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Interactive comment on "Sex-associated variations in coral skeletal oxygen and carbon isotopic composition of *Porites panamensis* in the southern Gulf of California" *by* R. A. Cabral-Tena et al.

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Response to Interactive comment on "Sex-associated variations in coral skeletal oxygen and carbon isotopic composition of Porites panamensis in the southern Gulf of California" by R. A. Cabral-Tena et al.

To Anonymous Referee #1

Thank you very much for your comments; we have taken into account all your suggestions. We carefully read the comments, suggestions and questions and we rewrote,

delete or added paragraphs to the manuscript as needed. Below we address the questions or suggestions.

Specific comments

We made the necessary changes and will be included in the manuscript as follows:

Page 18796, lines 2-3: delete 'near'; add (SST) after 'temperature'.

Coral δ18O variations are used as a proxy for changes in sea surface temperature (SST) and seawater isotope composition.

Page 18796, line 6: 'lesser extent' than what?

Coral growth rate is known to influence the δ18O and δ13C isotope record to a lesser extent than environmental variables.

Page 18796, lines 7-8: make it clear that these growth differences refer to the gonochoric brooding coral P. panamensis.

Recent published data show differences in growth parameters between female and male coral in the gonochoric brooding coral Porites panamensis

Page 18796, line 9: replace 'assess this difference' with 'test this'.

to test this, this study describes changes in the skeletal δ18O and δ13C

Page 18796, line 11: add country after 'La Paz'.

four female and six male Porites panamensis coral collected in Bahía de La Paz, Mexico, whose growth bands spanned 12 years.

Page 18796, line 12: photosynthetically active radiation (PAR).

The isotopic data were compared to SST, precipitation, photosynthetically active radiation (PAR)

Page 18796, line 18: change 'implies' to 'could introduce'.

A difference in the skeletal δ18O could introduce an error

Page 18796, lines 25-26: again make it clear that these findings relate to one gonochoric brooding species though they may have implications for commonly used gonochoric spawning species such as P. loabta and P. lutea.

Although these findings relate to one gonochoric brooding species, they may have some implications for the more commonly used gonochoric spawning species such as Porites lutea and Porites lobata.

Page 18797: lines 2-4: Make it clear that this does not refer to all corals, only certain species; also it is not only their growth that is affected by environmental conditions but that materials (isotopic and trace elements) are incorporated into the skeleton during growth.

Massive hermatypic coral are useful as recorders of oceanic conditions because their growth and skeletal materials incorporated during growth are affected by environmental variables, the calcareous material is deposited in annual density bands that allow for the determination of events over time

Page 18797, line 8: delete 'changes'

centennial timescale of El Niño–Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO),

Page 18797, line 9: change 'events' to 'variability and change'.

pre- and post-industrial climate variability and change

Page 18797, line 11: change 'from' to 'with'.

predictable way with environmental variations

Page 18797, line 19: change 'estimate' to 'measure'; I am not necessarily convinced that _13C has been as easy to interpret as _18O.

skeletal δ18O and δ13C are the most common measurements because they are relatively easy to measure

Page 18798, line 15: 'upwelling events that bring nutrients to surface waters'.

coral skeletal δ13C decrease during upwelling events that bring nutrients to surface waters

Page 18798, line 21: be consistent throughout ms, here 'vital effect', elsewhere 'Vital effect'; 'constant along the growth'.

We have checked all the ms and have changed all "Vital" to "vital. This departure from equilibrium is referred to as "the vital effect" and appears to be constant along the coral growth axis

Page 18799, line 20: replace 'recording was' with 'measurements were'.

Oxygen and carbon isotope measurements were used to

Page 18800, line 4: what year were the colonies collected? Also, what was the approximate size of the colonies? Are these the same 10 colonies from La Paz presented in Cabral-Tena et al (2013)? If so, then say so.

The specimens were collected in 2011 at depths of 3–4 m. Divers used hammer and chisel to remove the colonies from the substrate. A fragment from each colony was fixed in Davison's solution for a histological examination and identification of sex (Howard and Smith, 1983). These are the same ten colonies presented in the Cabral-Tena et al. (2013) study.

Page 18800, line 15: replace 'labelled' with 'identified as'.

The colonies were identified as female

Page 18800, line 17: replace 'labelled' with 'identified as'.

the colonies were identified as male

Page 18801, line 1: replace 'placed in' with 'located on'.

Optical density tracks were located on the maximum growth

Page 18801, line 20: delete 'equal'.

minimum δ18O value in a year to summer

Page 18801, lines 21-22: What is meant by 'different sampling resolutions' when they were all sampled at 1 mm resolution? Is it sampling resolution in relation to different linear extension rates of the samples?

To eliminate the effects of different sampling resolutions on the calculation of mean coral δ18O values due to differences in linear extension rates of each colony, the results were interpolated to create four equally spaced values per year

Page 18801, line23 to Page 18802, line 2: suggest move this description of statistical analyses to separate section of Materials and Methods.

