

Biogeosciences Discuss., referee comment RC3
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Comment on bg-2021-149

Anonymous Referee #3

Referee comment on "Biogeochemical controls on ammonium accumulation in the surface layer of the Southern Ocean" by Shantelle Smith et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-149-RC3>, 2021

General Comments

Ammonium (NH_4^+) is an important macronutrient in marine ecosystems and the dynamics of its production, utilisation, and regeneration are reasonably well studied within the marine microbial food web. However, how these dynamics play out in the Southern Ocean is not well understood and this is especially so during the winter months when conditions in this region are challenging due to large storms, low temperatures, limited light availability, and the presence of sea ice. In their paper, Smith et. al provide a detailed snapshot of NH_4^+ concentration and dynamics (uptake and oxidation rates) in the surface water and winter mixed layer during a winter voyage in the Atlantic sector, bordering the Indian sector, of the Southern Ocean. To better understand these dynamics, the authors investigate links between macronutrient concentrations, microbial community composition and biomass, net primary production, particulate organic matter, and nitrogen isotopic fractionation. This is a substantial data set to both analyse and interpret and I commend the authors for their very thorough analysis of the data and its links to the available literature on this topic.

There are, however, some weaknesses in the manuscript that need to be addressed. Most notable of these is the presentation of new results and data analysis in the discussion. Particularly Section 5.2, which presents a completely new data set of three additional cruises adjacent to the region being studied. This year-round analysis of NH_4^+ in Southern Ocean surface waters is indeed complementary to the current study and allows for analysis of seasonal cycling of NH_4^+ . However, this seems like a separate paper on its own and is indeed, presented as such in this section (methods, results & discussion). In addition to this, there are also data and analysis presented in the supplement (Text S2 & S3) that appear to be critical for some of the analysis presented in the discussion and have not been presented or referenced at all in the results section.

Visualising such an extensive data set is a difficult task, but a lot of information is being presented in the figures and tables, which makes some of them very difficult to read or interpret, especially at publication size. The authors discuss implications of a better understanding of the seasonal NH_4^+ dynamics in the Southern Ocean but don't really explain how this present study may alter or affirm the current knowledge base. Lastly, the authors seem to focus on CO_2 uptake and drawdown in the mixed layer in the introduction and conclusion but there is no real mention of this in the discussion. If the authors

consider this an important implication of the research being presented and it should also be discussed.

Specific Comments

Introduction:

L124-135 – NH_4^+ oxidisers are an important group of microorganisms in this study and are discussed in length in the discussion (L643-680), but it is never really explained what this microorganism group is composed of. Please provide some context in the introduction so the reader understands this better.

Methods:

L188 – what concentration of acetone was used?

L208-9 – were these filters combusted? Storing them in combusted foil suggests they were?

L257-8 – here, the authors distinguish each of the fractionated size classes into 0.3-2.7 μm "picophytoplankton", >2.7 μm "nanophytoplankton", and >0.3 μm "bulk" but do not consistently use this terminology throughout the rest of the manuscript. It would aid in understanding if the manuscript was updated so that this terminology was consistently applied through the rest of the analysis and discussion (examples below).

L310 – the conventional size range for microplankton is 20-200 μm so this microscopic analysis of cells >5 μm also includes most of the nanoplankton size range.

L315 – there is no mention that the flow cytometry analysis was on cells sized <15 μm . It is only mentioned in the caption of Fig. 6.

L328 – it appears from the discussion (Section 5.1.2) that these "small heterotrophic cells" are being counted as heterotrophic bacteria. Is this correct? It appears to be implied from the data but not directly specified in this section of the methods.

Results:

L383 – the >2.7 μm size class has previously been defined as "nanophytoplankton" (see L257-8 above) so there should not be a need to redefine it with a different, albeit very similar, name.

L380-6 – there is no mention of the picophytoplankton (0.2-2.7 μm) size class results here.

L388-9 – the percentage contributions of POC & PON of the nanophytoplankton size class, when SD is taken into account, range from 48.8-112.4% and 19.5-120.1%, respectively. From Table 1 it appears that in the PAZ the proportion of POC in the nanophytoplankton class was 143.02%, and the PON for this class in the PFZ has a SD of 121.41%. I would question an analysis where a size-fractionated class displays values that are far greater than the bulk. Can the authors explain why the POC & PON proportions reported are higher in the >2.7 μm filters than the >0.3 μm filters? The authors may want to consider whether the way the data is being presented is appropriate.

