Response to reviewers: Seasonal cycles of biogeochemical fluxes in the Scotia Sea, Southern Ocean: A stable isotope approach, by Belcher et al.

Reviewer 2

The manuscript „Seasonal cycles of biogeochemical fluxes in the Scotia Sea, Southern Ocean: A stable Isotope approach" authored by Belcher et al. investigates the particulate material (and fluxes) from sediment traps in the northern Scotia Sea from different seasons. The data is of high quality and most aspects of the findings are adequately discussed. However, I have some moderate (major) comments (and a few minor, see below) that needs to be addresses. As this topic fits well into the scope of BGD, I recommend publication after careful revision.

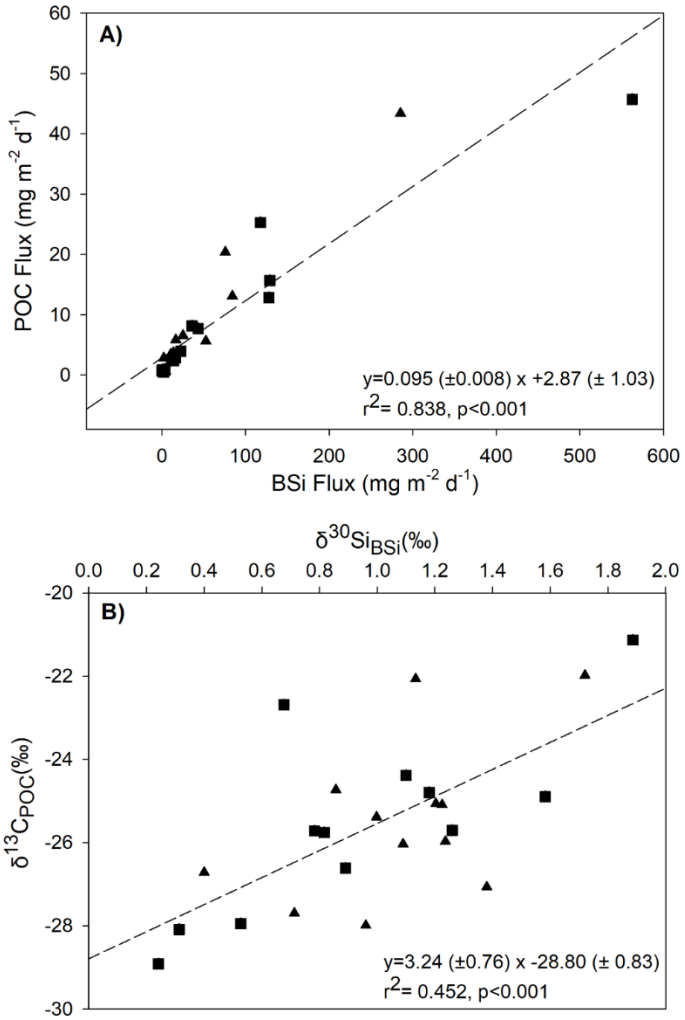
Reply: We thank reviewer 2 for their insights and believe we have made improvements to the manuscript by addressing them below. Where we give line numbers we refer to the marked up version of the revised manuscript.

General comment

I think, this is a great dataset, especially the combination of sediment trap data (even from two different depths and seasons) with three different stable isotope systems. However, some parts of the manuscript are a bit hard to read (and I had to re-read couple of times). It rather reads like a long description of result, whereas, in my opinion, some important aspects are missing. The authors never show or discuss in detail about the POC/PN to BSi ratios. This could shed some light on the connection between the silicon and the carbon cycle and especially the carbon drawdown associated to siliceous phytoplankton. Did the authors ever plotted, the d13C and d30Si data against each other (or d15N versus d15Si). I think it would be really interesting to see, how they positively and partly also negatively (d30Si with d15N) correlate. However, in order to address these issues new figures (e.g. POC/BSi ratios) have to be included in the main text and parts of the result as well as the discussion have to be re-written.

Reply: We have added in figure 5 (shown below) showing relationships between Si and POC fluxes as well as isotope ratios. Additionally, we have added in information about POC:PN and BSi:POC ratios in the results, and bring this into the discussion. No correlation between Si and N, or C and N isotopes was found based on linear regression analysis. We have revised and restructured the discussion to make the manuscript clearer. In the results section we add (lines 330-335):

"The mean POC:PN ratio (mol:mol) throughout the study period was 6.40 (± 0.73) and 6.02 (±0.90) in shallow and deep traps respectively with higher ratios in the productive periods compared to the winter months. Mean POC:PN ratios were 6.75 (±0.46) and 6.63 (±0.71) during period 1 and period 2 in the shallow trap, and 6.61 (±0.65) and 5.51 (±0.87) in the deep trap. Over the winter months POC:PN was 5.68 and 5.92 in shallow and deep traps respectively."



Methods

L145: Please check the coordinates, I guess you mean 54.8036°S and 40.1593°W, the "minus" is used for "South" and "West". If you state the direction, you do not have to use the "minus".

