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# ***Interactive comment on “Oxygen and carbon isotope composition of modern planktic foraminifera and near-surface waters in the Fram Strait (Arctic Ocean) – a case-study” by T. Pados et al.***

**T. Pados et al.**

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Anonymous Referee #2

Pados et al. present a set of measurements from the Farm Strait, which includes  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  of two foraminifera species in the water column and in the sediment as well as the corresponding isotope measurements of the water  $\delta^{18}\text{O}$  and DIC - $\delta^{13}\text{C}$ . As such, the results are interesting for calibration of the wide use of foraminifera in paleoceanographic studies.

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1. Comment: I have two major concerns, which are of a general nature: 1. what is the degree of the overlap between this paper and the Pados and Spielhagen (in press) paper? I did not see the later and cannot comment on that.

Authors' response: As mentioned in line 12-14 on page 8638, we analysed in the above-mentioned two manuscripts (Pados and Spielhagen, 2014 and present manuscript) the same samples taken during cruise ARKXXVI/1. However, the aims of the two studies are completely different and they were meant to give a detailed description of planktic foraminiferal fauna in the sampled area from two different perspectives. Pados and Spielhagen, 2014 focuses on the ecology (faunal composition and depth distribution) of planktic foraminifera, while the present manuscript reports on the stable isotope composition of the tests and aims at discussing the effects of environmental factors on the oxygen and carbon isotope composition of the shells. As the two papers are associated, the data presented in Pados and Spielhagen, 2014 holds important background information for present study as well. However, not every reader of present paper may want/will be able to download and read the other manuscript only to get an overview over the research area. Therefore, in chapter 4.2 we shortly summarized the results of Pados and Spielhagen, 2014.

2. Comment: 2. Overall, when isotopic differences are discussed (between water column and sediment or between water column foram and calculated equilibrium) the rigorous Standard deviation should be presented. I also suggest to put the differences in a graphic presentation to make it clear to the reader.

Authors' response: The reviewer is right, we added the standard deviation in the adequate places. However, the reviewer's request for a graphic presentation of the differences "between water column and sediment or between water column foram and calculated equilibrium" leaves us a bit puzzled. These data are presented as red, blue and dashed green lines in Fig. 7, and we think that the differences can easily be picked visually from the horizontal offsets between the lines. Of course we could add another figure and display the offsets as horizontal bars of different length plotted on the red

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dots (data points) in the red lines. However, we do not think that this would make the differences more obvious that they already are from current Figure 7.

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Changes in the manuscript: We have added the standard deviations in the adequate places.

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Other comments:

1. page 2 line9-10: why do you ignore temperature?

Authors' response: We regret that we had forgotten to mention the kinetic effect that temperature exhibits on the  $\delta^{18}\text{O}$  -variability of foraminifera.

Changes in the manuscript: We have added this information in the third sentence of the Introduction chapter.

2. Page 2 line 22: is it carbon or oxygen or both?

Authors' response and changes in the manuscript: Both carbon and oxygen isotope ratios of the calcite shell decrease with increasing seawater carbonate ion concentration (Spero et al., 1997). We added this information to the sentence.

3. Page 3 line 8: what are the disciplines?

Authors' response and changes in the manuscript: The reviewer is right. We have changed ""results from a multidisciplinary approach" to a more appropriate "results from isotopic analyses".

4. Page 5 line 23: please add oC to T.

Authors' response and changes in the manuscript: Agreed. We have changed "T" to "T( $^{\circ}\text{C}$ )".

5. Page 6 Figure 4: axis of isotopes are missing from the graphs

Authors' response and changes in the manuscript: In Figure 4 the lower x-axis represents the axis for both temperature and isotopes, while the upper x-axis is for the

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salinity. We added this the information to the figure caption.

6. Page 6: what is the slope of d18O/salinity

Authors' response and changes in the manuscript: We have added a regression line and the corresponding equation to Fig. 3.

7. Page 7: Fig 7 appears before Fig. 5-6 8.

Authors' response and changes in the manuscript: The reviewer is right. We have corrected the order of figures and have changed the figure references in the text accordingly.