L393 – the statistical analysis here is not mentioned in the methods and appears to be the only time difference among zones was analysed and reported. Are there significant trends with any of the other factors being assessed? This would be interesting to know.

L401 – the "small size class (0.2-2.7µm)". Another example where a size class (picophytoplankton) has been redefined.

L400-402 – this is the only time where the relative contribution of the picophytoplankton size class is presented. It's not really clear why the authors have chosen to present this information in this context.

L423 – see comment above, L310, about microplankton size range.

L423 Section 4.5 – there is a very big difference in the counts presented between the microscopy (>5-10µm) and flow cytometry results (<15µm). If there is an overlap between the microscopy and flow cytometry of 5-10µm in the nanophytoplankton range, then were there cells in the microscopy samples that were observed but not counted? Can the authors explain this discrepancy?

L445 – "small cells" have been previously defined as 0.3-2.7µm (see L401) so this creates confusion by lack of consistency again.

Discussion:

L596-634 – there are a lot of results and correlations presented in this section that should be in the results section.

L602-5 – "0.3-2.7 µm size fraction". This has already been defined by the authors as "picophytoplankton". See comment on L257-8 above.

L630-2 – where does this relationship data come from? The correlation between pennate abundance and NH_4^+ at the PF seems tenuous considering the low pennate count numbers and high variability of NH_4^+ south of the SAF.

L643-5 – the data presented here comparing NH_4^+ oxidation and uptake rates is not at all clear in Fig. 5.

L660-1 – this is new data again.

L685-6 – This section references the supplemental Text S2 and I can't see how these two relate. It is also not clear why the results presented in Text S2 are not presented in the results section of the manuscript as they seem to relate to Section 3.2.5 of the methods.

L688-736 – I would suggest a reassessment of this entire section on heterotrophic activity by bacteria and zooplankton. It contains a lot of results and there are number of relationships and assumptions made that don't seem strongly correlated to the available data (e.g., L702-3 – the POC:PON relationship with zones is reported as non-significant in the results (L391-3) so I'm not sure a southward increase can be inferred, L730-732 – this assumption is made off a single data point and other stations with similar NH_4^+ concentrations don't show the same thing). The presentation of heterotrophic-to-photosynthetic cell ratios is misleading here because the terminology is the wrong way around. The ratio presented on the side of Fig. 7a is the ratio of photosynthetic-to-heterotrophic cells (e.g., 50.0°S is 9.6:1). Thus, it makes no sense to be discussing "higher ratios of heterotrophic-to-photosynthetic cells" when the data presented shows low ratios of photosynthetic-to-heterotrophic cells. This makes the analysis of this section very confusing.

Section 5.2 & 5.3 – comments on these sections made in the "General Comments" above.

Figures & Tables:

I found it very difficult to see all the detail on the figures and interpret them at the size presented in the printed publication. All of the overlays and contour values are quite distracting and make the figures overly complex and difficult to interpret.

Table 1 – I'm not sure how the "% of total of >2.7um" values were calculated but they don't seem to add up to the other data presented. I don't think these add anything to the analysis and should be removed.

Figure 5 – there is too much information presented on these figures. It is not clear why the percentage of NPP for the 0.3-2.7 size fraction is presented here. It's also worth noting that the y-axes are different for each sub-figure, which was not immediately clear. A lot of the data in these figures that are discussed in the manuscript, such as differences in concentrations between zones, is better displayed and easier to interpret in Table 1.

Figure 6 – microzooplankton is present on the legend in Fig. 6b, which displays flow cytometry data <15um.

Figure 9 – it is incredibly difficult to interpret this figure due to the size.

Supplement:

It can be helpful for the authors to provide additional commentary and background on analyses presented in the manuscript to aid the reader in their understanding. Text S1 is a good example of this. The content of Text S2 & 3 include results and discussion that seem to be integral in their analysis and should be presented in the results section.

Technical Corrections

L372 – "from <1 uM and <10 uM, respectively, in the STZ",

L741 – the starting point of the rebuttal ("However,") of the previous statements is not very clear. I would suggest using a different phrase.

L744 – "likely to be",

L757 – It's not "Finally," if the next sentence starts with "Additionally,". Rerword.