Biogeosciences Discuss., 7, C5174–C5178, 2011
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Biogeosciences Discussions

Interactive comment on "CO_2-driven compromises to marine life along the Chilean coast" *by* E. Mayol et al.

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Received and published: 2 March 2011

Reply to Reviewer #2

We appreciate the comments from referee #2 and we will try our best to address the issues raised. Below is a reply to each of the main criticisms of reviewer #2.

Reviewer #2: 1) "This is a potentially interesting topic and the set-up presented here is acceptable. However, there are few new results (if any?) form those works published by Torres for the coastal upwelling area off Chile or from other colleagues for other eastern boundary systems. Equatorial subsurface waters support elevated pCO2, and obviously this implies a reduction in pH. These conclusions should not come as a surprise as they have been repeatedly shown for coastal upwelling areas worldwide

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(Torres et al. 1999 and specially Torres et al. 2002, Lefevre et al. 2008). Which is already new?, maybe the estimation of some values of saturation of aragonite by using the same standard measurements. In consequence, much of the presented results seem to be trivial, textbook information for an eastern boundary system with oxygen minimum zone and pCO2 saturated waters. I feel that there is vagueness in the treatment of this matter through all the manuscript and the paper contains little that offers new insight into how pCO2 levels may impact marine life along the Chilean coast. However, the title of the manuscript makes mention to "compromises to marine life"."

Reply: The title of the manuscript includes the statement "compromises to marine life". While we acknowledge the fact that there is a wealth of physico-chemical data from the Humboldt Current System, our intention goes beyond presenting such data to the community. We are very much aware of the work by R. Torres, who is a co-worker of ours and participated in the Humboldt 2009 cruise. However, most of the work to-date along the Chilean coast, including that of R. Torres, focuses on on-shore – offshore transects and/or surface pCO2, and has not explored the along-shore patterns we describe here.

Moreover, the main point of this manuscript is to examine the co-variation between CO2 and pCO2 to explore how ocean acidification and hypoxia trends are not independent threats but are connected to one another trough the effect of CO2 on both respiratory activity and calcification rates. Indeed, we extend the thermodynamic model of Brewer and Peltzer on joint effects of pCO2 and O2 on respiration to also address the effects of pCO2 pH and calcification. With the definition of the RI index (respiration index) and saturation states of aragonite, we have attempted to delineate water masses in the Humboldt Current System where respiration and calcification may be compromised. Moreover, in this study we partition the challenges to respiration into those derived from reduced oxygen values, which have been studied in the past in this system, and those derived from the high pCO2 levels, which have never been addressed in the past for this system. We show that high pCO2 contributes to exacerbate the challenges to

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respiration in this region. We believe this is the first study that addresses these key aspects to understand ecological patterns in upwelling areas.

In a revised version of the manuscript we will revise the introduction to highlight the innovative and original aspects of this study and discuss previous studies on CO2 along the Chilean coast by Torres and others.

Reviewer #2: 2) “First, when I read the title "CO2-driven compromises to marine life along the Chilean coast", I was excited with the idea of seeing information about how such high levels of pCO2 could impact the life along the coast of Chile. However, to begin reading the manuscript I was disappointed to see that information comes from one 15-station transect, located more than 200 miles offshore (see Figure 1). Accordingly, the first point is to change the title of this work to something like... "pCO2 and pH along the Humboldt Current System during summer", because authors hardly might talk about how such levels of pCO2 can impact marine life along the coast of Chile (maybe for coccolithophors it’s OK).”

Reply: We agree that the title may be missleading, and will modify the title as suggested by the reviewer to better delineate the study area as the “Humboldt Current System during summer”.

Reviewer #2: 3) “The second is that this work is based on information taken during one single cruise of 11 days in the oceanic area off the coast of Chile, so the issue of seasonality is not considered. Coastal upwelling in some parts of the coast of Chile is seasonal (between 30 to 40_S), therefore the “big picture” pCO2, pH, and saturation of aragonite may change, and authors show just a ‘snapshot’ of this history.”

Reply: We agree that this is a snapshot that cannot capture seasonality. However, it is almost impossible to capture seasonal dynamics of these water column properties, not amenable to remote sensing, along the large latitudinal gradient we encompassed. Attempts to resolve seasonal dynamics in this region are limited to short normal-to-shore transects, which cannot capture the long-shore patterns along the broad latitudinal

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patters included here.

In the revised version we will acknowledge the seasonal dynamics of these properties, not captured in this study, and will discuss the possible influence of seasonal dynamics on the large-scale patterns reported here.

Reviewer #2: 4) “For some inner shore areas off Central Chile there is probably other forcing that may intermittently cause suboptimal conditions for marine life, and probably much more important than coastal upwelling, for example, fresh water discharges. They are low in pH relative to the sea, and in case of rivers with high eutrophication levels (e.g. Maipo, Maule, Bío-Bío, Itata, Valdivia), it can be expected a high pCO2 where acidic river water may mixing into the surface ocean and affect coastal chemistry on broad regional scales to an extent that could compromises to marine life more than expected 200 miles offshore.”

Reply: Riverine discharge may, indeed, affect carbonate chemistry and pCO2 in coastal waters. However, as the reviewer also noted, the study reported here was really conducted offshore, where riverine influences are unlikely.

Reviewer #2: 5) “At Page 8902, Line 26 “The additional stress to biota in the hypoxic water mass of the Humboldt Current System arising from the high pCO2 levels has not been discussed earlier” and again, at, Page 8905, Line 9-10 “. . .may compress the habitat suitable for important commercial species, driving changes in the ecosystem in a high-CO2 future. However, no mention about which kind of important commercial biota they are speaking about at 200 nautical miles from the coast. . .!!!!! fishes?, I can imagine that the authors are restricting their discussion to calcifying organisms, such as cocolitophorids?, but they are not commercial biota, at least for the moment. In addition, the broad discussion about oxygen limitation for marine life is trivial, and again, just textbook information for an eastern boundary system.”

Reply: The constraints reported here do not refer to calcifying organisms alone, but to all aerobic metazoans. Indeed, the waters studied do support important fisheries,

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including squid and other resources. We delineate both thresholds for calcification and respiration in the water column. Moreover, in this study we partition the challenges to respiration into those derived from reduced oxygen values, which have been studied in the past in this system, and those derived from the high pCO2 levels, which have never been addressed in the past for this system. We show that high pCO2 has an important contribution to exacerbate the challenges to respiration in this region. The trends towards increased pCO2 and reduced O2 concentrations in the future may compress the water column available for aerobic organisms and expand the minimum oxygen zone until zones where fisheries species, such as the Humboldt squid and fish species, are located. In the literature are described mechanisms of long and short-term sensitivity to CO2 in fish and there is much information about the risks of elevated CO2 levels in different organisms, included fish, and how in combination with others factors may exert synergistic effects on marine fauna (Pörtner and Langenbuch, 2005).

In the revised version we will discuss the living resources inhabiting the area sampled that may be constrained by the challenges we describe.

Reference:

Pörtner, H.O. and Langenbuch, M. (2005) Synergistic effects of temperature extremes, hypoxia, and increases in CO2 on marine animals: From Earth history to global change. Journal of geophysical research 110: C09S10.

Interactive comment on Biogeosciences Discuss., 7, 8895, 2010.