

## ***Interactive comment on “Distribution of known macrozooplankton abundance and biomass in the global ocean” by R. Moriarty et al.***

**R. Moriarty et al.**

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We are grateful to Anonymous Referee #3 for taking the time to review the manuscript, their thoughtful comments and careful reading of the manuscript.

Referee #3: Our main objection to this MS is that the author excludes copepods, especially *Calanus* copepods from this paper. The comparison between Arctic (*Calanus* copepod dominated) and Antarctic (krill dominated) is therefore not representative, either as an expression of macrozooplankton biomass or abundance.

Author Response: In response to a similar comment by Referee #2, we have added a new paragraph at the end of Section 3.2.1 (Page 11, lines 294-305) to justify our exclusion of large copepods where we could: “There is potential ambiguity about whether

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large copepods are included in meso- or macrozooplankton sampling. Although we have used a cut-off of 2 mm adult body size for other taxonomic groups, previous work on mesozooplankton has used cut-off sizes between 5 and 30 mm to delimit mesozooplankton (supplementary table 3 in Buitenhuis et al. 2006). To prevent double counting with the MAREDAT mesozooplankton database (Moriarty and O’Brien, 2013), we have excluded copepod species that were available in the COPEPOD database. However, in the HOT and BATS databases, we only had access to the total macrozooplankton biomass data, which did include copepods greater in size than 2 mm. Large copepods can avoid nets with a small mesh size, such as is used for sampling small copepods (typically  $200\ \mu\text{m} < \text{mesh size} < 330\ \mu\text{m}$ ; Harris et al., 2000; Moriarty and O’Brien, 2013), but this under sampling has not been comprehensively quantified. We were therefore unable to estimate whether there is double counting or a gap between the mesozooplankton and macrozooplankton datasets”.

We have also tried to be careful in our claims, and only say that we have done some of the groundwork towards a quantitative analysis, e.g. in the Abstract: “biomass observation coverage is only good at high latitudes”, Introduction: “The synthesis presented here is a step towards gathering all available data”, and Conclusions: “This work is presented as a first step towards a quantitative analysis of global distribution of macrozooplankton biomass.” Our main goal has been to provide an estimate of global biomass, in carbon, that may be used to validate PFT models. There are many challenges associated with collecting datasets such as this. It is an enormously time consuming task, usually with little hope of publication, that is why it has taken so long for a global dataset like this to emerge. We wish to share with and encourage the observation and modeling communities to share, distribute and synthesize datasets such as this. We hope that scientists from a variety of fields will use this data and each will probably mold the dataset to their needs. When we synthesized this dataset we did not require that it contain large copepod data.

Referee #3: The authors have compiled and analyzed an impressive amount of data.

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The manuscript does however not offer much of a discussion or interpretation of the observed results but is more a presentation of the available data in the selected databases.

Author Response: According to the ESSD guidelines we have limited the discussion (there is no discussion section, only a results and conclusion section) to a very basic description of the data. The Aims and Scope of Earth System Science Data states: "Any interpretation of the data is outside the scope of the regular articles", which we have read to mean 'no hypothesis testing'. Please see: <http://www.earth-system-science-data.net/home.html> Aims and Scope, third paragraph.

Referee #3: We are a bit skeptical what can actually be achieved with this kind of analysis. What does a global estimate of biomass and abundance really tell us, especially since it is based on data analyses that exclude the most important macrozooplanktonic groups in the Arctic the Calanus copepods, and is based on samples from different seasons and with different methods? The strongest part of the analysis is probably the global overview over where the (non Calanus) macrozooplankton abundance and biomass are registered and where there are gaps (spatial and temporal) in the datasets. Data analyzed in this MS from the Arctic are scarce, and there are probably more data available. Are the data assembled by Russ Hopcroft included in this analysis?

Author Response: As the referee points out above "The strongest part of the analysis is probably the global overview over where the macrozooplankton abundance and biomass are registered and where there are gaps (spatial and temporal) in the datasets". This is one of the main objectives of this manuscript – to document where macrozooplankton are and in what quantities. The data we have gathered is not perfect and working within the limits of this data we have used the distributions to estimate a global annual average macrozooplankton biomass. This value and the biomass distribution presented here are of limited use to the wider biological oceanography community, i.e. they are not the type of information that is useful within this community but they are critical in the field of biogeochemical and Plankton Functional Type modeling. We

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hope that this dataset can be continually improved and added to and that eventually we will have enough data to examine seasonal and methodological differences within the data.

A follow up publication to this manuscript is already underway for 2015. For now we have identified many of the weaknesses of using this type of data to create global estimates of macrozooplankton biomass and we hope that some of this information may be useful to those who collect the data at sea and would like it to be valuable to many different members of the oceanographic and modeling communities, as alluded to in the conclusions.

For a reply to the comment about large copepods, see our reply to the first comment above.