A new section in Materials and Methods was written as follows: 2.5 Statistical analyses Normality and homoscedasticity of the data were tested using Kolmogorov–Smirnov and Bartlett tests, respectively. Student's t-test for independent samples with uneven variance was used to assess statistical differences in δ18O and δ13C between sexes. Pearson's correlation test and simple linear regressions were used to estimate relationships between mean skeletal extension rate, skeletal density, and calcification rate with isotope data of both sexes. An ANCOVA test was used to assess the differences between slopes and the y-intercept of linear equations of δ13C versus δ18O plots of the results of male and female data. Pearson's correlation test and simple linear regressions were used to estimate relationships between environmental data and isotope data of both sexes. Regime shift index for environmental and isotope data were calculated with the Sequential Regime Shift Detection Software (Rodionov, 2004).

Page 18802, line 2: 'linear'.

differences between slopes and the y-intercept of linear equations

Page 18802, lines 4-15: provide the temporal resolution of the various data sets (e.g. daily, weekly or monthly?) and the time periods they cover.

Monthly SST, PAR, and concentration of chlorophyll a data were obtained from the NOAA live access server (http://las.pfeg.noaa.gov/oceanWatch/oceanwatch.php), the environmental data spanned from 1997 to 2009

Page 18802, line 10: indicate the time period of this comparison and temporal resolution of the data.

Compared in situ and satellite data were both monthly covering from 2003 to 2007.

Page 18802, lines 15-18: delete first sentence and add the description of the Regime shift change software to the suggested new section on statistical analyses.

This was included in the new section of materials and methods.

Page 18802, lines 21-24: Please provide details of the years covered by each of the colony growth and isotopic records. Could provide this in a Supplementary Table, possibly with all the annual growth and isotopic data?

This will be included in the supplementary material.

Page 18802, Results: Please make it clear throughout the Results what the temporal resolution of the data being compared is e.g. annual, monthly, seasonal? Also whether time series or average colony values are being compared.

We detailed along all the results section that the time series is from 1997 to 2009, and the resolution of data is quarterly.

Page 18803, lines 6-7: Unclear what 'strongly correlated between sexes' means – what is being correlated here? Also, suggest using 'significantly' rather than 'strongly'.

significantly correlated between sexes ($r = 0.45$, $p > 0.000001$), thus both sexes showed the same seasonal pattern

Page 18803, line 15: Refer to Fig. 1b.

changing from 15.76 to 30.25 mm, with a RSI of 0.30 ($p = 0.01$), as seen in Figure 1b.

Page 18804, line 2: ‘correlate with’.

significantly correlate with

Page 18804, lines 4-5: Delete first sentence and add period covered to second sentence.

The linear regression (Fig. 3) equations for δ18O dependence on SST (1997-2009) were:

Page 18804, lines 10-11: ‘small seasonal variation’ – compared to what?

We deleted this sentence.

Page 18805, line 4: here and elsewhere change ‘strong’ to ‘significant’.

Changes from “strong” to “significant” were made in all cases.

Page 18805, line 6: delete ‘Table 4’.

annual skeletal density was found (Table 4; $r = -0.78$, $p = 0.001$).

Page 18805, lines 17-25: Please make it clear what the temporal resolution of these different studies is, and how they compare to this study. High correlation coefficients can always be obtained when simply correlating two annual cycles (see Lough 2004. Palaeo Palaeo Palaeo 204: 115-143).

The requested information was included; the paragraph will read as follows: Our isotope data showed a significant dependency of skeletal δ18O on SST , with a low r (–0.45 in female coral, and –0.28 in male coral), and a gentle slope of the δ18O–SST calibration equations (0.09‰ °C–1 F; 0.11‰ °C–1 M; Fig. 3), compared with slopes

(>0.20‰ °C–1) in Porites spp. in other areas of the Pacific: the Great Barrier Reef (Gagan et al., 1994), Costa Rica (Carriquiry, 1994), Panama (Wellington and Dunbar, 1995), and the Galapagos Archipelago (McConnaughey, 1989). These studies show high correlation coefficients (better than –0.80) of δ18O and SST, all these studies have isotopic records varying to 5 to 40 years long, and with a high temporal resolution sampling (weekly to monthly). Our results are similar to studies reporting small correlation coefficients of δ18O and SST (less than –0.70) and a gentle slope (<0.17‰ °C–1) of the δ18O–SST calibration equations, such as at Clipperton Atoll (Linsley et al., 1999), Fiji (Le Bec et al., 2000), and Guam (Asami et al., 2004), these studies have long isotopic records (20 to 25 years) and a high temporal resolution sampling (daily to monthly) compared to our data (12 years of data with a quarterly sampling resolution).

Page 18806, line 19: ‘depleted in nutrients’.

becomes depleted in nutrients.

Page 18808, line 14: ‘fast extension rates’ – fast compared to what? Compare to other reported average Porites spp. linear extension rates?

