

***Interactive comment on “Impact of seawater  $p\text{CO}_2$  changes on calcification and on mG/cA and sR/cA in benthic foraminifera calcite (*Ammonia tepida*): results from culturing experiments” by D. Dissard et al.***

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Answer to anonymous referee 2

Comment A limitation, which may be beyond the scope of the current contribution, is that the experiment only examined two values of  $p\text{CO}_2$ . The values chosen also represent extremes, at 120 ppmv and 2000 ppmv. Perhaps this is a good place to start, but it would be good to see experiments on foraminifera grown in conditions that really have applied in the past, and/or are likely to apply in the near-future. Perhaps

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these will be the subject of further experiments. A significant omission, though, is any indication of a “control” for *A. tepida* calcification and Sr/Ca and Mg/Ca at the ambient (probably mean) natural conditions in which it grows in the wild. Answer: Data for ambient  $p\text{CO}_2$  (380ppmv) have been added to the manuscript and are now presented in new figures 5b and 6 (see also reply to comment 1 reviewer 3).

Comment: Similarly, what are the conditions, in terms of  $p\text{CO}_2$ , temperature, and salinity where the specimens were collected? The natural range of conditions the foraminifera experience should definitely be added to the paper. As an intertidal environment, the sampling location probably has quite large diurnal as well as seasonal variability. Answer: To accommodate this comment the following sentence: “The symbiont-barren species *Ammonia tepida* is characterized by the broad range of temperatures (5 to 40°C, Pascal et al., 2008 ), salinities (12 to 40, Brasier, 1981, Murray, 1991; Pascual et al., 2002) and seasonal regimes (Bradshaw, 1961; Walton and Sloan, 1990) under which it can survive. This robustness makes *A. tepida* a particularly suitable species to conduct experiments with.” was added to the manuscript.

Comment: There is no indication of the statistical significance of the relationship between size normalized shell weight and carbonate ion (Figure 4c), and this should be added before the paper is published. Also this relationship seems to depend on the relationships between shell weight and diameter (Figs. 4 a and b) which themselves seem to have quite a bit of scatter. Can the null hypothesis - that’s there’s no relationship between shell weight and carbonate ion concentration – be rejected in this data set? Answer: We agree with the reviewer, and after applying different statistical methods, no significant difference between the two relationships: size normalized shell weight vs carbonate ion and size normalized shell weight vs temperature, could be seen. Therefore, figure 4c as well as the discussion on the differential impact of carbonate ion concentration vs temperature was removed (see new section 4.1).

Comment: It’s not clear why the particular combination of temperature, salinity, and  $p\text{CO}_2$  conditions used in the study were chosen. If the object of the experiment was

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evaluate the impact of seawater pCO<sub>2</sub> changes, as the title suggests, why not hold temperature and salinity constant and vary carbon dioxide through a more extensive set of intermediate values between 120 and 200 ppmv? I'm not suggesting the authors go back and do all this before this paper is published, but rather to see more discussion of the rationale for the experimental design. It would help other investigators setting up similar experiments (which I think this paper will inspire). Answer: The referee is right, it would have been of great interest to run experiment at least at five pCO<sub>2</sub> conditions. However, due to practical constraints we could only run parallel experiments at 2 CO<sub>2</sub> concentrations (high and low pCO<sub>2</sub>). Within these limitations we chose to run two experiments at two different salinities and temperatures, since this will also change the carbonate ion concentration. In addition we have now added data for ambient pCO<sub>2</sub>.

Comment: The section on cleaning procedures notes that "specimens were removed from the reagent directly after complete bleaching, in order to avoid dissolution of the final, (often thinner), chambers." This raises a concern that the bleaching procedure may have already dissolved some of the final chambers. Is there a way to establish that dissolution is not induced by the bleaching procedure itself? For example, is calcein stain present in the water in which the shells are bleached after the bleaching? Has the pH in the solution changed before and after the bleaching? These might be quick and straightforward ways to check. Answer: After cleaning, specimens were checked with scanning electron microscopy and showed no visible signs of dissolution (see figure 2).

Comment: The discussion notes other studies which document changes in foraminiferal shell weight in response to natural variations (temporal and/or spatial) in seawater carbonate chemistry, notably the Barker and Elderfield 2002 Science paper. However, since the Barker and Elderfield paper (and probably after this paper was submitted), other evidence of similar (at least in sign) sensitivity to changes in seawater [CO<sub>3</sub><sup>2-</sup>] in planktonic foraminifera has been published from the Southern Ocean (Moy et al., 2009) and should be cited here. Similarly, work also in Biogeoscience Discus-

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sions, suggests a reduction in planktonic foraminiferal calcification in the Arabian Sea since pre-industrial times (de Moel et al., 2009). Answer: As suggested by referee, we have added the references of Moy et al. (2009) and de Moel et al. (2009).

Comment: It's not clear why, in Figure 7, Sr/Ca is plotted as a function of pH rather than as a function of carbonate-ion concentration and/or as a function of pCO<sub>2</sub>. Presumably one would want to compare Sr/Ca in the planktonic foraminifera *O. universa* and *G. bulloides* directly to the results obtained for *A. tepida* here, so why not plot their Sr/Ca ratios in the same variable space? Answer: Lea et al. (1999) and Russell et al. (2004) have both plotted their data versus pH. In addition, Lea et al. (1999) do not mention a second parameter of the carbonate system, which would be necessary to recalculate [CO<sub>3</sub><sup>2-</sup>]. Therefore, all results were plotted versus pH.

Comment: A few minor quibbles and typos: Fix the capitalization of Sr, Mg, and Ca in the title. Answer: Capitalization were changed in the title.

Comment: Page 3774, Line 20: is that meant to be "over a 63 $\mu$ m mesh?" rather than "630 $\mu$ m?" Answer: No, "over 630 $\mu$ m" is correct (in order to remove larger meiofauna).

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Interactive comment on Biogeosciences Discuss., 6, 3771, 2009.

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