

## ***Interactive comment on “Photosynthetic production in the Central Arctic during the record sea-ice minimum in 2012” by M. Fernández-Méndez et al.***

**M. Fernández-Méndez et al.**

mmendez@awi.de

Received and published: 8 May 2015

The authors would like to thank Referee #1 for the useful comments that will definitely improve the manuscript. Below you can find the comment and our answer starting with an “A:” below it.

General Comment: I request that all figures and tables placed in the SI be included in the manuscript as they are very frequently referred to in the main text. Then the figures are necessary, not supplementary. SI is thus NOT the place for them! It is annoying to have to go to the SI to find these figures.

A: We agree and hope the editor allows for the extra space. All figures are now placed  
C1963

in the main text. Only Table S1 and Table S3 will remain in the supplementary since they show Pangaea dois and data that is shown in Fig. 4 anyways.

2898 L16 ‘light limitation in which season? Growth season? summer?’

A: Light limitation in late summer (August-September). This information will be added in the text.

2899 L4 add “as a proxy for nutrient stocks” after winter mixing.

A: Added.

2900 L2-4 that’s a single snapshot! one station! Anything in Olli et al 2007? Any russian pubs?

A: We added more references to this statement.

2900 L11 add Miller et al. 2015 Elementa

A: Added.

2902 L4 define Atlantic inflow, maybe in station cartoon? please add the water column stations in fig 1

A: The Atlantic inflow has been defined in the text and an arrow has been added in Figure 1a to depict it. Adding the water column stations to Figure 1 would make it very crowded, but we added a note in the caption indicating that the water column was sampled along the entire transect and that the stations are depicted in Figure 2 (which will become Figure 4 when all the supplementary figures are added to the main text).

2902 L15 what size filter was used? Where did the FSW come from? were the cores shaved of their outerlayer to minimize contamination or any other such measure? what diameter corer was used?

A: 0.2  $\mu\text{m}$  poresize filter was used to filter the sea water added to the melting ice cores. This water came from deep waters at previous stations. The ice cores were not shaved

but immediately stored in sterile plastic bags to prevent contamination. The ice corer diameter was 9 cm. All this information will be added in the text.

2902 L24 were any tests done to determine any cell loss due to pump action? such as a comparison with a bucket or similar? or, bottle attached to ice-CTD?

A: No specific test was performed but no difference in debris (broken cells) content was observed in the flow cytometer samples from pump vs CTD collected water samples.

2903 L8 add ' ; ship's

A: Added.

2904 L19 please add (Table S1) after sea ice concentration

A: Added.

2905 L5 how is the lateral upscaling from single point to 10km done?

A: We rephrased this for clarity: "NPP was calculated analogous to section 2.2 for each grid point of a 10 km polar stereographic grid".

2906 L22 the community composition after 6d and 4d under melted conditions may not have been the same one as at To. Was any species composition or size fraction frequency or other descriptor done at To and Tf?

A: Yes, this is a recurrent issue when working with sea-ice samples. The shift in community composition during melting is a known issue that affects mainly flagellates. After melting, the community composition was monitored using light microscopy in a qualitative way. From this observations no major shifts in the sea-ice diatom based community could be observed. This information will be added to the manuscript.

2907 L19 Ah! but not measured at the beginning; too bad

A: Yes, also at the beginning.

2911 L23 a "measurable" increase?

C1965

A: Correct. We added "measurable" to the sentence for clarity.

2911 L23 Interesting that this was not due to micrograzers but microalgae compositions sea ice diatoms!!

A: Indeed a few micrograzers (flagellates) were observed with the microscope and they might have contributed to nutrient uptake. This will be added to the manuscript.

2913 L9 please add as many figures from supplement into full ms! If cited (and they are cited multiple times), then the figures are necessary, not supplementary.

A: Agreed.

2913 L15 please use INPP and NPP consistently throughout the manuscript; ie, always INPP if the value represents an integration

A: INPP represents depth integration and the manuscript will be checked for consistency when using this abbreviations.

2913 L28 The value could also decrease if you take into account that bacteria also may use nutrients. But it could also be underestimated if there is nutrient replenishment by physical or biological processes

A: This is a very good point that will be added to the discussion. There are indeed some assumptions made when doing this type of calculations.

2915 L25 almost two decades earlier! Much could have changed, there is much inter-annual variability, and then there are so few data available for that region.

A: We agree that this difference could be due to interannual variability and highlights once more the lack of NPP data available from the Central Arctic Ocean. This has been added to the manuscript for clarity.

2916 L18 "and other Arctic ice-covered regions (Matrai & Apollonio [or the other way around] 2013)" A: Reference added.

C1966

2917 L22 replace 'double' with 'twice' as much

A: Replaced

2918 L16 fix ref formatting

A: Rudels is single author in that paper. No reformatting is needed.

2918 L19 due to \*the large seasonal\* riverine input. But you have used LeFouest to support a minimal influence of river nutrients. Which one is it: min or max influence? And the river freshet will have occurred long before the summer sampling time; was there much flow still then?

A: The increased silicate concentrations in the area adjacent to the Laptev Sea could be due to riverine influence at the shelf. However, the influence of riverine nutrients in the deep Eurasian Basin is not able to maintain an increase in new production. Some lateral advection might occur but has not been quantified yet. Yes, the main river discharge occurred before the sampling time and that is probably the reason why the nitrate in that area is depleted. The surplus of silicate in summer might be due to the phytoplankton composition during the spring bloom that might have been formed by not heavy silicified diatoms or by the upwelling of deep Atlantic waters at the continental slope. This is very speculative and was therefore not included in the manuscript.