8. Page 7 line 27: please add STDEV to all numbers

Authors' response and changes in the manuscript: We added the STDEV to all numbers.

9. Page 8 line 7: please put numbers + STDEV on highest and lowest

Authors' response and changes in the manuscript: We put the numbers but as they are raw values we cannot provide any standard deviations.

10. Page 9 line 3: this is not a theoretical equation. It is an empirical calibration

Authors' response and changes in the manuscript: We have changed "theoretical d18O value" to "potential d18O value".

11. Page 9 line 20-26: please provide numbers

Authors' response and changes in the manuscript: We added the numbers where appropriate.

12. Page 10 line 5: needs a better explanation although rejected later

Authors' response and changes in the manuscript: Here we refer to the theory of Volkmann & Mensch (2001). Similar to us, they observed greater offsets between the

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equilibrium calcite values and the oxygen isotope composition of tests under the sea ice. They conclude that unfavourable conditions here make the individuals grow faster (i.e., increase their metabolism). However this statement it is not explained furthermore in their paper, among other things, this is why we cannot agree with it. Nevertheless, we followed the suggestion of the reviewer and added the above explanation to the text.

13. Page 10 line 12: do you numbers to support the claim of high Primary Production? The  $d_{13}C$  does not show it.

Authors' response: In Pados and Spielhagen, 2014 we reported on a major increase in absolute abundances of planktic foraminifera at the sea ice margin, probably caused by enhanced phytoplankton biomass. The ice margin offers increased food supply for the foraminifera with higher primary production caused by diatoms that are the major food source for *N. pachyderma* (Hemleben et al. 1989). Diatoms typically do not develop well under permanent ice cover due to the light limitation, but they prefer seasonally stratified water conditions that occur in the marginal ice zone (Smith et al. 1987; Williams 1993). Ice melting increases stratification and consequently the stability of the water column, which triggers phytoplankton blooms (Alexander 1980).

Changes in the manuscript: We added a sentence with three references (Alexander 1980; Carstens et al. 1997; Pados & Spielhagen 2014) to support the hypothesis of high primary production.

14. Page 12 line 9: please change throughout the text to either station numbers or longitude.

Authors' response and changes in the manuscript: We changed the station numbers to longitude or provided both information.

15. page 13 line 20: needs STDEV

Authors' response and changes in the manuscript: We have added the standard devi-

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ations to the manuscript.

16. Page 14 line 1-2: not clear

Authors' response and changes in the manuscript: We have rephrased the sentence for a better understanding.

17. Page 14 +STDEV

Authors' response and changes in the manuscript: We provided the standard deviations.

18. Page 14 Line 6-13: this is a place where the differences should be graphically presented.

Authors' response and changes in the manuscript: As explained above (response to reviewer's major comment no. 2), we do not think that an additional figure would make the differences more obvious than they are in Figs. 7 and 8. Instead, we have slightly expanded the text discussing the results displayed in Figs. 7 and 8 to lead the reader to the important points. (Note: in the revised manuscript Fig. 7 changed to Fig. 5, see comment 7).

19. Page 15 line 1-5: this contradicts the conclusion of oxygen difference between sediment and water column. If the Suess effect is the explanation it is restricted to 250 years and not 1-3Ka.

Authors' response: We do not fully understand this comment. We believe that we have explained in sufficient detail that there is a significant age difference between the living foraminifera from the water column and the dead specimens from the sediment surface samples (the latter having an average age of ca. 1 ky). The significance of this age difference lies in the developments that have occurred in the last ca. 100 years: A freshening of the Arctic Ocean near-surface waters (resulting in lower  $\delta^{18}\text{O}$ ) and the intrusion of low- $\delta^{13}\text{C}$  carbon dioxide (Suess effect). Since the foraminifera from the water column have both lower  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  than those from the surface sediments,

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we propose that the differences observed can be explained by the two effects explained above and in the manuscript (see also conclusion no. 6).

Changes in the manuscript: We have slightly modified the last paragraph of the discussion to make the point more obvious to the reader. We have also slightly changed conclusion no. 6 which summarizes the findings.

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