

Comment on bg-2021-90

Anonymous Referee #2

Referee comment on "The Bouraké semi-enclosed lagoon (New Caledonia) – a natural laboratory to study the lifelong adaptation of a coral reef ecosystem to extreme environmental conditions" by Federica Maggioni et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-90-RC2>, 2021

1. GENERAL COMMENTS (overall quality)

This research provides a detailed physical and biogeochemical characterization of a semi-enclosed coral reef lagoon in New Caledonia, remarkable for the presence of a diverse and healthy coral reef ecosystem. The authors carried out systematic sampling over a three years period, accomplishing the local characterization of diel and seasonal fluctuations. This work is definitively a valuable contribution to baseline knowledge of environmental conditions in natural laboratories, which can greatly contribute to shed light on the drivers of the biological responses of local organisms.

Nevertheless, I have to draw the attention of the authors in two issues. The first one was already addressed by Referee1 (RC1) and I fully agree with RC1 that this site can't be claimed as a natural analogue to future climate change conditions. However, since RC1 already provided a detailed argumentation on this regard, my comment about this will be very general. The second issue I must comment on, is the claim that local adaptation of these coral species could hold new hope for the future of coral reefs in general. I explain my position in detail in the "Specific comments" section.

2. SPECIFIC COMMENTS (individual scientific questions/issues)

- In general terms, the overall text could benefit from a better synthesis of ideas.

- Along all the manuscript, it's advice to use "extreme environmental conditions" instead of "climate change-like conditions".

- I fully agree that coral reefs growing on extreme environments are remarkable and perfect natural laboratories to study local adaptation. However, I disagree with the idea of using these ecosystems to predict the general response of coral reefs under future projected changes, as the rate of change is totally different (different time scales).

The fact that some coral species currently thrive in extreme environments (such as volcanic CO vents, semi-enclosed lagoons and mangrove estuaries) resulted from an extensive period of exposition to these particular conditions, therefore adaptation. This is not the case under future projections, where the exposition time will be considerably shorter and it is very likely that coral species growing on "more stable" environments (other than volcanic CO vents, semi-enclosed lagoons and mangrove estuaries) won't be able to adapt to this rate of change. And even if they do, probably it would be due to acclimation but not necessarily adaptation. All this said and taking into account a recent publication regarding persistence of coral reefs under future ocean acidification and warming conditions (Cornwall et al. 2021, PNAS), I disagree with the authors (lines 16-17) when they state that the sole presence of "diverse and high cover reefs that already thrive under extreme conditions" contradict the projections of coral reefs disappearing under the CO2 business-as-usual scenario.

Even if you bear to consider these special sites as future analogues to future conditions, you must keep in mind that these coral species with high diversity and coral cover are thriving because they were able to adapt to these local environmental conditions over a long time scale. Therefore, they won't be a good worldwide model to "explore how reefs could keep pace with climate change" (lines 19-20). The way as I see it, you are dealing with two different issues: in one hand you have the physical location *per se* (site), which could be a great natural scenario to explore how coral species would respond to future-like conditions, by transplanting coral species from other "stable" locations. And on the other hand, you can study the adaptation of the local coral species currently living on these natural laboratories. But you can't extrapolate the response of all coral reefs to future conditions by using these local "super corals" broad as models.

Based on their results, the authors can definitively draw a future projection for the Bouraké coral reefs. But they must be cautious and restrain themselves from extrapolating these conclusions to coral reefs in general (L818-819).

Additionally, precaution must be taken when drawing conclusions for these potential refuges (lines 98-99). It's true that these coral species can cope with a great environmental variability and thrive under extreme conditions. However, this not necessarily means that they will survive under future changes, as it's also possible that they are already living close to their environmental threshold and future conditions might push them beyond it (see Sánchez-Noguera et al. 2018, Biogeosciences). For example, this site already presents low-pH conditions as expected under climate change projections, but it's very likely that the pH values will continue decreasing in the future due to buffer capacity (TA) of its waters. Therefore, despite these corals thrive under current low-pH conditions, probably they will experience lower pH values (or "harsh conditions" as the authors state in L799-801) as CO2 uptake continues.

Material and methods

Glass electrodes (as the one from the Metrohm pHmeter and the SeaFET) are not very accurate and it's valuable that the authors carried out a calibration with TRIS buffer. Nevertheless, on top of the TRIS calibration, it's strongly advised that the authors validate their surface pH measurements with pH values calculated from TA and DIC samples.

Discussion

- L577-580: the last two sentences fit better in section 4.2, as section 4.1 focuses on physical and chemical characteristics of the lagoon but not the species responses.
- Line 583: suggest replacing "occasionally more than 25°C" by the range of temperature measured during winter.
- L597: temperature fluctuations are mentioned when discussing all environmental parameters (L596-L598). However, temperature was previously discussed from L582 to L594. In this second point the authors should focus the discussion on environmental parameters other than temperature and move up the sentence from L596-L598 to the first point of this subsection.
- Sentences from L607-L615 could benefit from a simplified explanation highlighting the main findings. The way as it's currently presented it seems that all the seawater (inflowing and outflowing) is acidic, warm and oxygen depleted.
- L642: clarify higher concentrations of what? (chemical species in general....?)

3. TECHNICAL CORRECTIONS (typing errors, etc.)

- Lines 281, 302, : replace "weakly" by "weekly"
- L589: delete extra "(" before Bellworthy
- Fig. 1: use a brighter color (red?) or enlarge the square marking the location in the embedded globe.
- Fig. 3: in caption
- Fig.5 d,e: include "inner/outer" label inside the panel (instead or in addition to St S/St R)
- Fig. 7: include "winter/summer" in plot