

Marginal reefs under stress: physiological limits render Galápagos corals susceptible to ocean acidification and thermal stress

Diane Thompson¹, Malcolm McCulloch², Julia E. Cole³, Emma V. Reed¹, Juan P. D'Olivo⁴, Kelsey Dyez³, Marcus Lofverstrom¹, Janice Lough^{5,6}, Neal Cantin⁵, Alexander W. Tudhope⁷, Anson H. Cheung⁸, Lael Vetter¹, R. Lawrence Edwards⁹

¹ University of Arizona, Department of Geosciences, Tucson, 85721, USA

² University of Western Australia, ARC Centre of Excellence for Coral Reefs Studies, Oceans Graduate School and Oceans Institute, Crawley, 6009, Australia

³ University of Michigan, Earth and Environmental Sciences, Ann Arbor, 48109, USA

⁴ Freie Universität Berlin, Berlin, 12249, Germany

⁵ Australian Institute of Marine Science, PMB 3, Townsville MC, Queensland 4810, Australia

⁶ ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Queensland 4811, Australia

⁷ University of Edinburgh, School of Geosciences, Edinburgh EH9 3JW, UK

⁸ Department of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI 02912

⁹ Department of Earth Sciences, University of Minnesota, Minneapolis, MN

Files Uploaded Separately

Original Version of Manuscript (2021AV000509)

First Revision of Manuscript [Accepted] (2021AV000509R)

Author Response to Peer Review Comments

Peer Review Comments on 2021AV000509

Reviewer #1

Review for AGU Advances

Thompson et al: Marginal reefs under stress: physiological limits render Galápagos corals susceptible to ocean acidification and thermal stress

The authors present boron isotope and trace metal geochemistry modern and fossil corals from the Galapagos that have experienced of extreme thermal stress and

accelerated rates of acidification. The motivation for the paper is sound; it clearly of great importance to understand the biocalcification of corals, especially those already living "on the edge". I find the paper well written and easy to follow. I would recommend the manuscript for publication with minor revision.

Minor points

Line 28: Aragonite supersaturation should be ($\Omega > 1$) rather than just Ω

Line 55: Just low coral diversity or all reef taxa?

Line 56: this "accelerated rate of OA" puzzling when, yes, figure 2b suggested Ω is low in the Galapagos, yet figure 2c suggests that the all-important change in Ω since the 1700s has been small in this region.

Line 61: Suggest: "A critical question remains however:..."

Line 107: overuse of the work leverage

Line 126: specify here "coral cores"

Line 128: Removed "m =". It has been established that these are gradients, the "m" is therefore redundant

Line 211: If inclusion/exclusion of this outlier makes no difference why flag it up at all?

Line 212: Citation needed for Suess effect

Line 213: data are needed

Line 260: This pH_{cf} drop due to El nino is very interesting!!

Line 264: Unclear how a regional increase in pH_{sw} would cause a decrease in pH_{cf}.

Line 439: Samples were taken at 2mm intervals down core, but how much material was integrated laterally? Porites have small polyps so I'm guessing a specific sub-structure could not be targeted throughout.

Line 444: Something wrong with the wording here

Line 456: deionised is clearer than DI.

Line 459: Errors assumed to be {plus minus} 50%? This seems rather large and doesn't match with {plus minus} 5yrs CE quoted

Line 487: How did the average measurements of JCp-1 compare to the Harthorne et al 2013 G3 interlab values? Are there any systematic lab offsets to consider? It is also interesting that no oxidative cleaning was applied to coral powders. This is known to be important for Li/Mg (Cuny-Guirriec et al., 2019) and $\delta^{11}\text{B}$ measurements (Gutjahr et al., 2021) to remove organics.

Line 492: equations should be written in full rather than $m =$ and $b =$

Line 509: What was the average lab $\delta^{11}\text{B}$ value for JCp. How does it compare to uncleaned JCp-1 compilation data by Gutjahr et al., 2021 GGR?

Line 542: Define SODA

Line 565: bracket position. Should read "...formulation of McCulloch et al., (2017)". Check for other citations where the reference is part of the sentence like this rather than just added on the end.

Line 588: TE is unnecessary shorthand. Just say trace element chemistry

Box 1:

I see why the authors have chosen this "Box" approach that keeps words out of the main text word count, but I'm not sure that this is the best approach or if this complies with

the journal guidelines. A Figure within Box is confusing; either call it a box or a figure, not both. I suggest that this is revised, making the figure more schematic and with short bullet point labels rather than large blocks of text.

Unclear what is the difference or the need for separate 1,2,3... a, b,c... and a*, b*, c*... lists. Why can't these points be merged and made more concise?

Calcifying fluid "exaggerated". Does this mean the schematic changes in chemistry are exaggerated, or the size of the layer? If it is the size the extra label is unnecessary as you already state it is not to scale.

Figure 2. Labels of Wolf (This Study) and GBR McCulloch could be added to the figure panels to make this visually clear.

Figure 3: GBR data should be less prominent (slightly greyed out or smaller points) to make the new data in this study clearer.

Editor Comments

1. I found this manuscript confusing and the results seem to confirm what is already known about coral responses. The structure of the manuscript is part of what contributes to this confusion. The combined Results and Discussion section for each topic makes it difficult to extract the advances made by the study and to see linkages between the different topics covered in the manuscript. The new results/advances are lost in the details. A recommendation is that the results and discussion be separated into individual sections with subheadings. Perhaps it is possible to develop a summary schematic that shows how the different factors/stressors interact and structure the discussion section around such a figure. Also, a summary section that places the results into context would be helpful in showing what is new.

2. For AGU Advances, the Data and Methods section is included in the main manuscript text, rather than at the end, as is done for some other journals. Some of the Data and Methods section can be included as supplementary materials, if appropriate. Please look at recent AGU Advances articles for examples.

3. Box 1/Figure 1: I understand that the authors are trying to provide considerable technical information in a succinct manner. However, Box 1/Figure 1 is not useful. The text and figure are too condensed and as a result are confusing and distracting. For example, does every reaction for multiple cations and anions need to be shown along with detailed explanations? My knowledge of coral responses to stressors would not be increased by Box 1/Figure 1. In fact, the opposite would happen. This Box/Figure should be removed from the main text and replaced with a simpler schematic/conceptual diagram that can be understood without assuming detailed knowledge of the subject and will engage the reader. If the current Box 1/Figure 1 is retained, it should be moved to supplementary materials.

4. Line 72, define pHcf at first use in manuscript