Reply: Amended

Results

L352 Did the assemblages only include siliceous plankton (like diatoms and silicoflagellates)? Or did you also observe other taxa (e.g. dinoflagellates, coccos). Maybe you can add one sentence in the beginning that states that only specific type of plankton was observed.

Reply: Diatoms, silicoflagellates and dinoflagellates were observed in the sediment traps, we have added a sentence to state this. We also observed micro-zooplankton in small numbers, in particular radiolarian and tintinnids and have added this in (lines 415-418).

"Diatoms, silicoflagellates and dinoflagellates were observed, with a dominance of diatoms. Micro-zooplankton were also recorded, in particular radiolarian and tintinnids, though these were not dominant by biovolume or abundance."

L344 "…, but shallow and deep traps have d15N of similar magnitude". Not sure, if I understand the sentence correct. D15N in shallow samples are much higher compared to d15N in deep sediment trap samples. Even though error is large, the highest mean (shallow) is associated with the lowest (mean). I think, this is an interesting observation, that is not sufficiently discussed. What would be the consequences for paleo reconctructions, if we observe difference in d15N with depth.

Reply: We have removed the statement about similar magnitude. We point the reviewer to the discussion, section 4.2.3, lines 644-669, where we discuss more about changes in D15N with depth.

Table 1: Can you please be more precise on how the error of the mean is derived. How does it include the analytical as well as the replicate error? Is it a 1 sd error or a propagated error? Please provide more information.

Reply: Considering the small number of repeat measurements, we chose to use pooled variances as a measure of uncertainty and have used these in table 1 in place of the uncertainties surrounding the formalin preservative. Where the number of degrees of freedom is small (i.e. with 2 repeat measurements, as in our case), the 95% confidence interval for the standard deviation is 0.03-2.24 σ, which is a range that spans a factor of almost 100. Pooling 10 such twice measured samples gives a 95% confidence of the sample interval of 0.57-1.4 σ. Pooling the variance of measurements (i.e. from each sediment trap cup measured) made within the time period of interest (here, full season, period 1 and period 2, DOF = X, Y and Z respectively), increases the robustness of the uncertainty estimate. This method assumes that the underlying distributions from which the data are drawn all have the same scatter. Table 1 has been appended with these pooled variances, and the caption amended to state that we use pooled variance as a measure of uncertainty on the seasonal flux-weighted isotopic ratios.

L366 The authors list Dictyocha together with all the diatoms, but it is a silicoflagellates. I think, it would be good, if the taxonomic groups (e.g. diatoms, silicoflagellates, dinoflagellates) are given (see also the comment above).

Reply: We have added in the taxonomic groups so it is clear which group the species mentioned belong to.

Figure

Figure 3: The figure should be improved. The authors could display the fluxes as boxplots. Please increase the dots size and choose different colors, e.g. open versus filled in black.

Reply: We have altered this plot to use bars to better show the length of time each sediment trap sample cup is open for. As requested we have increased the size of the dots, and used open and filled. We keep the blue and red colours for the dots to be consistent with the colours used for the bar plot for deep and shallow particle fluxes.

