

Interactive comment on “Natural ocean acidification at Papagayo upwelling system (North Pacific Costa Rica): implications for reef development” by Celeste Sánchez-Noguera et al.

Anonymous Referee #1

Received and published: 1 December 2017

General comments: This manuscript describes the intra-annual variability in carbonate chemistry in a naturally acidified environment in Pacific Costa Rica. As the authors point out, such natural laboratories are very important to improving our understanding of coral-reef development under future climate change. The manuscript is generally clear and well-written and the implications of their findings to the future of coral growth and reef accretion are significant. It is, therefore, my suggestion that the manuscript be accepted to Biogeosciences after some, generally minor, revisions, as described below:

First, I think it's important that the authors make it clear at the beginning of the

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manuscript (Abstract and Methods) that they did not measure coral growth in this study that they used previously published data to evaluate the relationships between carbonate chemistry and coral growth, because this was not obvious to me until the Discussion. I would also say what studies you derived the ecological data from in the Methods and include a brief description of the methodologies those researchers used so that readers can evaluate those data.

The authors should also consider adding some additional text in the Methods/Discussion regarding the collection and interpretation of the carbonate-chemistry data. I've listed a number of specific comments below, but my most significant concern is with the statement that DIC is temperature-independent. Temperature impacts the solubility of CO₂ and directly impacts DIC. Additionally, since the DIC data are derived from pCO₂ measurements, which are dependent on T, this does not get rid of the temperature effect on pCO₂. I would like to see the author address this issue more thoroughly.

Specific comments:

P2, L25: But see Toth et al. 2012. Accretion rates in Panama when reefs were growing were comparable to rates observed on reefs in the Caribbean and the authors did not find a significant difference in reef accretion between upwelling and non-upwelling sites. I would suggest making the language here more conservative.

P3, L23: Please provide information on the pH scale used as suggested by the OA best practices: <http://oceanrep.geomar.de/8471/1/Guide%20best%20practices%202011.pdf>

P3, L28: How can you be sure that the carbonate chemistry at 30 cm was the same as where the instrument was (1.5 m)?

P4, L8: Did Rixen et al. 2012 use the same methodology for measuring carbonate chemistry? I think it's important to include this information so that readers can fully

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evaluate the results.

P4, L11-12: I would suggest including the statement "All GLM assumptions were met" here instead of in the Results.

P4, L19: Please include a citation for the rain-ratio (Archer and Maier-Reimer 1994?) and describe what it is

P4, L23: What are the ROI values of -2.6 and 0.8 based on. Please explain in the text where these numbers came from.

P5, L16-17: Temperature variability also can impact DIC. Also since these data are derived from pCO₂ measurements, which are dependent on T, this does not get rid of the temperature effect. I would like to see the author address this issue more thoroughly.

P5, L22: include error term for the aragonite saturation state

P6, L5-7: It would be more informative to talk about how much DIC dropped during the "upwelling-like" event in 2012 than to talk about the overall average for the whole sampling period.

P6, L16: You can't really make conclusions about how regular these sorts of events are based on a few weeks of data from just two years. I would change the wording here to reflect this.

P6, L26: The wording of this sentence is confusing. I would rephrase to something like: Although the pCO₂ cycles in 2013 followed a similar pattern to 2012, pH was more variable (or less predictable). I would also move this sentence to the end of the previous paragraph and start the next paragraph with "To characterize..."

P7, L3: I don't understand what this sentence means. Which cycles? Could not be observed in the data? In the model? I actually think that this whole paragraph needs to be fleshed out more. It's not clear to me what the authors are trying to say.

P7, L10: add a reference to Fig. 5c&d at the end of the sentence ending with "respira-

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tion"

P7, L10: Clarify whether you are describing changes that just happened during the cold-water event or during the entire sampling period in 2012.

P7, L30-31: This sentence is misleading. I think that what you mean to say is that saturation state in each of those locations predicts extension rate. I'm assuming that you used the saturation states/linear extension determined by Manzello 2010 for Panama and Galapagos, but this is not clear in either the text or the figure.

P8, L11-12: I think it would be good to compare your observation of reef thickness with reef thickness elsewhere in Costa Rica or elsewhere in the ETP, as most reader won't be familiar with how thick a reef "should" be see:

Glynn, P. W., E. M. Druffel, and R. B. Dunbar. 1983. A dead Central American coral reef tract: Possible link with the Little Ice Age. *Journal of Marine Research* 41:605–637.

Cortés, J., I. G. Macintyre, and P. W. Glynn. 1994. Holocene growth history of an eastern Pacific fringing reef, Punta Islotes, Costa Rica. *Coral Reefs* 13:65-73.

Toth et al. 2012, *Science*

or summary in: Toth, L.T., I.G. Macintyre, and R.B. Aronson. 2017. Holocene reef development in the Tropical Eastern Pacific. In Glynn, P.W., D.P. Manzello, and I.C. Enochs (eds). *Coral Reefs of the Eastern Pacific: Persistence and Loss in a Dynamic Environment*. Springer-Verlag, New York. doi: 10.1007/978-94-017-7499-4_6

P8, L14: It's not correct to talk about "coral" accretion because accretion is a net measure of the growth of a reef. I would re-phrase the beginning of this sentence to something like: Gaps in coral-reef accretion. I would also specify that these gaps are known from the geological record of the ETP. They are not common elsewhere.

P8, L20: It's likely that OA will threaten places like Bahia Culebra sooner than elsewhere right? It might be interesting to include a brief discussion of when/how OA may

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impact reefs in the ETP vs elsewhere and what the implications of this would be.

P8, L31: I would make it clear here that previous studies have shown that reef accretion is low in Bahia Culebra.

Technical corrections:

P1,L18: change to: 2009 upwelling season or upwelling season in 2009

P1,L22: change to: also occurs sporadically in the non-upwelling season

P1, L25: change to: during the upwelling season fall

P1, L28: I would add a phrase like the continued growth of between threaten and reefs

P2, L5: Delete "ones"

P2, L6: Add comma after references

P2, L14: Delete extra "A"

P3, L25: add was before "used"

P4, L20: add hyphen between "rain" and "ratio"

P4, L21-22: change / to and to be consistent with the ends of the sentences

P4, L21: comma before "respectively"

P5, L9: change "did" to was

P5, L15: change "between" to among

P5, L30: delete "an"

P6, L2: change "those" to that

P6, L4: change "to" to with

P6, L6: change "fell below" to were lower than

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P6, L9: I would suggest starting a new paragraph here

P6, L9: delete "only" change to: had already increased by June 7th

P6, L13: Somewhere else than where? maybe just change to something like: "a different location than they are during the upwelling season"

P6, L16: change "whereas" to and. I would also suggest rewording "it affects the" to something like: these types of events have the potential to affect the...to be more conservative

P6, L17-18: I don't think the phrase at the end of this sentence is necessary

P6, L31: change "loss of" to decline in

P7, L12: I don't understand the phrase "is particular but not completely unusual". Do you mean peculiar?

P7, L13: I suggest changing the beginning of the sentence here to: Similarly, dark...

P8, L3: change the end of this sentence to read: corals' relatively high annual mean growth rates in Bahia Culebra.

P8, L4: I would change the beginning of this sentence to: implies that coral growth should be sensitive...

P8, L6: add the before "period"

P8, L18: I suggest saying should approach

P8, L24: I suggest changing "contributing with" to that provide and "carried out with" to from

P8, L28-30: reef-building corals needs a hyphen

P8, L30: change "due to which" to which may explain why

P8, L31: delete "s" at end of accretion

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