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Interactive comment on "Secondary calcification and dissolution respond differently to future ocean conditions" *by* N. J. Silbiger and M. J. Donahue

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We thank you very much for your helpful review. Below are responses to your comments and specific questions.

-One problem with TA anomaly when looking at bioerosion is that it measures only the "chemical dissolution". The breaking of $CaCO_3$ structure is also important and it would have been nice to do buoyant weight measurements to quantify the overall decrease in weight of rubbles (i.e. how much is dissolved vs how much is broken in smaller pieces).

This is an important point. Using the TA anomaly method, we can only address the impacts of climate stress on chemical dissolution and not the breakdown of $CaCO_3$

into smaller pieces (e.g., the production of sponge chips). We have added text to section 2.3 Experimental Design in the revision to clarify this limitation. Note that, because the rubble communities had both secondary calcifiers and bioeroders, the distinction between chemical and mechanical breakdown could not be distinguished using buoyant weight: the change in weight includes both the addition of $CaCO_3$ by secondary calcifiers and the breakdown of $CaCO_3$ by eroders. Additionally, it would have been challenging to obtain an accurate estimate of change in buoyant weight given the short duration of the experiment and, therefore, the small magnitude of weight changes relative to the weight of the rubble pieces (1748 g, on average). Nonetheless, we have highlighted this limitation of the TA anomaly method and noted that it is an important distinction for future studies to address.

Specific points:

-P12804: What were the flow rates in the mesocosms?

Flow rates were 115 ± 1 (SD) ml min-1, as reported in section 2.4 – Mesocosm Set-up

-P12804-l-19: Please provide _ sizes of the rubbles. How was the homogeneity of the rubbles determined? I guess dissolution of old rubbles would be different than the one of "young" rubbles?

There was approximately 1.2L of rubble in each tank, as reported in the third paragraph of section 2.3 – Experimental Design. In response to the reviewer's question, we have added some additional information describing the characteristics of the rubble (3-4 pieces of average weight 499 ± 148 g , average skeletal density of 1.53 ± 0.1 g cm-3 (mean $\pm$ SD, n=85)) to give the reader a better sense of the volume and homogeneity of rubble pieces. To keep rubble consistent among aquaria, we kept the volume, weight, and skeletal density of individual rubble pieces consistent and put a similar total volume of rubble in each aquarium. In addition, NEC and NCP rates were normalized to the surface area of rubble in each aquarium. We agree with the reviewer that the age of the rubble could be relevant to the dissolution rate. However, the age of the collected rubble is unknown. We accounted for this in two ways: we controlled for rubble density (expecting that rubble density may be a proxy for rubble age), and we randomized rubble pieces across treatments (so that variation in age adds noise, but not systematic bias, across treatments).

-P12804-l-19: Why were the incubations not replicated? 24h incubations are easy to replicates and could have inform on temporal changes.

This manuscript reports the experiment as it was performed. Limitations of facility time and sample cost prevented us from repeating the 24-hour incubations. Despite this limitation, we believe that the results of this experiment give important insights into community calcification processes and will be of interest to Biogeosciences readers.

-P12805-l-10. I guess the TA changes in the mesocosms were very limited. Were the errors associated with measurements small enough to be sure to detect a change in calcification? Maybe you should provide the range of TA changes during incubations.

We have added information on the magnitude of TA changes during the day and the night to the methods text in 2.5.1 – Total Alkalinity, the same section where the accuracy and precision of the TA measurements are reported: "The accuracy of the titrator never deviated more than $\pm$0.8% from the standard, and TA measurements were corrected for these deviations. The precision was 3.55μEq (measured as standard deviation of the duplicate water samples).During the 24-hour control experiment, the average changes in TA were 37μEq over the day and 20μEq over the night (day and night TA changes were of larger magnitude in the treatment experiments): these are measurable changes given the precision and accuracy of the TA measurements." In addition, the regression analysis indicates that the systematic differences due to treatment effects exceeded the variability due to error, including measurement error.

-P12808-l-5: What do you mean by normalized to DIN? Do you mean that TA was corrected for the changes in NH4+ etc? Please clarify.

TA was corrected for changes in the concentration of nitrate, nitrite, ammonium, and phosphate. We have changed the wording in section 2.6 Measuring Net Ecosystem Calcification and added a citation. It now says "TA was normalized to a constant salinity (35 psu) to account for changes due to evaporation and then corrected for dissolved inorganic nitrogen and phosphate to account for their small contributions to the acid-base system (Wolf-Gladrow et al., 2007)."

-P12808-l-11: A change in TA in mmolCaCO3 m-2 h-1? Reformulate this sentence.

Sentence changed to read, "F_TAin is the rate of TA flowing into an aquarium (= average TA in the header tank times the flow rate), F_TAout is the rate of TA flowing out of an aquarium (= average TA in the aquarium times the flow rate), and , d"TA" /dt is the change in TA in an aquarium during the measurement period (change in TA normalized to the volume of water and the surface area of the rubble). The rates are measured in mmol CaCO3 m-2 hr-1 (specific calculations are given in the supplemental material)."

