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Biogeosciences Discussions

Interactive comment on "Twentieth century delta;¹³C variability in surface water dissolved inorganic carbon recorded by coralline algae in the northern North Pacific Ocean and the Bering Sea" *by* B. Williams et al.

B. Williams et al.

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We thank both referees for their constructive reviews, which significantly improved the paper. Our replies to their specific comments are below.

Referee 1

RC Line 24 (5804): The discussion of marine mammals did not flow (I thought there would be sessile organisms eg bivalves) with data available- so it was not clear at first why they talked about marine mammals. Perhaps the authors could discuss the

data from the soft coral first and then say the only other data available is from marine mammals.

Response: We have revised the text L16, P5804 to L11, P5805 to say: "In these studies, the depressed influence of the δ13C-Suess effect in the surface waters of the subarctic Pacific water was attributed to rapid renewal of surface waters which prevents the subpolar gyres from equilibrating with the atmosphere (Quay et al., 2003). This reduces the penetration of atmospheric CO2 into the surface waters, and drives the disequilibrium between atmospheric CO2 and surface water δ13CDIC values. However, instrumental δ13CDIC measurements are limited both in temporal (i.e., repeat cruise data limited to two data points) and spatial (i.e., one location at station KNOT) distribution. In contrast, skeletal δ13C values available from marine proxy records decrease at a rate exceeding that of instrumental records. In a gorgonian soft coral in the Alaskan stream, δ13C values declined at a rate of 0.015‰ yr-1 (Williams et al., 2007). However, this is the only record available from sessile organisms in the northern North Pacific. The δ13C values from subarctic Pacific marine mammals declined at a rate of 0.02 to 0.06‰ yr-1 (Newsome et al., 2007; Schell, 2001). These records are also useful, but their source from marine mammals has inherent disadvantages. For example, it is difficult to differentiate changes in the baseline δ13CDIC relating to anthropogenic causes from temporal shifts in foraging zones of the marine mammals that have different isotopic values at the base of the food web (Newsome et al., 2007; Hirons et al., 2001). Variability within a marine mammal sample set, i.e., in size, gender, and age, may also obscure baseline changes (Hobson et al., 2004)."

We have also removed the sentence on L19-23, P5805 to reduce repetition.

RC: Line 15 (5807)is this one standard deviation?

Response: We have clarified that this was one standard deviation.

RC: The use of the word of secular- I was unclear of this since it refers to either something which occurs over an indefinitely long time or something occuring once in an age or century. I did not understand how this related to the manuscript.

Response: We have changed secular to no overall trend on P5809, L5 and P5810, L10, decreasing δ13C and increasing temperature/decreasing salinity on P5811, L7, and long-term on P5812, L21.

RC: Fig. 5 I do not think this Fig. is necessary. Response: We have removed figure 5.

Referee 2: RC: The paper is written in a variety of tenses which ranges between past and present and active and passive. The authors should carefully consider in which tense they want to write the paper and stick to it.

Response: We have revised this throughout the text.

RC: Sentences are not normally supposed to start with abbreviations.

Response: We have revised this throughout the text.

RC: The authors use the term 'calcified tissues' for the coralline skeleton. I am not sure this is correct.

Response: We have changed calcified tissues to skeletons.

RC: The authors cite some references out of context.

Response: We believe the referee is referring to the reference on L24-25, P5812. We have revised this to say: Decreases in skeletal δ13C values greater than that observed in atmospheric CO2 have also been found in corals from restricted environments, and in these cases, the increased rate of decline was attributed to enhanced input of organic material that oxidized to release isotopically depleted CO2 (Swart et al., 2010).

RC: No ages are presented. The coralline algae has annual bands, but it is not clear no their annual nature has been established. Age data are obtained from a previously published paper, yet they are critical and therefore should be included so readers can assess the error of the age. I think some discussion of this is needed.

Response: The number of years sampled for each specimen is provided on L14-17, P5809. We think this is more important than the absolute ages of each specimen.

