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Interactive comment on "Impact of anthropogenic ocean acidification on thermal tolerance of the spider crab *Hyas araneus*" *by* K. Walther et al.

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Author comment to I. J. McGaw – Referee 1

We appreciate the constructive comments by I. J. McGaw In the following we answered the questions and tried to develop a hypothesis to explain the observed results.

1. In our opinion the standard unit for CO2 widely used in the community is ppm, the community, not us on our own would have to consider changing it, e.g. to SI units.

2. CO2 penetrates the surface ocean level by air-to-sea equilibration. The distribution of CO2 is occurs by ocean circulation (Orr et. al, 2001). In the German Bight the water depth is less than 100m (Pohlmann, 1996), in this case the whole water body will be equilibrated with CO2.

3. Hyas araneus live on hard, stony, sandy and soft bottoms from < 1 down to 360 m, most commonly at depths less than 50 m. Males may reach a carapace length of 105 mm (Christiansen, 1969). We add this information to the manuscript. To our knowledge this species is not used commercially.

4. We prevented haemolymph clotting around the oxygen probes by rinsing the probes with a heparin solution. We added this information to the methods section. We calculated heart rates continuously at each temperature step independent from pauses of heart rate, which were not observed for significant time during the incubations.

5. We used 25°C as the upper temperature because the orginal aim of our study was to show effects of CO2 on pejus limits. In this case it was not our aim to expose the crabs at temperatures beyond their critical temperature. However, the experiments showed that the citical temperature is largely affected by CO2. In future studies it is necessary to quantify the critical temperature under normocapnic conditions.

6. We changed this section accordingly.

7. We eliminated these sentences.

8. We eliminated the repeated mentioning of results in the discussion part.

We developed a hypothesis why increased CO2 affects heart rates and PO2 levels: Short-term exposure to acidification results in enhanced ventilation and an accompanied rise in heart rate which supports CO2 release and alleviation of pH disturbances (cf. Pörtner et al., 2005). The additional decrement in heart rate at low temperatures was possibly caused by the accumulation of adenosine under CO2 exposure. Adenosine was found to depress ventilation rate in Sipunculus nudus (Reipschläger et al., 1997). In crustaceans, adenosine also depresses spontaneous activity and the responsiveness of interneurons to electrical and chemical stimuli in the brain (Derby et al., 1987) and elicits bradycardia (Brevard et al., 2003). In contrast, adenosine can display a stimulatory effect on heart rate, haemolymph flow and scaphognathite frequency (Maurer et al., 2008; Stegen and Grieshaber, 2001). This apparent discrepancy resembles the contrasting CO2 effects at low and at high temperatures. Such stimulatory effect might in fact be involved in the increase in heart rate with rising CO2 concentrations in the warmth (Fig. 5). Further experiments are required to test these hypotheses.

9. Yes the North Sea around Helgoland showed an increase in temperature during the last 40 years by 1,1 °C to a mean temperature of 18 °C and maxima of about 20°C (Wilthire and Manly, 2004). Due to rising temperatures in the North Sea the projected critical temperatures of H. araneus can be reached in the near future.

10. We demonstrated the effect of CO2 on the acute thermal tolerance window. During 24h of incubation the pH level of the extracellular space would reach a new level. This is the same during exposure to longer periods (days). It is conceivable that the crabs fully compensate their extracellular pH close to the starting point when exposed over a longer time (months).

11. We haven't done thermal preference experiments yet. To answer the question longterm exposure to CO2 is necessary. This is a nice suggestion for future studies.

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