

## ***Interactive comment on “Late Pleistocene Glacial–Interglacial related shell size isotope variability in planktonic foraminifera as a function of local hydrology” by B. Metcalfe et al.***

**Anonymous Referee #2**

Received and published: 9 February 2015

Metcalfe and co-authors present new size-specific single specimen stable isotope (d13C and d18O), abundance and average text size data from three planktic foraminiferal species (*G. truncatulinoides*, *G. inflata* *G. bulloides*), spanning a glacial-interglacial transition (MIS7-8) at ~230 kyrs. These data are used to assess the relationship between body size and stable isotope values within each species and the stability of any trends through time. This is an important (and rare) study because it addresses the assumptions underpinning the size-fraction selected for palaeoreconstructions as a means of reducing vital effects.

Ultimately the authors find that *G. bulloides* shows little variation in d18O values between size fractions and a positive relationship with size-d13C values. In contrast, *G.*

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*truncatulinoides* and *G. inflata* both show positive size-d18O and size-d13C relationships although the gradient varies through time. The authors highlight the role of the d18O of key species for reconstructing past changes in seasonality and stratification.

The figures are nice and clear and the text is generally good. My main comment is that the authors need to remember to be specific in the statements that they make to avoid confusion and would also do well to streamline some of the text to avoid losing the reader. Get your main points upfront and then discuss them. That said, I think that the data is good, the study well designed and the figures beautiful and this manuscript deserves to be published pending revision. Specific comments on the text and figures are included below.

First a comment on terminology. The authors consistently use the terms ‘enriched’ and ‘depleted’ to describe both isotopic ratios and the amount of each isotope. This is at times very confusing. Can I please request that when referring to enrichment or depletion of a specific isotope that it is noted which one is being discussed. Further, isotope ratios themselves are not strictly speaking enriched/depleted they are, e.g., higher/lower. A little thing but separating the terms out this manner would help to simply matters considerably.

Title – ditch the “related”

P136-L5 – delete “the” so text reads “from equilibrium”

P136-L12 – please clarify what you mean by “dynamic” – this could refer to using difference sieve size fractions in different samples for example. I think you mean, “. . . utilizing measurements from multiple narrow sieve size fractions spanning a large range of total body sizes”

P136 L13 - do you mean that size-isotope trends within each species are not constant through time and thus, comparison of isotopic data from same sized-individuals in different species are also not constant through time? Can you please be more explicit

about which of these options you're referring to or if both.

P136 L15 – define small in um

P136 L20 – implying that these taxa calcify in a similar water depth throughout their life cycle – worth being explicit here as for the globorotalids?

P136 L23 - "...may be used to reconstruct past..."

P137 L3 – “physical proxies determine”

P137 L5 – specify here d13C and d18O

P137 L10 - This sentence doesn't make too much sense at the moment needs reorganizing, e.g., “Vital effects are isotopic offsets from equilibrium values reflecting..”

P137 L13 – specify reduce effects on palaeoenvironmental reconstructions?

P138 L13 – are planktic foraminifera really limited in their ability to track favorable conditions? If plankton can be anywhere (see Norris, 2000) then they can maintain populations wherever suitable conditions pop up.

P138 L15 – need to add “that growth occurs”

P138 L17 – 25 – very long sentences consider breaking up for increased clarity.

P138 L26 – delete “sized”

P139 L4 –The first sentence is a little unclear so some suggestions below to increase clarity. “Here we test”, specify planktonic foraminiferal tests and “. . .to large-scale environmental perturbation across a glacial-interglacial transition (TIII). We utilize data from Feld... and present new data that expands upon shell-size isotope relationships between species and through time”

P139 L8 – a little expansion on the methods please – e.g., Individual foraminifera were picked from narrow sieve size fractions from JGOFS. . . . Please specify your sieve size fractions.

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P139 L12 – specify dextrally and sinistrally coiled?

P139 L15 – perhaps “multiple specimens” would be better?

P139 L15 – Specify multi-specimen analyses were repeated and delete “seen” as unnecessary. Add reference for this statement as has been demonstrated elsewhere and very specific in L18.

P139-L19 – Specify “In other words by combining multiple specimens for each analysis, . . . .” for clarity.

P140 L 1 – typo “recrystallization”

P140 L5-14 – necessary? Seems nicer to finish mentioning that single specimens give us a discrete snapshot of ocean conditions at time of calcification? Can you include some of this info at the beginning of the section when you say why MIS7-8?

P140 L17-20– specify planktonic. Also a bit more detail needed here. Specify if dry residue weighed within each narrow sieve size fraction or total dry bulk weight? why 200 particles? Abundance counts usually on >300 specimens to obtain representative numbers. Also please note if sample splitter used to obtain aliquots or if they are representative splits.