The annual periodicity of the growth increments in Clathromorphum sp. from mid-to-high latitudes has been well established in the literature. Specifically, Adey (1965) demonstrated that the formation of the reproductive structures, the conceptacles, in Clathromorphum sp. are annual and that the growth increment lines separate large, poorly calcified cells below from small, heavily calcified cells above the increment line. In addition, the annual character of the growth increments has been independently validated by identifying the 14C-bombcurve in a live-collected specimen (Frantz et al., 2005) and by absolutely dating using U/Th (Halfar 2007). In specimen Attu 11-4, U/Th dates matched precisely the number of annual increments (Halfar et al., 2007) indicating there is minimal error to the age models. Finally, the high correlation between Mg/Ca ratios in Attu 11-4 and AM-KR-80 and temperature (Hetzinger et al., 2009) supports the growth models. Presenting additional chronological development for these specimens will contribute substantial text to the paper. Since these data are already published, we do not think it is required here. Therefore, to incorporate the referee's comment within the scope of the current paper, we have revised the text as follows: L 2-17, P5809: "In Clathromorphum sp., seasonal decreases in temperature and light during winter periods reduce the calcification rate of the algae resulting in growth increment lines in the skeleton (Adey, 1965; Halfar et al., 2007; Hetzinger et al., 2009). In addition, conceptacles, which are annually-formed reproductive structures (Adey, 1965) were also present (Fig. 2). Therefore, the clear growth increments visible here (Fig. 2) were assumed to be annual. The width of the annual growth increment varied from 140 to 680 μm with an average of 381 μm for all three specimens. There was no ontogenic or secular variation in annual growth increment widths over time in any of the specimens.

Seasonal variability in Mg/Ca ratios in all of the specimens and δ18O values, as well as absolute dating by U/Th in Attu 11-4 the annual periodicity of the growth increments

(Halfar et al., 2007; Hetzinger et al., 2009)."

RC: General the sentence structure is very poor. There are several native English speakers in the author list and I suggest that the senior authors use them to help improve the paper!

Response: We have incorporated all improvements to the language as recommended by the reviewer in the marked pdf, as well as minor additional edits to facilitate reading the paper.

RC: There is some significant repetition such as the portion making the case for the fact that coralline algae may be better archives than mammal based archives.

Response: We have revised the text discussing comparisons to the mammal-based archives as suggested by referee #1, and removed the sentence on L19-22, P5805 as suggested by referee #2.

RC: The coralline algae is composed of HMC yet the authors talk about calcite rather than HMC. In Figure 3 they once again plot calcite equilibrium rather than HMC equilibrium. I am not sure what they have plotted.

Response: As discussed in the text on P5824, we used a value of 9.9 mol % Mg obtained from Hetzinger et al. (2009). This is just below the >10 mol % Mg used by Jimenez-Lopez et al. (2004) to define high magnesian calcites. Therefore, we had plotted the equations for pure calcite with the addition of 0.17‰ to the δ18O value for each mol % Mg according to Jiménez-López et al. (2004) to account for the higher amounts of magnesium in the skeleton. To account for the high Mg content, we have added the 0.024‰ to the δ13C value for each mol % Mg according to Jiménez-López et al. (2006). This has been updated in the Figure 3 legend: "Figure 3. δ18O values plotted against δ13C values for the calcified tissue of three specimens of coralline algae with regression lines. Larger grey symbols represent the average δ13C (for 1992-1993) and δ18O (for 1990, 1993, and 1995) for Attu11-4 and AM4-1. Predicted isotopic equilib-

rium for inorganic calcite is plotted (grey diamond) based on δ13C and δ18O values for seawater from 1992-1993 and 1990, 1993, and 1995, respectively, and equations from Romanek et al. (1992) and Kim and O'Neil (1997), respectively. In order to account for the fact that coralline algae are High Mg-calcite, the equation for δ18O value incorporated the addition of 0.17‰ for each mol % Mg according to Jiménez-López et al. (2004). The equation for δ13C value incorporated the addition of 0.024 ‰ for each mol % Mg according to Jiménez-López et al. (2006). The value of 9.9 mol % Mg used was the median value from the range given in Hetzinger et al. (2009). Error bars indicate one standard error around the average. Error bars not visible are smaller than symbol. Predicted equilibrium is not plotted for AM-KR-80 as this sample was collected prior to the early 1990s."

The equilibrium relationships used in the study are also included in the main text on L19-22, P5807, and we think they are better suited here than in the discussion as suggested by the reviewer L15, P5811. We have updated the text on L19-22, P5807 to be consistent with the figure legend: "The predicted isotopic equilibrium values for δ13C and δ18O in inorganic high-Mg calcite were estimated from the equations of Romanek et al. (1992) and Kim and O'Neil (1997), respectively, with the addition of 0.24 ‰ and 1.68 ‰ for δ13C and δ18O, respectively, to account for the average 9.9 mol % Mg content in the skeleton (from Hetzinger et al., 2009) according to Jiménez-López et al. (2004; 2006)."

Interactive comment on Biogeosciences Discuss., 7, 5801, 2010.