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Biogeosciences Discussions



# *Interactive comment on* "Kinetic bottlenecks to chemical exchange rates for deep-sea animals II: Carbon dioxide" *by* A. F. Hofmann et al.

**Anonymous Referee #1**

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Hoffmann et al. present an elegant theoretical paper concerning the ability of marine organisms to rid themselves of excess CO_2. Specifically they look at the problem as a diffusive boundary layer problem, in which the rate limiting step occurs in that d.b.l. They show that since CO_2 is subject to chemistry in the d.b.l. (unlike O_2) that the transfer of CO_2 is significantly enhanced. They also contrast their CO_2 results with results of O_2 transfer (presented in a companion paper) and show that O_2 dominates the (potential) negative impacts to orgamisms given current and predicted oceanic conditions. However if pCO_2 throughout the ocean is tripled the negative impact of CO_2 (through d.b.l. flux) may become important in some locations. _____
General comments

This paper is for the most part well-written and clear. Section 3 is less pleasant to read

than the rest of the document, but it is still clear.

There are numerous references in the text to the O_2 companion paper. For the reader interested in the details of the derivations, I strongly suggest that the reader be directed more exactly to the material of interest - e.g. "Equation X, Hofmann et al. 2012 companion paper" or "Section X, Hofmann et al...".

A Table that simply lists each symbol used and its meaning and units would be exceptionally useful for the reader. Not only are these symbols used in the equations, but they also appear frequently in the text. Quickly glancing at a table is much less cumbersome than finding the text in which the symbol was first defined.

Regarding choice of figures and presentation, since E^{CO_2}_{max} and RP_{CO_2} plots tell similar stories (at least to this reader, they are linearly related..). I would suggest focussing on only one of those parameters - E... if it were me, since that one includes the b.l. thickness, which is a critical feature, in the main text and relegate a suite of plots of the other param (say R) to an appendix. Section 3 may be less cumbersome and more focused. Figure 1 is an excellent figure and gives the reader a quick sense of what matters in these equations.

_____ Specific comments (scientific questions issues)

There are two places in which the text could benefit from a little more explanation in the technical development of the theory, at least for this reader. In general I think that the paper could be made accessible to a wider variety of readers by adding this detail. (That said, most of Section 2 is clear and well explained.)

(1) First, preceding equation 5, the equation makes perfect sense if E_tissue » E_dbl, however E-tissue is not discussed (at least in this paper) and this point (I think) is quite important to the article. Why are the rates in tissue so much greater? A non-biologist simply does not have a sense of these aspects even if they are perfectly obvious to a biologist.



BGD

9, C7404–C7407, 2013





(2) The concept of "enhancement factor" is also central to this paper. The paper would benefit from a brief justification of its use (in addition to the supplied references). Specifically the kinetics of these reactions.. convince me that the residence time of CO2 in the d.b.l. is long enough for it to reach eqm with biocarbonate. And a small point - isn't "Quinn and Otto, 1971" the original ref?

n section 2.1.3 (p10 para 1) the authors point out that a planar EF description is appropriate in this study (makes perfect sense), and state that the boundary layer property is 'meant for large scale oceanic comparison only and appropriate values... can be substituted". It is unclear to this reader what other systems the authors might be referring too and what the critical aspects may be. A little more text to flesh this aspect out after curiousity is peaked would be welcome. Also, suggest point to the section in which sensitivity to fluid flow is explored.

Bulk flow velocities are an important feature in determining the b.l. thickness. I assume that this flow velocity is the 'relative velocity', i.e. if a fish is swimming the velocity of the flow that it is experiencing. Some discussion of the range of u_{100} chosen would be most useful. For example, what are typical currents over the SC shelf? (or a range of these currents.. ) and what organisms are the authors focusing on? Benthic dwellers will experience much smaller currents in the bottom b.l. (of the flow) than pelagics, or at least I assume so. Since vertical profiles of the derived parameters are shown and discussed I assume that pelagics are of interest here, but is there a limit in size or capability? At what speeds (u_{100}) do the diffusive flux b.l. equations break down?

In Section 3.1 - Fig 1 E.H. goes to 1. Do the equations reduce to the exactly to the simple diffusive flux equation (with no enhancement) when E.H. approaches one? In other words are there any approximations made in order to solve the more involved case in which the residence time of CO_2 is a similar order to the diffusive flux time? If there are no caveats then the authors simply need to reassure this reviewer. If there are - then some mention needs to be made, when 'assumptions' for equations are being violated etc.



BGD

9, C7404–C7407, 2013

_____ Technical correctons

Abstract line 15 - sentence starting "For organisms..." is too long making it difficult to follow.

Abstract - in general - the last half, which pertains to the detail in this paper is not as well written and would benefit from some focused editing.

Introduction - pg 4,line 15 - reference to Shaffer. Shaffer et al. aren't the only modellers to publish oxygen results. The authors list a host of carbon dioxide related papers at the end of the same paragraph - suggest that they expand their literature a little on the oxygen side as well.

Section 2.1.3, line 5 "this results" "this" what? approximation?

Section 2.6, line 9 "Bulk fluid free stream" isn't this desriptor redundant? I thought that 'bulk ocean' was 'free stream' here. line 10 - does it matter to the reader that the chemical solutions were obtained using 'R'?

Section 3 - I like the sensitivity discussion, especially made relevant to oceangraphic locations. However the description of many of the Figures reads like a data report in this section. "Figure X shows..." It almost looks like some paragraphs are written by one author and some by another. The whole section would benefit from a revision that focused on the story that is being told. Section 3.2 - begins with "Figure 2... It can be clearly seen.. that E.H. dominates". The dominance of EH wasn't clear to this reader from this figure. ? - same paragraph line 5 - there is a 'then' that should be 'than'

Figure 1 (and others) - y-axis labels "\ m" makes it look like the units are "^-1" - suggest "\" removed

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Interactive comment on Biogeosciences Discuss., 9, 15787, 2012.