

**Review comments for the manuscript “Long-term impacts of mixotrophy on ocean carbon storage: insights from a 10,000-year global model simulation” by Puglia et al.**

This article investigates the impact of mixotrophy on the ocean’s long-term DIC storage. They do so by running a mixotrophy plankton model in a low-resolution ocean model for 10000 years and comparing the outcome with a run with strict phyto- and zooplankton (without mixotrophs). The results show that in the mixotrophic case, there was an increased carbon and nutrient export. This increase in export resulted on an overall increase in remineralized DIC and PO<sub>4</sub> in the ocean interior, but a decrease in preformed nutrients, which became apparent in the north Atlantic. All in all, mixotrophy resulted in a net increase in the ocean carbon storage.

The article is interesting as it goes one step further to the carbon export metric and looks at the ecological effects on the overall ocean DIC storage, which is often omitted. Results are clear and address the stated objective. My comments center on text clarifications, especially regarding the caption of some figures. I also suggest adding some figures in an appendix to make the results more comprehensive.

**Comments:**

L32-33 “could potentially lead to a deeper sequestration of nutrients and an associated decline in primary production at the surface.” An image showing the changes in NPP and total biomass with time would also be nice (perhaps in an appendix). Just to confirm that indeed there is no change in any of these metrics by the end of the 10K years.

L39-40 “mixotrophy also led to a decline in carbon sequestration in the North Atlantic.” Consider mentioning that this decline is due to a decrease in preformed nutrients (to be consistent with the abstract, as now this sounds like a new result, and the reader does not know why this is relevant).

L55 it would be nice to provide a description of how stoichiometry is modeled. Mostly because this seems to be an important driver of the observed results. There is no need to write all the equations of the model, but perhaps some equations showing mixotrophic growth and stoichiometry would be great to improve the understanding without having to read the methods in Ward et al 2018. Otherwise, a paragraph explaining how/why

mixotrophs can have different stoichiometries would be good (and trying to link this to the differences observed between low and high latitudes would be even better).

Figure 2: caption needs a more detailed explanation. I guess ESD is derived from the depth-integrated biomass? At which depth approximately is carbon export estimated? Are DIC and PO<sub>4</sub> concentrations for the surface layers only? Or are they integrated over a specific depth range or the entire water column?

Figure 2 caption “Values greater than one (red) indicate regions where mixotrophy increased the variable in question, whereas values less than one (blue) indicate a decline.” This seems to only apply to panels m-p, the others are centered on 0. Also, I guess the colorbar in panels m-p is in log scale(?) This makes it a bit tricky to read the magnitude of change other than 10 times smaller/larger, because the ticks are not evenly distributed and are not shown in the colorbar. Consider adding some ticks or more labels (in-between 10, 0 and 0.1).

Figure 2, it would be good to have a figure (perhaps in an appendix) showing the base-line values of each panel (e.g. the actual ESD values across latitudes for the mixotrophic run and for the separate guild run etc), so that the reader knows whether the absolute differences shown in the figure are large or not. Otherwise, showing the relative differences (e.g. in percent change) could work too.

L131 “Contrary to Fig. 1, in which large and stable differences between the Two-Guild and Mixotrophic are established within the first year of the simulations, noticeable difference between the two configurations only begin to emerge on multi-decadal timescales (green colours).” This sentence is somewhat confusing, isn’t the difference simply because these two figures show two different things? i.e. figure 1 shows surface only while figure 3 depth-resolved differences? I guess the sentence is just confusing and needs to be rephrased (i.e. instead of saying that the difference is between the figures, mention that the difference is between surface and deep ocean).

L136 “The response within the Atlantic Ocean is more complex. Over the first 500 years, mixotrophy leads to increased DIC storage at all depths below the thermocline, but after about 1000 years, there is a decline in DIC storage between about 1,500 and 3,500 m.” but these differences are barely noticeable. Is it really that relevant? Or am I missing something? I guess the interesting point here is that the Atlantic Ocean barely sees any difference while the other two oceans show larger differences.

Figure 6. A bit subtle, but it seems to me that DIC total in panel c is “redder” than DIC remineralised from panel a, is this correct? If DIC preformed decreases, shouldn’t DIC total be lower than DIC remin?

Table 2 caption. Mention that these differences correspond to the ones found at the end of the 10K years. Also, for consistency with the other figures, switch “exported” DIC with “remineralised” DIC. A similar table showing the differences in the exported carbon and PO<sub>4</sub> at a given depth would also have been interesting.