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Interactive comment on "The recent state and variability of the carbonate system of the Canadian Arctic in the context of ocean acidification" *by* Alexis Beaupré-Laperrière et al.

Alexis Beaupré-Laperrière et al.

alexis.beauprelaperriere@mail.mcgill.ca

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Author Responses to Anonymous Referee #2

Reviewer's comments are marked as RC and author responses as AR

RC: The Arctic Ocean is particularly vulnerable to acidification due to its relatively low buffering capacity and, thus is considered as a bellwether to study global ocean acidification. The manuscript "The recent state and variability of the carbonate system of the Canadian Arctic in the context of ocean acidification" written by Alexis Beaupré-Laperrière et al, descripts characteristics of carbonate system in the Canadian Arctic

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Archipelago and its adjacent Canada Basins in the recent 5 years. However, the MS needs to be majorly revised as to answer those questionnaires such as the follows:

RC: The abstract needs to rewrite as to focus on important conclusions and avoid too much descriptive.

AR: See response to specific comment #2.

RC: Lack of nutrient DO and other auxiliary parameters data. This is odd, because these parameters are usually obtained at the same time as the carbonate system. This also leads to the discussion of this article is not strong.

AR: The manuscript focuses on the carbonate system parameters and other inorganic parameters, which, given the spatial extent of the study area, represent a sizeable dataset and allows for a pertinent analysis within this scope.

Nutrient and dissolved oxygen data were indeed collected by other researchers in most of the oceanographic campaigns (and in some cases are available through the various data repositories listed in this manuscript). We acknowledge that a more comprehensive discussion, including correlations between DIC and AOU, could be elaborated with the inclusion of these data, and it is our hope that our manuscript will inspire other to do so.

RC: Although this article is logically organized, it seems that there is too much information that is not important which affects the reader's reading.

AR: We are unsure about what the reviewer is specifically referring to. Given the spatial extent and the complexity of hydrographic features of the study area, we believe that detailed background information is warranted.

Specific comments:

RC1: Suggest change the title of 'Canadian Arctic" to "Canadian Arctic Archipelago and adjacent Basins".

AR1: We thank the reviewer for this suggestion. The suggested formulation was in the original title of the manuscript but was changed in the interest of keeping the title short. We will apply this suggestion to the revised manuscript.

RC2: The abstract is poorly written. There are too many summaries of the previous work, and the conclusion and discussion should be mention more.

AR2: We acknowledge that the abstract contains a large amount of background information and few key results. A more complete summary of the key results will be added to the abstract. We will shorten the background information in the abstract, but we believe that some of this information is critical to most readers' understanding of the context and impetus of this study. We plan to keep this information in the abstract, albeit written more concisely.

RC3: The CCGS appears for the first time, giving it its full name.

AR3: The acronym will be defined in the revised manuscript, it stands for Canadian Coast Guard Ship.

RC4: In figure 1, blue and red lines can be used to represent the direction and scope of influence of Pacific water and Atlantic water respectively.

AR4: The (blue) arrows in figure 1 represent the dominant surface circulation flow paths, for which there is no clear distinction between Pacific and Atlantic sources, as these latter water masses only dominate at greater depths. If the reviewer insists, we could add colored lines to represent the major inflows of Pacific and Atlantic waters at depth, but these would clutter the figure. A description of the structure of the water column and the location (depth) of the Pacific and Atlantic waters masses can be found in the text of manuscript.

RC5: The color bar in figure 4 represents the suggested source in red for easy identification.

AR5: The color code in Figure 4 represents pCO2 in the surface waters (< 5m). We do

not understand what the reviewer refers to by the 'source' and what he proposes. Is he referring to the surface or deep flow pattern?

RC6: In figure 5, there are only two colors of red and blue, so it is difficult to see the regional difference. It is recommended to use a variety of color gradients to distinguish.

AR6: We deemed that a divergent color scale was the most appropriate choice to distinguish between the omega-aragonite values above (supersaturated) and below 1 (undersaturated). Multi-color diverging colormaps exist, but include both red and green, colors that should be avoided for colorblind readers.

