

bg-2016-230

The metabolic response of thecosome pteropods from the North Atlantic and North Pacific Oceans to high CO₂ and low O₂

A. E. Maas, G. L. Lawson, and Z. A. Wang

We would like to thank the referee for their helpful feedback on this, and a previous version, of this manuscript. We have responded to each suggestion on a point by point basis with referee comments in plain text and author response in bold.

Comments:

Abstract: The first sentence is a bit confusing. It reads like the burning of fossil fuels directly cause a decrease in O₂.

The sentence has been modified to:

“As anthropogenic activities directly and indirectly increase carbon dioxide (CO₂) and decrease oxygen (O₂) concentrations in the ocean system, it becomes important to understand how different populations of marine animals will respond.”

L72: This sentence is misleading and tends to indicate that with OA all oceans will be undersaturated.

The sentence has been modified to:

“In some regions, as ocean acidification continues, the water becomes undersaturated and corrosive, meaning that, in the absence of compensating biological action, conditions will favor the dissolution of the CaCO₃ found in the shells and skeletons of ...”

L79: Probably the change in saturation state is not the only driver (DIC/proton ratios, pH itself, ..). I would replace this by “modifications of the carbonate chemistry”.

Good point – the sentence has been modified to:

“Perturbations of seawater carbonate chemistry can also affect the ability of some calcifying animals...”

L101: It would be good to compare this value with what is found in the other oceans.

The sentence has been modified to provide context for the value as:

“On top of this natural process, ocean acidification also plays a role: the pH of the upper water column in the North Pacific is decreasing by about 0.002 pH units per year (Byrne et al. 2010; Chu et al. 2016), similar to the global average of 0.0022 pH units per year (Williams et al. 2015). Such a change corresponds to a total CO₂, or dissolved inorganic carbon (DIC), increase of 1–2 μmol kg⁻¹ yr⁻¹ (Peng et al. 2003; Sabine et al. 2008; Sabine and Tanhua 2010; Chu et al. 2016).”

L146-148: You mention it in the discussion, but it could be interesting to indicate here that they are potentially different species.

Text has been added as:

“The taxonomy of thecosomes has recently begun to be revisited using molecular and paleontological tools (i.e. Hunt et al. 2010; Jennings et al. 2010; Janssen 2012; Maas et al. 2013) and there is growing evidence of cryptic speciation for some pteropod groups (Gasca and Janssen 2014; Burrige et al. 2015). It thus should be noted that these inter-basin comparisons may be of cryptic congeners rather than conspecific populations. Using these organisms, which are presumably adapted to their local conditions, we can test whether species or congeners exhibit a population-specific physiological response to these environmental conditions indicative of different sensitivities.”

L-226: Add “Surface” before “carbonate chemistry”.

The change has been made.

L340: The effect is probably minor, but pteropod calcification and excretion can change the TA.

Very true. The sentence has been modified to reflect the uncertainty that is contributed by these processes, but with the assumption that on the timescale of the experiments the influence would be minor:

“TA of experimental water was assumed to have been constant over the course of each experiment as water was filtered (0.2 µm) and antibiotic treated (thus microbial activities were kept at minimum). Although pteropod aerobic respiration, excretion and calcification within a respiration chamber could influence TA, it is presumed to have not had a significant influence over the time scales in question.”

L350: Could the difference in TA be due to the bubbling that caused evaporation?

The bubbling was the same among the different batches of water, and thus it seems likely that the error in TA due to evaporation would have been consistent throughout.

L456: Increased not decreased?

Increased. Thanks for the catch!

The results section contains a large part of methods and discussion. It reads well but I wonder if for clarity the methods and discussion statements should be moved to the corresponding sections.

In previous versions of the manuscript reviewers found presentation of some of the results confusing. The methods were thus partially repeated in the results section to make sure that the reader understands how the data were collected as it is presented. This was in particular with regards to the carbonate chemistry uncertainty and error. Based on earlier drafts we feel that it is best to retain this material in the same place (results).

We have gone through the rest of the results, however, and removed other text that is more discussion based as per the reviewer’s recommendations. Specifically, the text that mentions cryptic species has been moved to the introduction and some comments about the distribution of the species to the discussion.

Burrige AK, Goetze E, Raes N, Huisman J, Peijnenburg KT (2015) Global biogeography and evolution of *Cuvierina* pteropods. BMC evolutionary biology 15 doi 10.1186/s12862-015-0310-8

Byrne RH, Mecking S, Feely RA, Liu X (2010) Direct observations of basin-wide acidification of the North Pacific Ocean. Geophys Res Lett 37: L02601

Chu SN, Wang ZA, Doney SC, Lawson GL, Hoering KA (2016) Changes in anthropogenic carbon storage in the Northeast Pacific in the last decade. Journal of Geophysical Research: Oceans 121 doi 10.1002/2016JC011775

Gasca R, Janssen AW (2014) Taxonomic review, molecular data and key to the species of Creseidae from the Atlantic Ocean. Journal of Molluscan Studies 80: 35-42

Hunt B, Strugnell J, Bednarsek N, Linse K, Nelson RJ, Pakhomov E, Seibel B, Steinke D, Würzberg L (2010) Poles Apart: The “Bipolar” Pteropod Species *Limacina helicina* Is Genetically Distinct Between the Arctic and Antarctic Oceans. PLoS ONE 5: e9835

Janssen AW (2012) Late Quaternary to Recent holoplanktonic Mollusca (Gastropoda) from bottom samples of the eastern Mediterranean Sea: systematics, morphology. Bollettino Malacologico 48: 1-105

- Jennings RM, Bucklin A, Ossenbrügger H, Hopcroft RR (2010) Species diversity of planktonic gastropods (Pteropoda and Heteropoda) from six ocean regions based on DNA barcode analysis. *Deep Sea Research Part II: Topical Studies in Oceanography* 57: 2199-2210
- Maas AE, Blanco-Bercial L, Lawson GL (2013) Reexamination of the species assignment of Diacavolinia pteropods using DNA barcoding. *PLoS ONE* 8: e53889 doi:10.1371/journal.pone.0053889
- Peng T-H, Wanninkhof R, Feely RA (2003) Increase of anthropogenic CO₂ in the Pacific Ocean over the last two decades. *Deep Sea Research Part II: Topical Studies in Oceanography* 50: 3065-3082
- Sabine CL, Feely RA, Millero FJ, Dickson AG, Langdon C, Mecking S, Greeley D (2008) Decadal changes in Pacific carbon. *J Geophys Res Oceans* 113: -
- Sabine CL, Tanhua T (2010) Estimation of anthropogenic CO₂ inventories in the ocean. *Annu Rev Mar Sci* 2: 175-198
- Williams NL, Feely RA, Sabine CL, Dickson AG, Swift JH, Talley LD, Russell JL (2015) Quantifying anthropogenic carbon inventory changes in the Pacific sector of the Southern Ocean. *Marine Chemistry* 174: 147-160