P140 L24 – “the absolute number of individuals by the split. . .” and “size frequency distribution (SFD) was approximated”

P141 L1 – careful here bulk measurements could be confused with bulk sediment analyses (i.e., total carbonate) so best to be specific that typically 8-40 . . . , use same number of decimal places on weights here.

P141 L7 – “. . .on the analytical methodology. . .”

P141 L10 – replace “about” with “up to”

P141 L15 – A little more specificity here please particularly for test 2 – so test 1 = to test

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for any statistical differences between size fractions with each species in each sample and test 2 = to test whether any differences between body size and isotope values are constant within each species downcore? And/or to assess whether the difference between same size fractions in each species varied downcore?

P141 L26 – I'd argue that this depends on what you're trying to determine!

P142 L30 – delete “are different”

P144 L9 – specify that figures in brackets are relative abundances “...have higher abundances during MIS7e and lower abundances...”.

P144 L18 – “during which time the abundance of the species is low”

P145 L12 onwards – mention in brackets with table that samples for which null hypothesis is rejected highlighted in grey

P145 L3 – specify d18O values

P145 L2 – also mention that these offsets are not constant through time and refer to insets here?

P145 L19 – Is this not also implied by the largest offset from the 1:1 line in terms of the gradient compared to other taxa?

P145 L23 – a little bit of text streamlining in this section, e.g., ditch “thus for this species” and “whereas all size fractions show a statistical difference and thus”

P146 – “with larger insolation differences ...”

P146 – Not really necessary to give all this detail about d13C values is it? Sometimes a little too wordy which reduces clarity. I'd suggest just go straight for the key points (1) D13C is typically lower in G. trunc and G. inflata small than large specimens but not clear distinction between small fractions continuously throughout record. May be larger = higher d13C. (2) bulloides more difficult to discern differences. Even better can you

C103

not integrate the descriptive observations of your graphs with the stats to cut the text and make this snappier?

P146 L23 – “deviate” typo

P147 – L10 – in reference to what are they statistically significant = new paragraph here so you need to be explicit.

P148 –L15-20 – references needed here. Also carbonate ion effect (Spero et al 1997) impacts values

P148 L22 “significant variation of size with d18O values..”

P148 L23 – should better employ Figure 10 here to mention that overall patterns are consistent with previous studies.

P148 L26 “with increasing...”

P148 L26 – I'm not convinced that the discussion of these curves in the context of Berger, 1978 really adds much as effectively repeats findings from sentences above.

P149 L7 – these physical parameters are presumably a function of depth habitat though with smaller individuals calcifying at shallower depths and thus the same as (iii)?

P149 – need to be specific that it's isotopic disequilibrium that you're referring to

P149 L7 – doesn't really explain why these factors might create the 'normal' trend.

P150 – the change in size during the interglacial is only really visible in truncatulinoidea so be explicit in this opening sentence. I'd actually restructure this sentence to be clear that you're talking only about bulloidea right up front at the beginning otherwise this is potentially confusing. Don't need the bit about concurrent in size or magnitude as already said see a minor change in abundance/size? So key point is that there is no isotopic variation between size fractions.

P151 L12 – be explicit that you're talking about your site

C104

P151 L15 -replace "occur" with "extend"?

P151 L19 - delete "occurring" as unnecessary

P151 L22 – not necessarily the zone of optimal conditions for bulloides may be much broader than in the modern ocean if bulloides prefers cooler and more eutrophic water masses. Feels like a lot of discussion in size change across the G-IG given no size change is apparent in the dataset to the naked eye at least. Does the Schmidt data show any significant changes across G-IG cycles in this taxa at a similar latitude? Removing unnecessary words and just giving the key information relevant to the story ultimately could significantly shorten this section that no decrease in size, implying optimal conditions at site and influenced but increased productivity in this region. P151 L23 – sentence overly long

P151 L3 typos "development" and "with a .."

P152 L12 - delete "for example occurring" as unnecessary

P152 L11 – be specific "species abundance counts in plankton tows" also isotopic analysis of foraminifera tests not sedimentary material – this implies bulk carbonate currently which is not what you mean

P152 L21 – be explicit that differences in the depth of the DCM relates to seasonality and water column structure

P152 L24 – Ok so seasonality controls the DCM by impacting stratification but did the Ottens paper say anything about whether the deeper habitat in april also corresponded to an increase in the deep of the DCM? If so, please say so.

P152 - ditch associated with subpolar to tropical water masses in above sentence because same info given in following sentence.

P153 L3 "in the South" typo

P153 L13 – too many "its" be specific and give species name in sentence somewhere

C105

P154 L7 – again please be specific. "Given the isotopic overlap. . ." redundant to say larger than and use > - pick one

P158 L6 – Suggest switching/adding reference to Birch et al. (2013) or Friedrich et al (2012) instead here as these papers look at all of the same species in your study in contrast to Franco-Fragaus et al. 2011 which just looks at truncatulinoidea and ruber. Also more explicitly link back to previous sentence, e.g., A positive size-d13C relationship have been explained by..."