2919 L21 reword 'some nutrients left' to 'reduced nutrient concentrations' or similar

A: Reworded.

2919 L22-27 I believe an Apollonio reference and a Mundy reference have already expressed this notion; please acknowledge them.

A: We were not able to find those references but added one to Cota's work in 1990.

2920 L1 replace 'able' by 'capable' I would be very cautious of deriving too much from a single experiment!!!

C1967

A: We agree that is a single experiment and therefore all conclusions derived from it are stated with caution.

2920 L5 replace 'is' with 'are'

A: Replaced

2920 L6 these the wrong references for zooplankton grazing on ice algae and phytoplankton. Both references are modeling studies simulating this system!

A: We agree and changed the references for two observational studies: Soreide et. al. 2006 and Hop et al. 2011.

2920 L18 how was algal C determined in the sed traps?

A: Using light microscopy counts and volumetric calculations. This is explained in the studies cited. In addition a sentence explaining this was added for clarity.

2920 L23 not 'indicate' but 'suggest'

A: Changed.

2921 L10 NO!! it has been \*\*predicted\*\*! Not observed. These are PP-chl models. There are many issues affecting the derivation of NPP from ocean color models and more complex models as well. Pabi et al 2008 is also an ocean color model and the Kara Sea estimates have no ground truth data to validate them with, sadly.

A: We agree and have changed the wording consequently.

2921 L15 replace 'A' with 'Another' modeling study

A: Replaced.

2922 L5-10 These seas are not part of the central Arctic which is the main topic of this paper. These results don't fit well in here, as attractive or controversial as they may be. What happened in the central Arctic? If you insist in keeping this one sentence, it is necessary to have another sentence that indicates how much of the seasonal NPP is

C1968

represented by this change in an ice free sept in each of these seas, according to your model. Something like "These increases still represent only x or as much as x% of the seasonal NPP in these regions, according to our model." Especially since most of the Greenland Sea is already ice free in Sept except for the E Greenland current and the mixed layer depths become very deep very soon once the fall storms begin.

A: The regions that we define in our study are a division of the Eurasian Basin north of 78°N. These different parts of the Central Arctic are named after the closest sea south of 78°N. To clarify this in the manuscript we added a reference to Figure S7 where the regions are depicted in the map (In the new version Figure 13). We also included a sentence indicating the percentage of seasonal NPP that September estimates account for. This puts in perspective the values discussed.

2922 L15 could be 'reduced'.

A:Modified.

2922 L18-21 All the processes listed will lead to a negative change in nutrient concentration. In other words, it may result in a decrease in NPP for the month of September.

A: From the processes listed all of them except increased winds and upwellings would lead to a decrease in nutrients and therefore in NPP. We modified the sentence as follows: "Depending on the future role of winds and sea-ice drift vs stratification by freshening and warming, nutrient availability in the euphotic zone could change. For example, if ice formation occurs later in September and winds that cause upwelling also increase, a second productivity peak might be observed at the end of the season (Ardyna et al., 2014). On the contrary if stratification increases its strength and less nutrients are available it may result in a decrease in NPP for the month of September."

2924 L7 replace ITPs with 'automated, autonomous systems' since floats, gliders and other buoys may also provide such information. Just making this sentence broader than ITPs

C1969

A: Done.

2924 Section 5 Conclusions: I would make your conclusions specific to your 2012 results and modeling. Exclude grazing, nutrients. No speculation or discussion here.

A: We tried to make our conclusions as specific as possible to our results. Grazing and nutrients are included in the study and therefore we feel that they should be mentioned in the conclusions.

2924 L17 replace 'can contribute' with 'contributed'

A:Replaced.

2924 L19 specify if these are 'measured' estimates or 'model-derived' estimates

A: They are measured estimates. This information has been added to the sentence.

2928 L30 RUBAO JI, MEIBING JIN and ØYSTEIN VARPE. Sea ice phenology and timing of primary production pulses in the Arctic Ocean. *Global Change Biology* (2013) 19, 734–741, doi: 10.1111/gcb.12074 A: Corrected.

2940 will the volumetric values of NPP and chl a also be available in Pangea? Please!

A: The volumetric values of NPP will be available in Pangaea. The volumetric Chla values will be published soon in another manuscript by I.Peeken.

2941 Fig 1: please indicate all stations sampled. Fig 2 has many more symbols than the 8 ice stations shown here

A: The water column was sampled throughout the entire cruise track almost constantly, therefore, including all these stations in Fig. 1 would be confusing and would make the figure too crowded. A reference to Fig. 2 (now Fig.4) will be added in the figure caption of Fig. 1 to refer to the water column stations. 2942 Fig 2: can you please circle which symbols correspond to the INPP of fig 4? Simply display a line around the symbol

A: This will be added in the final version of the figure.

C1970

2945 Fig 5: Any melt ponds or sea ice in the coastal beaufort left in sept 2012? please add the line of min sea ice extent in aug and sept or for a specific day in each month.

A:The coastal Beaufort Sea does not appear in the maps shown in Fig. 5 (in the latest version it will be Fig. 11). The line of average sea ice extent in August and September has been added to the maps.

---

Interactive comment on Biogeosciences Discuss., 12, 2897, 2015.

C1971