RC7: Line 270 should be Fig. 6b, c.

AR7: Figure 6 includes only one panel and therefore doesn't contain panels b or c. Nevertheless, a reference to Figure 7(k) will be added to the text, as it also shows the minima referred to in this sentence.

RC8: What does the color difference mean in Figure 7? Suggestions clearly marked.

AR8: In the panels with a legend and containing two colors (b, c, f, g, j, k), the colors are used to distinguish profiles from different sub-regions. In the panels where only one sub-region is displayed, multiple colors are used to more easily distinguish the continuity of the different profiles.

RC9: Line 325 aragonite saturation coincide with the temperature maximum but pH does not.

AR9: The passage in question reads as follows:

"The ΩA crosses the saturation threshold back to supersaturation between 200 and 250 meters, where Atlantic waters become predominant, as evidenced by a +0.8 °C temperature maximum at $\sim$500 m (in contrast to a temperature minimum of -1.5 °C in the UHL). ΩA and pHT remain, respectively, above 1.3 and 8.05 in this layer, with respective maxima of 1.74 ($\pm$ 0.16) and 8.17 ($\pm$ 0.03) that generally coincide with the

temperature maximum mentioned previously."

For space considerations, temperature is not shown in figure 7. We instead state that the temperature maximum associated with the Atlantic water mass is found close to 500m depth, an approximation, as the core depth of specific water masses varies between stations. The maxima in ΩA and pH do coincide with each other (they are measured at the same depth, at the same station), but are closer to a depth of 400m than 500m, which is why we used the formulation "that generally coincide with the temperature maximum". The depth of the ΩA and pH maxima at this particular station will be explicitly stated in the revised manuscript, but this does not modify the stated relationship between the trends in ΩA, pH and the nature of the predominant water masses.

RC10: From 460 to 465 lines, this part should be an important highlight of this article, it is suggested to strengthen the discussion.

AR10: We elected to focus the bulk of the section on the time of emergence in Appendix A, to keep the length of the article acceptable and because, as stated on line 466-467, we recognize that the dataset used to perform this statistical analysis is insufficient to insure its results are entirely reliable. With this in mind, we found it appropriate to briefly describe our results along with this important caveat in the main text, because these results are relevant to the discussion and might set an important precedent for estimating the time of emergence of the anthropogenic acidification signal using observational datasets. Nonetheless, we want to avoid putting too much emphasis on these results in the main text, as their predominance in the discussion might be misconstrued as a token of their validity.

RC11: Line 485-495 The author's description of the calculation method is not clear enough. My understanding is to calculate pCO2 by DIC and TA in the starting year, and then assume that the change of atmospheric CO2 is synchronized with the change of water body, calculate the DICvalue only affected by the atmosphere in given year, and

finally use the measured DIC minus DICatmosphere =delta DICorganism?

AR11: This issue was noted by another reviewer and will be addressed in the revised manuscript. A clearer description of the calculation procedures would be as follows: Delta-DIC-Bio is obtained by subtracting the DIC calculated at a reference time and adjusted for the atmospheric change in pCO2, from the observed DIC at the time of interest.

RC12: Line 520, Fig. 14 or Fig. 12

AR12: Figure 12. We thank the reviewer for pointing out this mistake, it will be fixed in the revised manuscript.

RC13: Suggest moving the Appendix to method.

AR13: The appendix contains some discussion and interpretation. We therefore do not consider it appropriate for the methods section.

RC14: It is shocking and strange that this MS does not mention this article: Azetsu-Scott, Kumiko, Calcium carbonate saturation states in the waters of the Canadian Arctic Archipelago and the Labrador Sea JGR 2010.

AR14: This article was indeed part of the literature review and will be added as a reference in the revised manuscript.

RC15: Suggest DICobserved and DICreference to simplify into DICobs and DICref for consistency of DICbio.

AR15: This suggestion will be applied to the revised manuscript.

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