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Interactive comment on "Carbonate saturation state of surface waters in the Ross Sea and Southern Ocean: controls and implications for the onset of aragonite undersaturation" *by* H. B. DeJong et al.

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Thank you for your detailed and thoughtful comments. We switched Fig. 1 and Fig. 2 since we now refer to the initial Fig. 2 first. In addition, we modified Fig. 4-6. Rather than defining the fronts on SST, we now use the mean front positions from Sokolov and Rintoul (2009) as they intersect our cruise track. Finally, Fig. 7 now only includes parts (a) and (c). Parts (b) and (d) are now appendix figures A1 and A2.

The track-change document is attached as a supplement. We refer to the page and

line numbers for the track-change document.

Comment: This is an impressive dataset and vastly increases the amount of surface carbon data for this undersampled region. The data is of very high quality and has been thoroughly cross checked with other datasets and between carbonate analyses. The authors are very honest about the offsets between the different analyses, with the CRMs and the calculated carbonate parameter values and are impressively close and for that the authors and those that undertook the analyses should be applauded. The paper is well written and succinct. However, a few minor changes would improve the papers readability and flow and it would be nice to have some discussion about the potential broader implications of the work – especially the future predictions.

Section 2: Study area - It would be good to have a bit more information on both the Ross Sea oceanography and the Southern Ocean.

Response: We expanded this section (P 4-5)

Comment: Over the last decade multiple jets have been recognised for each of the Subantarctic and Polar fronts – which one have you defined here? Can you see evidence for these different jets in your data? The SO fronts are now more commonly defined by their Sea Surface Heights (SSH – Sokolov and Rintoul 2009) rather than gradients in SST. How do you're the SAF and PF defined in the paper compare to the SSH changes at the same time? I appreciate that the SSH cannot be determined from the underway data and need satellite data to define. This would help others to compare these datasets with hydrographic data.

Response: We do not have the expertise to calculate the location of the fronts during our cruise. Therefore, we show the average location of the fronts from Sokolov and Rintoul (2009) as they intersect our cruise track.

Comment: At the bottom of page 8442 the definition of the subtropical waters is incorrect. Subtropical waters are found north of the Subtropical front rather than north of the

Subantarctic Front. The waters north of the SAF are the subantarctic surface waters (SAW or SASW).

Response: Done (P14 L14)

Comment: I also felt that the first two paragraphs at the start of the results and discussion should be in this section as this is background information on the Ross Sea – this would help to provide more info on the Ross Sea.

Response: We have moved and reworded these two paragraphs into the Study site section (P4 L21-26).

Comment: There is mention of west and central Ross Sea at the start of the results and discussion – but then this is not used later in the results and discussion?

Response: We discarded the west and central definitions.

Comment: It would also be good to have a link between the Southern ocean section and the Ross Sea to show the association between the two areas. At the moment they read as if they are two completely separate entities with no connection.

Response: In the study site section we now first discuss the Southern Ocean fronts, then describe the linkage between the Southern Ocean and the Ross Sea, and finally discuss the Ross Sea.

Comment: There are several previous datasets that are not mentioned – which surprised me when there are so few datasets in this region. The Sandrini et al., 2007 and Rivaro et al., 2014 data from the western Ross Sea are not mentioned.

Response: These datasets have now been mentioned (P3 L15-16)

Comment: Also it would be good to also reference the paper that was recently published by Kapsenberg et al., 2015 – from the Hoffman voyage – whose voyage report is referenced in the paper.

Response: This paper is now correctly referenced throughout

Comment: Where is the sub-surface data that is mentioned that was collected at 85 stations in the Ross Sea? None of this data is shown in the paper – so why is this mentioned? I assume it will be used in another paper.

Response: We used the sub-surface data to evaluate the controls on the seasonal surface ΩAr variability. The discrete data will be used in another paper and this is now clear in the methods section (P7 L6-8). We have also now referred to Eq. 2. in the results section (P11 L4) to make it more clear when we use the discrete data.

Comment: Personally I would have preferred a separation of the results and the discussion. But this is not critical.

Response: We initially wrote the results and discussion separately – we found the paper read easier when we combined the results and discussion

Comment: As the paper is fairly short it would have been nice to see more discussion and comparison with other regions of the Antarctic such as the Weddell Sea and the Mertz region. There are a couple of brief comments on the Arctic. How does the Ross Sea conditions and future scenarios compare with what is expected for other regions?

Response: We now compare current Ross Sea winter conditions with other regions in the Antarctic (P18). We also discuss future predictions by Mattsdotter Bjork in the Ross Sea (P19 L8-13).