-P12808-l-11: Rates are normalized in mmol CaCO3 m-2 h-1, does m-2 represents the surface of the mesocosms, surface of the rubble, etc? Clarify.

Data are normalized to the surface area of the rubble. This was stated in the original MS on page 12805 line 14 : "... and normalized all our calculations to the surface area of the rubble in each tank". For clarity, we added "change in TA normalized to the surface area of the rubble" to section 2.6 Measuring Net Ecosystem Calcification and included this detail in the description of the calculations in the appendix.

-P12809-l-10: What about the exchanges with the atmosphere? Were the tanks sealed? If not, exchanges with the atmosphere could have lead to under/overestimations of photosynthesis and respiration.

The tanks were not sealed. Air-sea CO2 flux is minimal for windspeeds less than 10 ms-1 (Wanninkhof 1992). In our indoor mesocosm system, the windspeed inside the mesocosm room was near zero. Therefore, we did not account for air-sea fluxes in our analysis.

-P12811-l-14: Provide details on the response of NCP.

We have added data on the response of NCP to the results section in the text and in a new table and an extended figure in the main text and in the supplement. Table 3 now includes the regression results for standardized climate change vs NCP, and Figure 3 now has an additional panel showing the relationship between Standardized Climate Change and NCP. Table A2 has the regression analysis for NCP and Figure A4 shows the means and standard error bars for NCP by treatment.

-P12812-l-12: Are the normalization the same? If in the present study the rates are normalized by the actual surface of the rubbles (which needs to be clarified, see above) it might be different than the study of Yates and Halley who normalized by planar surface...

Added this sentence for clarification, "It is important to note that we normalized our rates to the surface area of the rubble while Yates and Halley (2006) normalized their rates to planar surface area." to the discussion.

-P12813-l-2-14: I am really not convinced by this explanation for two reasons. – What was the importance of the CCA? Most of the photosynthesis was likely due to turf algae and not to calcify algae. - In addition the authors mention themselves later "non-photosynthesizing invertebrates in the community (such as bivalves) might be dominating the calcification signal in these conditions." In contrast I think that the second hypothesis makes much more sense and should be developed.

We expanded on this point in the discussion. We also added a thermally-induced metabolic response as a possible mechanism. This paragraph now reads as follows: “1) Some calcifiers can maintain and even increase their calcification rates in acidic conditions (Kamenos et al., 2013;Findlay et al., 2011;Rodolfo-Metalpa et al., 2011;Martin et al., 2013) by either modifying their local pH environment (Hurd et al., 2011) or partitioning their energetic resources towards calcification (Kamenos et al., 2013). For example, in low, stable pH conditions the coralline algae, Lithothamnion glaciale, increased its calcification rate relative to a control treatment but, did not concurrently increase its rate of photosynthesis (Kamenos et al., 2013). Kamenos et al (2013) suggest that the up-regulation of calcification may limit photosynthetic efficiency. In the present study, the increase in Gday coincided with a decrease in net photosynthesis (Figure 3a,b). Photosynthesizing calcifiers in the community may be partitioning their energetic resources more towards calcification and away from photosynthesis in order to maintain a positive calcification rate (Kamenos et al., 2013). Notably, turf algae likely have a major control over the NCP in this community which would not have any impact on calcification. 2) An alternative hypothesis is that the calcifiers may be adapted or acclimatized to high pCO2 conditions (Johnson et al., 2014) and have not yet reached their threshold because the rubble was collected from a naturally high and variable pCO2 environment (Guadayol et al., 2014; Silbiger et al. 2014). 3) In this study, the calcifiers experienced a combined increase in both pCO2 and temperature and, thus, the non-linear response in Gday may also be due a metabolic response. In a typical thermal performance curve, organisms increase their metabolism until they have reached a thermal maximum and then rapidly decline (Huey and Kingsolver, 1989; Pörtner et al., 2006), and we see this response in our results. A recent study found a similar nonlinear response to temperature and pCO2 in the coral Siderastrea sidera (Castillo et al. 2014). While they attribute the pCO2 response to photosynthesis being neutralized (we did not see this response in our non-coral community), they suggest that the thermal response is due to both changes in metabolism and thermally-driven changes in aragonite saturation state (Castillo et al. 2014). ”

-P12814-l-7-15: I agree with this paragraph but it would be important to specify that this is true for an ecosystem dominated by rubbles. In an ecosystems with very high coral cover, the story would likely not be the same...

We clarified that this generalization is specific to our rubble community. This sentence now reads, “Standardized Climate Change explained more of the variance in dissolution than in calcification in our rubble community: (R_(G_night)ˆ2=0.64> R_(G_day)ˆ2=0.33; Table 2) this result is not surprising”

Interactive comment on Biogeosciences Discuss., 11, 12799, 2014.