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Discussions

Interactive comment on "Calcifying invertebrates succeed in a naturally CO_2 enriched coastal habitat but are threatened by high levels of future acidification" *by* J. Thomsen et al.

Anonymous Referee #1

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The manuscript from Thomsen et al. aims at providing some answers on the future of calcifying organisms in a high-CO2 ocean. In this study, they investigated the growth of a bivalve species (Mytilus edulis) in a naturally CO2 enriched ecosystem in the Baltic Sea (Kiel Fjord). In this habitat, pCO2 ranges between atmospheric equilibrium and >2000 μatm, yet mussel beds are very important components of the benthic ecosystem, suggesting these organisms can easily tolerate such high pCO2 levels. This study can be divided in 3 parts: 1) the in situ study with a characterization of the carbonate chemistry in the Fjord as well as measurements of in situ shell growth and recruitment, 2) a short (2 weeks) laboratory-based study focusing on the acid-base regulation of large mussels under 6 different levels of pCO2 (atmospheric equilibrium to 4000 μatm)

and 3) a longer (8 weeks) incubation experiment in the lab focusing on shell and tissue growth as well as on shell mineralogy and structure at 3 different pCO2 levels (385, 1400 and 4000 μatm). The main conclusions of this study are that mussels from this area, although not able to regulate extracellular pH at moderately elevated pCO2 levels at which water is corrosive for both aragonite and calcite (1400 μatm), do maintain growth rates close to control rates at these pCO2 levels. This explains the predominance of this species in the Fjord, species that settles in summer coinciding with high pCO2 levels.

All in all, this is a very interesting paper and I would like to congratulate the authors for such a comprehensive study. I recommend this manuscript for a publication in BG but I would like the authors to consider the following suggestions and criticisms.

Whole manuscript

First of all, I would reorganize the manuscript for a better reading. For instance, the Material and Method should be organized with the same order than the Results and Discussion section: i.e. in situ study with carbonate system measurements and growth and settlement studies and then laboratory studies (2w and 8w). I am not sure the best place to discuss the potential evolution of pCO2 in the Fjord is in the conclusion section. As a plot is shown in Fig 1, I would discuss it at the end of the first paragraph of section 3 (3.1). Also be careful in the Results and Discussion section not to repeat what has been said in the Material and Method section: for instance in 3.2, until P5133L2 this has to be removed.

Section 3.1

The authors mention the manuscript from Hall-Spencer et al. (2008) as a similar study performed in a natural CO2 enriched habitat. I am surprised that Tunicliffe et al. (2009) are not cited as they also reported on the presence of mussels in a very acidic environment (a deep submarine volcano). These authors also compared growth rates of this species at these very low pH levels and growth rates of organisms living in an environment with higher pH levels (7.8). My questions are: Is there a place in the Western Baltic where you can find coastal waters with same T, S and food concentration but with higher pH levels? If yes and if mussels also inhabit these ecosystems, could you compare their growth rates? This would be of a great interest also for transplant studies.

Section 3.2

I do not agree, based on what is presented by the authors, that mussels do not regulate pH in the EPF. I am also not convinced of the opposite but it must be stressed that this conclusion from the authors cannot be supported by the presented data. Indeed, they reported that haemolymph pH (that is apparently not up-regulated) is of the same level than EPF pH. However, it must be stressed that in Table 3, the authors only present a comparison between haemolymph and EPF pH at 500 μatm for animals sampled in December when no shell growth occurs in the field (cf. Fig 2). This is insufficient, in my opinion, to conclude on the capacity of these organisms to regulate the carbonate chemistry at the site of calcification. Nevertheless, this should not prevent the authors to discuss on the mechanisms that could be used by bivalves to optimize the chemical conditions at the site of calcification. The authors mention: P5135L23 "Thus, mussels must possess a powerful calcification machinery to construct and maintain shell integrity in an EPF that is highly undersaturated with CaCO3". First of all, again, are you sure about that? And second, there is an extensive literature on the calcification mechanism used by these species, it would be interesting for the reader to have a short review on what is this powerful calcification machinery.

Section 3.3

I have troubles with the use of the word "control" for the treatment at which organisms are exposed to a pCO2 at 385 μatm. In the field, at the time of the experiment, organisms are exposed to much higher pCO2 values. Exposing the organisms to 385 μatm seems to me as a perturbation... Moreover, P5134L6, the authors state that shell

growth measured at 385 μatm in their experiment matches growth rates measured in the field in summer. This is not really relevant as, again, pCO2 is much higher in summer in the field and also because food concentrations are also certainly very different. Could you provide an estimate of decrease (e.g. %) in shell growth at the highest pCO2? The authors should mention that, in contrast to their findings, Michaelidis et al. (2005) actually showed a decrease of somatic growth for mussels at higher pCO2, parallel to the one observed for shell growth.

Section 3.4

As shell growth has been shown to be dependent on initial shell size, the comparison in shell structure (which could be dependent on shell growth) might not be relevant as initial shell sizes are higher for mussels exposed to 4000 μatm than the others.

Figures.

It would be nice to show the reconstruction of pCO2 values based on eq. 1. I do believe there are too many figures in this manuscript. I am not sure Fig 2b and Fig 6 are necessary. Furthermore, Figs 5 and 7 should be removed or reorganized as 1 figure.

References

Tunnicliffe, V., Davies, K. T. A., Butterfield, D. A., Embley, R. W., Rose, J. M., and Chadwick, W. W.: Survival of mussels in extremely acidic waters on a submarine volcano, Nature Geoscience, 2, 344-348, 10.1038/ngeo500, 2009.

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