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Biogeosciences Discussions

Interactive comment on "Physiological basis for high CO_2 tolerance in marine ectothermic animals: pre-adaptation through lifestyle and ontogeny?" *by* F. Melzner et al.

Anonymous Referee #1

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Melzner et al. have produced a well-written and accurate account of animal physiology as it relates to the acid-base disturbances associated with future ocean acidification scenarios. I have no major problems with the content per se.

However, I feel that this review offers little information that hasn't been reviewed extensively already. Although I think this manuscript does a better job of summarizing the information in some respects, provides more detail than some others, and provides a number of figures that are informative, the bulk of the information is repetitive of earlier efforts. What the community needs now is new data testing the specific responses of individual species to moderate elevations in CO2 over varying time scales. Ocean acidification literature is plagued by a very low data:review ratio (See excerpts from review papers below demonstrating similar conclusions).

The primary argument in this paper is that organisms with high metabolic rates will fare better in high CO2 because they have evolved mechanisms to deal with their own respiratory CO2. This argument was first made by Seibel and Walsh (2001; 2003) in relation to deep-sea carbon dioxide sequestration, but was applied more broadly to ocean acidification in Seibel and Fabry 2003, Pörtner et al., 2004; Pörtner, 2008; Spicer and Widdicombe, 2008; and Fabry et al., 2008. Thus it is not a new idea. Moreover, much of the information is much older than the issue of ocean acidification and has been reviewed many times in previous decades (see below). Pörtner's group originally argued that high metabolic rate animals would be more sensitive to high CO2 because of their highly pH-sensitive respiratory proteins (Pörtner and Reipschlager, 1997, and in the IPCC report on carbon sequestration). These seemingly conflicting hypotheses are not mutually exclusive but should be clarified and discussed.

Excerpts from previous reviews arriving at the same conclusion as the present paper "Ocean acidification acts especially on lower marine invertebrates, which are characterized by a low capacity to compensate for disturbances in extracellular ion and acid–base status and sensitivity of metabolism to such disturbances". Portner 2008. MEPS 373: 203-217. Ecosystem effects of ocean acidification in times of ocean warming: a physiologists view.

"Thus species that show poorly developed ion regulation should be less likely to possess the physiological machinery required for effective regulation of extracellular acid-base". Spicer, J. I. and Widdicombe., JEMBE 2008 Predicting the impact of ocean acidification on benthic biodiversity: What can animal physiology tell us?

"Those species with high capacity for metabolic production of CO2 have evolved greater capacities for buffering, ion exchange, and CO2 transport". Fabry et al., 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES J.

Mar. Sci.

"Sensitivity to CO_2 is hypothesized to be related to the organizational level of an animal, its energy requirements and mode of life". Pörtner et al., 2004. Biological Impact of Elevated Ocean CO_2 Concentrations: Lessons from Animal Physiology and Earth History. J. Oceanogr.

"However, generally speaking, animals with low metabolic rates have low capacities to buffer and transport acid-base equivalents and will therefore be relatively sensitive to hypercapnia". Seibel and Fabry, 2003. Marine biotic response to elevated carbon dioxide. Advances in Applied Biodiversity Science, 4.

Older reviews that cover the bulk of the data for these OA-specific reviews. Cameron, J.N. 1989. The Respiratory Physiology of Animals. New York: Oxford University Press. Heisler, N. 1989. Interactions between gas exchange, metabolism, and ion transport in animals: An overview. Canadian Journal of Zoology 67: 2923– 2935. Truchot, J.P. 1987. Comparative Aspects of Extracellular Acid-Base Balance. Berlin: Springer-Verlag. Walsh, P.J. & Milligan, C.L. 1989. Coordination of metabolism and intracellular acid-base status: Ionic regulation and metabolic consequences. Canadian Journal of Zoology 67: 2994–3004. Pörtner, H. O. (1989). The importance of metabolism in acid–base regulation and acid–base methodology. Can. J. Zool. 67(12): 3005–3017

Apparently conflicting hypothesis Among invertebrates, this type of CO_2 sensitivity may be highest in highly complex, high performance organisms like squid (IPCC report on carbon sequestration, 2005, Pörtner contributing author; based on Pörtner et al., 2004).

Interactive comment on Biogeosciences Discuss., 6, 4693, 2009.