluxes need to be more deeply discussed according to the above comments. Response: We updated the discussion section considering the above mentioned comments.

Some specific comments a) STZ area does not seem to be really oligotrophic. Nitrate concentration ranged between 0.25 to 2.01 umoles.l-1. Very low concentrations (<0.05 umoles.l-1), as indicated in section 3.2, are not presented in table 1. More POC values are very high in this region, ranging from 5-8 to 12 umoles.l-1. What is the origin of this biomass? Response: Figure 3 indicate the oligotrophic conditions (<0.05 umol/l, the detection limit of the analytical method). Table 1 was updated accordingly. The high POC concentrations observed is possibly due to the biomass build-up which results from phytoplankton escaping grazing pressure. Although this is also the region with the highest regenerated production, it is possible that bacterial biomass plays an important role in the microbial loop activity in this region.

b) Figures 5 and 6 are not really useful or need additional discussion. Response: Fig 6 is retained and discussed in further detail. N Specific uptake rates provide information on turnover times and potential for macronutrient-, light or iron limited growth with higher values characteristic of faster growth rates in nutrient and light replete environments. The highest VNO3 of the cruise were also found at this station (0.12 d-1), double that found in other regions (Fig. 5), indicative of potential relief of nutrient and iron stress (Lucas et al. 2007).

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Finally, I found the discussion of low level on the whole. All the points listed above need to be more deeply discussed. In conclusion, I consider this paper not enough accurate to be published as it stands. Response: We have addressed the reviewer's comments, and are hopeful that the updated manuscript will sufficiently comply with the reviewers concerns.

Interactive comment on Biogeosciences Discuss., 8, 4917, 2011.