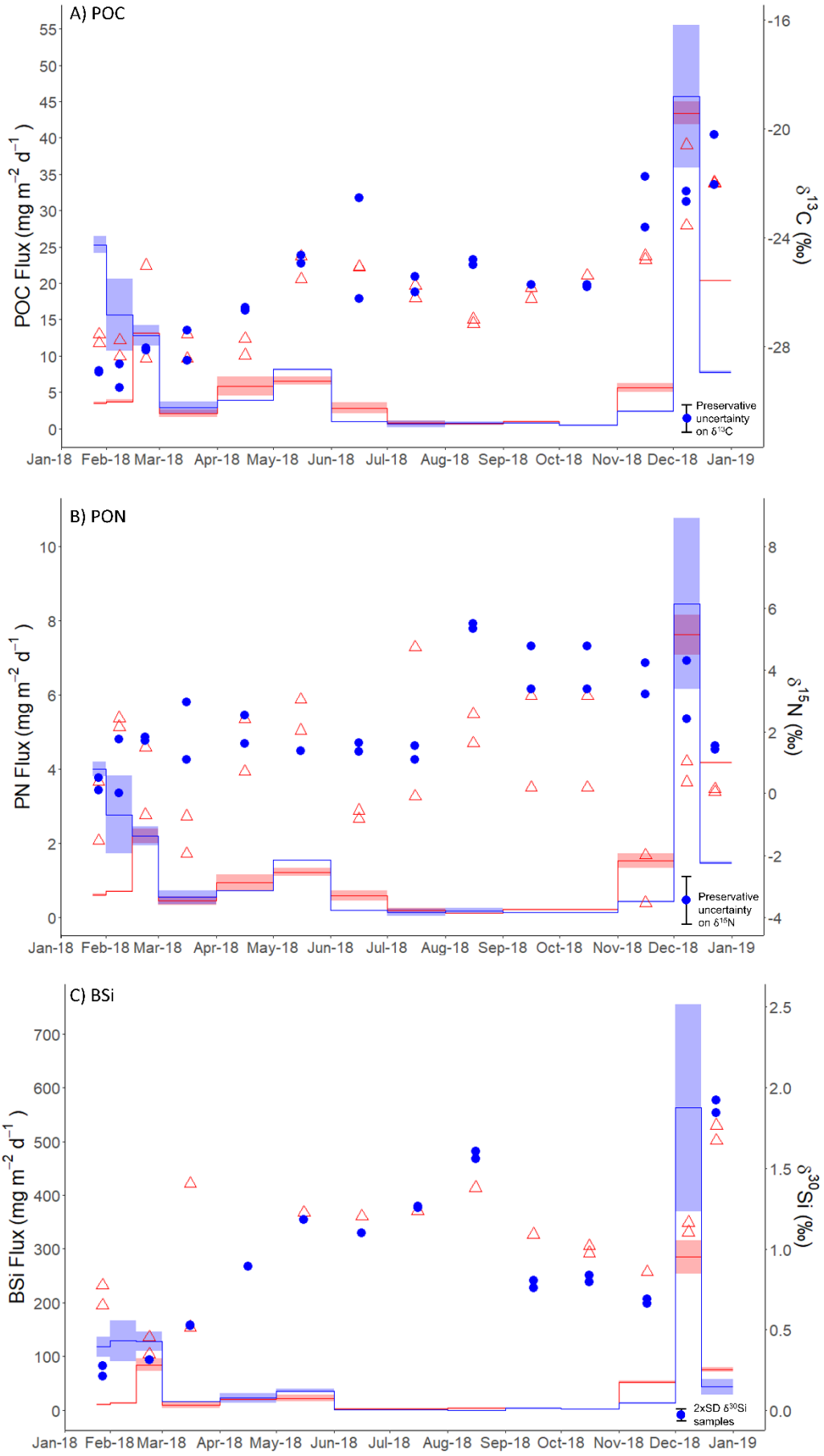

A) POC
POC Flux (mg m^{-2} d^{-1})
δ^{13}C (‰)
Preservative uncertainty on δ^{13}C
B) PON
PN Flux (mg m^{-2} d^{-1})
δ^{15}N (‰)
Preservative uncertainty on δ^{15}N
C) BSi
BSi Flux (mg m^{-2} d^{-1})
δ^{30}Si (‰)
2xSD δ^{30}Si samples
Jan-18 Feb-18 Mar-18 Apr-18 May-18 Jun-18 Jul-18 Aug-18 Sep-18 Oct-18 Nov-18 Dec-18 Jan-19

Figure 4: It is hard to read the legend and the x, y scale. Could you please increase the font. Can you please specifiy, what the difference between A) and C) and B) and D). Is this for different seasons. The authors could add an additional legend to make it more clear or edit the figure caption.

Reply: We have increased the font size, and also have reworded the caption to make it clearer that the plots show biovolume and abundance

Discussion

Please note here also my "general comment" in the beginning. I think the manuscript would benefit form a discussion on elemental ratios as well as a comparison between the stable isotopes. Additional figures could emphasize some parts of the discussion (e.g. L415).

Reply: As above, we have added in an additional figure and text.

L418 Even though POC and BSi can be closely linked and transfer carbon to the deep, the following statement (L418) has to be rephrased. Not all diatoms have greater densities and higher sinking velocities compared to non-siliceous phytoplankton. Sinking velocities are linked to size (e.g. Bauman et al., 2023) https://egusphere.copernicus.org/preprints/2022/egusphere-2022-814/) .Some fast bloomers (small, e.g. Chaetoceros spp.) often does not sink to the sediment (at least not the vegetative cells), as they are already remineralized in the upper water column. Instead, the big "late bloomers", at the end of a succession (e.g. Coscinodiscus) are often the ones, that are found in the sediments. For a comparison between plankton assemblages in surface water and sediments see also Grasse et al., 2021*. The authors have information about the biovolume, how does this align with the rest of the data. Maybe they could refer to some of their findings here.

Reply: Yes, good point, thank you for spotting this. We have amended the wording as follows:

"…suggest an important role of diatoms in transferring organic carbon to the deep ocean at this time. This could be achieved if cells are large through large mineral (silica) ballasted cells sinking at high velocities (Baumann et al., 2022), or through the bioprotection of internal organic matter from grazing and oxidation by the diatom silica frustules (Passow and De La Rocha, 2006; Armstrong et al., 2001; Smetacek et al., 2004)."

Since we only have data on biovolume for a small portion of the sampling period, and due to the ability to only count intact cells as explained, we do not think it appropriate to go into more depth in the biovolume data.

L566 what is the reference for the "exception of one culture study". What exactly is the isotopic baseline, the authors referring to.

Reply: We have amended the wording here to clarify our meaning.

* Grasse, P. et al. Controls on the Silicon Isotope Composition of Diatoms in the Peruvian Upwelling. Frontiers Mar Sci 8, 697400 (2021).