Comment: There are a couple of paragraphs in the introduction about the implication of aragonite undersaturation on biology – but this is not revisited in the discussion. Introductions should introduce what is then discussed later. . . so I was waiting for some comment at the end of the paper about the fact that you suggest that the region will not become undersaturated until 2070 at the earliest.

Response: We now discuss implications on biology (P19 L16-30; P20, L1-8)

Comment: The figures are generally very clear – except Figure 7 – there is too much data and the figures are too small to see the data. It would help if each of the maps and graphs were bigger for Figure 7. This may be just the way that it has been published on line in BGD and might be larger in the final paper.

Response: We have now reduced Fig. 7 to 2 panels (using Fig 7a and 7c). The initial Fig. 7b and 7d are now separate appendix figures.

Comment: Figure 2 – I assume there is missing alkalinity data from a section of the voyage and that is why there is a gap in Figure 2f. . .

Response: There is missing alkalinity data since we consumed the certified HCl in the Ross Sea. This has now been clarified in the text (P6 L4-5).

Comment: P 8430, L16: Not clear whether you mean double from todays values or from preindustrial values. Please clarify.

Response: We meant from today's values – this should now be clear (P1 L24-26)

Comment: P 8430, L21: I think preindustrial "levels" is more appropriate.

Response: Done (P2 L2)

Comment: P 8431, L9: the calcification rates of certain species... I think you need to make it clear that this is only for some species and perhaps mention a few. This is a rather vague sentence at the moment.

Response: Done (P2, L14-16)

Comment: P 8431, L14: Global climate models have predicted that surface waters..... it needs to be clear that these are predictions based on models.

Response: Done (P2, L21)

Comment: P 8431, L 27: within 48 hours, rather than after.... please write out hours in full - may not be obvious to others.

Response: Changed after to within; 'h' is the convention for Biogeosciences (P3 L3)

Comment: P 8432, L 10: Sandrini et al., 2007; Rivaro et al., 2014, Recent paper by Kapsenberg et al., 2015

Response: We added these references (P3 L15-16)

Comment: P 8433, L 15: How do the ROss Sea and the Southern Ocean link... it would be good to show how they are linked together here with a sentence or two. At the moment they seem quite separate. Several of these fronts have multiple streams - e.g. NPF and SPF and NSAF and S-SAF... can you see these in your data? Have you defined the NPF or the SPF?

Response: As described earlier, we now discuss how the Ross Sea and Southern Ocean link and discuss the multiple jets in the fronts (P4).

Comment: P 8433, L 22: THese days the PF and SAF are usually defined by SSH - Sokolov and RIntoul, 2009 rather than by SST gradients. But these have to be determined from satellites rather than shipboard instruments - so may be hard to compare directly. Would be nice to just check....

Response: We now have labeled the average location of the frontal jets from Sokolov and Rintoul (2009) instead of using SST gradients.

Comment: P 8434, L3: Undertook rather than made.

Response: Done (P5 L19)

Comment: P 8436, L 20: Typically you would put the references in chronological order with the oldest first.

Response: We changed this for the entire manuscript

Comment: P 8438, L 15: This seems like it should be in the introduction in the region/Ross sea information as this is background info.

Response: Done

Comment: P 8439, L 1: THis should be the start of this section.

Response: Done

Comment: P 8439, L 25: do you mean partial derivative?

Response: We meant potential alkalinity. We changed the abbreviation pTA to PALK to avoid confusion (P11, L13)

Comment: P 8442, L 27-28: Subtropical water is found north of the Subtropical front - not north of the SAF. The water north of the SAF is the Subantarctic Waters.

Response: Done (P14 L14)

Comment: P 8444, L 20: Did you use salinity twice?

Response: Salinity is used both to calculate TA and as an input into CO2SYS. We reworded this to make it clearer (P16 L1)

Comment: P 8447, L 3: This is now published in the kapsenberg paper

Response: Done

Comment: P 8448, L 3: I assume you mean more than 2 carbonate parameters - to give a good estimate. Might want to just say this more clearly for your audience.

Response: This has been reworded (P20 L28)

References: Sokolov, S. and Rintoul, S. R.: Circumpolar structure and distribution of the antarctic 16 circumpolar current fronts: 1. Mean circumpolar paths, J. Geophys. Res. Ocean., 114, 1–19, 17 doi:10.1029/2008JC005108, 2009.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C6569/2015/bgd-12-C6569-2015-supplement.pdf

Interactive comment on Biogeosciences Discuss., 12, 8429, 2015.