P158 L8 - Need to be more specific because strictly speaking 13C of plankton didn't invoke photosymbiosis previous studies invoked photosymbionts etc. to explain the trend so please rephrase.

P158 L11 – sentence overly long. Split into two for clarity.

P158 L120-123 – do you mean that forams calcifying in surface waters have a higher d13C values than those calcifying at depth? a shallower depth habitat relative to what? specify "foraminiferal d13C" here

P158 L123 – This sentence is another example of where it is important to be more specific as to exactly what you're referring to – enrichment of 12C in deeper dwellers? I think you need to clearly distinguish between size-isotope trends and inter-specific offsets between similar sized fractions so that the two (and most importantly the mechanisms are not confused)– separate paragraphs? Perhaps talk about the absolute offsets between taxa, i.e., some species live deeper than others with lower d13C values and then lead onto the size-specific isotope relationships?

P159 L1 – "increases"

P159 "for an enrichment in oxygen isotope composition with increasing size"

P159 L15 – now using test rather than shell – be consistent

P159 L18 – "raising their d13C values"

C106

P159 – 160 – Lots of discussion of controls on d13C but not well-linked back to original data. For instance no conclusion is reached on the main mechanisms controlling the datasets presented here and only for gametogenic calcite is it mentioned whether or not the hypothesis is consistent with the new data,

P159 29-P160L6 – sentences provide essentially the same info consider combining.

P160 L12 – it might be worth mentioning earlier in the text that the deeper dwellers particularly *G. truncatulinoides* may actually have a longer life span than 2-4 weeks like *bulloides* and *ruber* perhaps more like a year, which may help to explain calcification in different seasons.

P160 L26 – on what basis is 300-355 um best? Can you add a comment about why? Most consistent offsets?

P160 L3 – clarity “whilst we find no systematic differences between the d18O of *G. bulloides*....”

P160 L20 – be specific -Variability between size fractions? Between species? And relative to what? Consider combining this sentence with previous.

P160 L23 “and that previously published” Also rephrase next sentence consider deleting “between studies” so reads “lack of a resolution in the existing literature as to the recommended size fraction ...” – doesn’t birch make a decision about the best size fraction based on correlation of foram d13C to d13C of DIC? 250-300 um?

P160 – the authors use differences between size fractions – I wonder whether it would be better to discuss size-isotope trends to avoid confusion with differences between the same size but different species?

It might be worth checking out the new paper in *Paleoceanography* by Ezard et al. 2015, which compiled and modeled the size-isotopic relationships for all modern taxa and includes a large discussion of potential biases on isotope-size trends. Specifically you should consider the potential role of changes in preservation (particularly disso-

C107

lution) on your datasets given the large associated changes in carbonate chemistry. These authors also nicely highlight that in sediment cores, body size doesn’t necessarily equate to foram ‘age’ something alluded to here and that it may instead relate to maximum adult size a function of growing conditions so consider tying this into the discussion.

Figure 1 – Nice clear map. Just need to specify in caption that main ocean currents indicated by arrows and that these are surface? currents. Without a key for temperature need to write that red is warmest and blue coolest temperatures.

Figure 2 – specify top, middle and bottom ROWS in caption

Figure 3 – specify in caption that “Size in planktonic foraminifera across MIS7-8”. In caption use lowercase a-d but in figure capitalized – style? No need to mention oxygen isotopes explicitly on y-axis of a if also use d18O. Is this the relative abundance of each taxa from whole sample or relative to each other. I assume the former but please specify in caption. Please note what vertical dashed lines and HI5 etc.. are. To avoid confusion with how average size was calculated can you please explicitly mention average size within the text of section 2.1 – is average size = sfd?

Figure 4 – Y-axis “Single specimen” and add space between number and units on figure for sizes. Any reason why axis given to 2 dp? Might be neater to stick to 0 dp? Are Heinrich events HI4 etc. in which case please note in caption explicitly for non-specialist..

Figure 5 - Mean insolation not marked on figure – remove note in caption?

Figure 6 – Specify in caption header that isotopic differences are for each species. “. . .in d18O (top panel) and d13C (bottom panel). Careful phrasing - Equations of linear regressions not shown by coloured lines – regressions are shown and equations in table 4.

Figure 9 – Just use d13C not necessary to include description in full here. Perhaps

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add the coloured species outlines behind a-c rather than grey for increased continuity.

Figure 10 - Just use d13C/d18O not necessary to include description on figure axes.

“..an average size-isotope curve was . . .”

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Interactive comment on Biogeosciences Discuss., 12, 135, 2015.