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Biogeosciences Discussions

Interactive comment on "Effect of carbonate ion concentration and irradiance on calcification in foraminifera" *by* F. Lombard et al.

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Anonymous referee #1 is gratefully acknowledged for his comments which have improved our manuscript.

"it would be interesting to get an explanation of the production of light shells at high [CO32-], i.e., 504 μmol kg-1, although heavier shells are produced at slightly higher and lower carbonate ion concentrations"

Response: With regard to the group of foraminifers grown at 504 μmol kg-1 of [CO32-] that produced lighter shells than those grown under lower carbonate ion concentrations, it should be emphasized that a relatively large variability was observed under all conditions. The fact that specimens grown under higher or lower carbonate ion concen-

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trations follow a general trend where shell weights increase with increasing carbonate ion concentration, seems to indicate that the data point at 504 μmol kg-1 is simply an "abnormal" point. We assume that natural variability, may be in combination with a slightly different condition of the specimens or the natural sea water at the time of collection is the most probable explanation.

"Taking into account the upcoming decrease in [CO32-] over the next century, as well as past variability in foraminifer test-CaCO3 mass, the authors predict significantly reduced planktic foraminiferal calcite production in the near future, of >4 to <27 % in different species. Those numbers have possibly been produced on the assumption of linear extrapolation of earlier results."

Response: The choice of the linear regression was motivated by the facts that our data do not support any evidence for a more complex relationship and that most studies on calcification rates as a function of [CO32-] also used linear regressions (Leclercq et al., 2000; Riebesell et al., 2000; Gazeau et al., 2007). We also want to point out that the estimation of reduced calcification rate in hypothetic future conditions were not obtained using linear extrapolation, but linear interpolation within the [CO32-] range investigated.

"Mayor conclusion of the paper is that 'at higher temperatures, foraminifera are usually more abundant (Bé and Tolderlund, 1971), have higher growth rates (Lombard et al., 2009) and larger shell sizes (Schmidt et al., 2006)', 'counteracting the negative impact of ocean acidification.' To my view, the interpretation of data, and the discussion of the effects of changing seawater pH on the calcification of foraminiferal shells is too simplistic. In the following, I will discuss the major conclusion of the paper of Lombard and co-authors."

Response: We want to point out that the sentence "at higher temperatures, foraminifera are usually more abundant (Bé and Tolderlund, 1971), have higher growth rates (Lombard et al., 2009) and larger shell sizes (Schmidt 5 et al., 2006)" is not a conclusion of

BGD

6, C3468–C3471, 2009

our work. It is meant to emphasize that our study only focuses on the effect of [CO32-] on calcification rate but that antagonistic or synergistic effects could occur, for example with elevated temperature. The possible counter-acting effect of temperature, and other factors mentioned by referee #1 such as food availability (which may be lowered by the global change), and the effect of dissolution or crust formation will be added to the revised version of the manuscript.

"To conclude, higher SSTs would cause diminished standing stocks of planktic foraminifers, and a rather unpredictable (but possibly small) reaction of growth rates at the predicted 0.5-2 °C change in SST (IPCC, 2007; not including the Arctic Ocean)."

Response: We do not think that the effect of temperature on growth rate is small: a 0.5-2°C increase in seawater temperature would, on average, increase growth rate by 2.8 to 12% (all species combined). However, growth rate is not linear, but exponential ($W(t)=W0\ e(\mu t)$ with W0= weight at time zero, W(t) weight at time t and μ the growth rate) and a small increase in growth rate may result in a larger difference in terms of final weight (depending on the generation time of foraminifer). This could be enough to counter-act the negative impact of ocean acidification on rates of calcification. On the other hand, an increase in growth rate does not necessarily mean that calcification should increase as well. The combined impact of carbonate ion concentration, temperature and food availability on calcification rate needs to be studied in more detail. As pointed out by referee #1, decreased food availability may have a strong effect on either abundance, growth, and/or size of foraminifers.

Literature cited

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BGD

6, C3468–C3471, 2009

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Interactive comment on Biogeosciences Discuss., 6, 8589, 2009.