The average yearly extension rates of all sampled coral can be considered as fast (1.05 cm yr–1 F, and 1.27 cm yr–1 M) in accordance with the work of McConnaughey (1989).

Page 18808, line 16: ‘are more enriched than in male’.

All δ18O ratios of female colonies are more enriched in 18O than in male colonies

Page 18809: line 6: ‘associated with colony’.

“vital effect” associated with colony sex,

Page 18811, line 8: delete ‘would’.

exemplify what a difference in δ18O

Page 18812, lines 6-9: Suggest emphasise that this study based on a gonochoric brooder and that the majority of paleoclimatic reconstructions from massive Indo- Pacific Porites spp. have been based on gonochoric spawners. Thus a fruitful area of future research would be to determine whether the sex differences the authors have identified are also characteristic of gonochoric spawners such as P. lobata and P. lutea.

Changes to the last paragraph of the discussion were made considering your suggestions and will read as follows: This study provides evidence of sex-associated variations in coral skeletal δ18O and δ13O of P. panamensis. This has some implications and has to be considered when climate conditions are estimated based on comparisons of δ18O and δ13O values of gonochoric brooder coral genera, if sex identification is not taken into account when possible. The findings of this study are based on a gonochoric brooder species (P. panamensis), the majority of paleoclimatic reconstructions in the Indo-Pacific and Caribbean have been based on massive gonochoric spawners (such as Montastrea cavernosa, Porites lutea and Porites lobata), so, it remains unclear if the same phenomena (sex-associated variations in coral skeletal δ18O and δ13O) can be observed in gonochoric spawners, this may have some serious implications in the paleoclimatic reconstructions studies made so far leading to erroneous conclusions due to errors in isotopic estimation, variability of isotopic data may have been overestimated due to the mixing of male and female isotopic data in past studies. Thus, a fruitful area of future research would be to determine whether the sex differences identified in this study are also characteristic of gonochoric spawners.

Page 18820, Table 1: Indicate years covered by each series.

Table 1. Summary of the overall average extension rate, skeletal density, calcification rate, δ18O and δ13C of Porites panamensis colonies from Bahía de La Paz, Gulf of California. Time period of data is from 1997 to 2009.

Page 18821, Table 2: Indicate temporal resolution of data and also time period covered by correlations.

Table 2. Correlation coefficients between skeletal δ18O of Porites panamensis colonies

and: Sea surface temperature, precipitation, photosynthetically active radiation and chlorophyll a from Bahía de La Paz. Time period covered by correlations is from 1997 to 2009. Temporal resolution of data is quarterly. Bold numbers indicate significant ($p < 0.05$) correlations.

Page 18822, Table 3: Indicate temporal resolution of data and also time period covered by correlations.

Table 3. Correlation coefficients between skeletal δ13C of Porites panamensis colonies and Sea surface temperature, precipitation, photosynthetically active radiation and chlorophyll a from Bahía de La Paz. Time period covered by correlations is from 1997 to 2009. Temporal resolution of data is quarterly. Bold numbers indicate significant ($p < 0.05$) correlations.

Page 18823, Table 2: Indicate temporal resolution of data and also time period covered by correlations.

Table 4. Correlation coefficients between skeletal extension rate, skeletal density and calcification rate, and skeletal δ18O and δ13C of Porites panamensis colonies from Bahía de La Paz. Time period covered by correlations is from 1997 to 2009. Temporal resolution of data is yearly. Bold numbers indicate significant ($p < 0.05$) correlations.

Page 18824, Figure 1: Explain the shift in the rainfall mean in the figure caption.

Fig. 1. (a) Seasonal variation in δ18O composition (VPDB) from Porites panamensis coral colonies along the major growth axis. Blue lines represent male colonies; Red lines represent female colonies; red dotted line female colonies' regime mean; blue dotted line, male colonies' regime mean. (b) Satellite sea surface temperature and precipitation (1997–2009) records. Sea surface temperature (red line; °C), mean sea surface temperature (dotted red line; °C), precipitation (blue line; mm), mean precipitation (dotted blue line; mm). Note the regime shift in the precipitation mean in 2003.

Page 18826, Figure 3: Is this based on all annual data for all years from each colony?

If so, make this clear in figure caption.

Fig. 3. Linear regressions between satellite derived sea surface temperature (°C) and skeletal δ18O (VPDB) of female, and male Porites panamensis coral from Bahía de La Paz. Time period covered by analyses is from 1997 to 2009. Temporal resolution of data is quarterly. This includes all isotopic data of all colonies. Line equations and coefficients are shown.

Page 18827, Figure 4: Is this based on all annual data for all years from each colony? If so, make this clear in figure caption.

Fig. 4. Plot of δ13C vs. δ18O of female (red dots), and male (blue dots) Porites panamensis coral from Bahía de La Paz. This includes all isotopic data of all colonies. Line equations and coefficients (red represents females; blue represents males) are shown.

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