In relation to seasonal and methodological differences among samples across project methodologies are thought to have less of an effect than the random error associated with sampling in general see Section 3.1, paragraph 2. Here we also mention briefly some seasonal differences. It is important to note that our dataset holds data with a record of the month it was collected and that we hope (as alluded to above) to extend this dataset and once there is sufficient data we hope to quantify seasonal and regional variations in macrozooplankton distribution and biomass across the global ocean

To create this dataset we did a broad sweep of existing datasets - standard practice for modeling validation datasets. This was not a literature-based search. Data that Russ Hopcroft has assembled is included in this dataset although the data comes from a different origin. Both Todd O'Brien at COPEPOD and Russ Hopcroft have individually digitized some of the same datasets, i.e. WEBSEC (from a 1970s Tech memo) and Burton Island datasets. To the best of my knowledge Russ Hopcroft is in the process of reprocessing OCSEAP data but an old NODC copy, from NOAA Tech Rep. NMFS SSRF-679, is already included in COPEPOD. None of Russ Hopcroft's own data, where he is the original owner of the data is included in our analysis, it has not

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been added to COPEPOD yet, but I am informed it should be added at some point soon.

\*Specific comments\*

Referee #3: There appears to be large variability in the data set concerning depth distribution and I wonder why the authors didn't focus on the upper 200-300 m as most data seems to originate from here.

Author Response: We have changed the Abstract to clarify that our global biomass estimate was integrated over the top 350 m.

Although there is currently not very much information for deeper macrozooplankton they may have significant biomass in deeper water (Buitenhuis et al., 2012). We have therefore included all data that was available in the original datasets to allow further investigations into biomass at all depths, but in our presentation of the global database we have emphasized the top 350 m. We have added text to the Section heading for 3.3 that outlines to what depths are calculations are based on and the rationale behind choosing 350 m:

"3.3 Global estimates Here, we use the gridded dataset to determine the depth integrated global values for macrozooplankton abundance and biomass in the top 350 m. Ninety-three percent of the abundance observations and ninety-nine percent of the biomass observations are found in the top 350 m of the global ocean. We have specifically chosen data gridded in the top 350 m of the ocean for use in these calculations of global epipelagic macrozooplankton annual average abundance and biomass as this is where macrozooplankton are usually found and because we have considerable coverage down to that depth (Figures 2d & 3d)."

Referee #3: Also with regard to the variability in sample depth: If abundance data at one station was vertically resolved how was that data treated for the general analysis (Figure 2 and 3): were abundance/biomass data averaged over depth or abundance/biomass from each single depth included in analysis?

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dance/biomass from each single depth included in analysis?

Author Response: We have clarified in Section 2.4 that "It should be noted that all figures presented here have been created using data from the Excel files (pre-gridding), in order to showcase the original datasets."

Referee #3: Concerning the definition of macrozooplankton: The authors state that they define zooplankton with adult > 2mm as macrozooplankton? Why were copepods species that are > 2 mm not included in the analysis (see comments above)?

Author Response: When this dataset was originally created there was a mesozooplankton dataset [http://lmacweb.env.uea.ac.uk/green\\_ocean/publications/Buitenhuis\\_et\\_al\\_GBC\\_2006\\_supr](http://lmacweb.env.uea.ac.uk/green_ocean/publications/Buitenhuis_et_al_GBC_2006_supr) that included large copepods (up to 5-30 mm dependent on the data source). At that time we decided not to add the large copepods to the macrozooplankton dataset to avoid over representation of this group. See comments above and comments in response to Referee #2.

Referee #3: Page 9, first paragraph: if the outliers are most likely real values why were they removed?

Author Response: Referee #1 has also asked this question. To help with the continuity of this review I will reiterate my reply to Referee #1. This manuscript is part of a wider effort to publish a global ocean plankton biomass database and an ESSD special edition - MAREDAT: Towards a world atlas of marine plankton functional types. The authors decided upon standardized statistical methods across all papers intended for the special edition. The exclusion of outliers was carried out across all datasets submitted to the special edition. All authors agreed that some form of outlier exclusion was necessary even if those outliers could be real. Chauvenet's criteria was used in order to retain as many data points as possible while still identifying extremely high biomass values.

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The reason why Chauvenet's criteria removes outliers even if they are real values is given in more detail in the references provided in Buitenhuis et al. 2012, Glover et al. 2011 and Luo et al. 2012. We have added a very brief summary of the reasoning to Section 3.1: "The reasoning behind the rejection of the higher values is thus, if two hypothetical databases were constructed that were as similar as possible to each other, but in which one is stochastically skewed with respect to the other because of an unrepresentative number of extremely high values, than those values are rejected to remove the skew. So while we think the data are values that reflect reality we are conscious of working to remove any skew."

Referee #3: Page 10, line 6-8: "where the southern hemisphere has fewer observations peaking at 30°N": I don't understand what the authors trying to say here? Do they mean 30°S?

Author Response: Yes, this should be ~ 30°S. This has been corrected in the text.

Please rephrase: Referee #3: Table 1b: The "y" at the end of Germany is missing several times in the table

Author Response: This has been corrected in both Tables 1b and 1c.

Referee #3: Table 2: Clione limacina (not limacine)

Author Response: This has been corrected.

Referee #3: Figure 2c and 3c: Both figures show log transformed abundance or biomass against latitude. In how far does that indicate "latitudinal depth distribution" as stated in the figure text'?

Author Response: This does not demonstrate 'latitudinal depth distribution' as stated. It should simply read 'latitudinal distribution'. Both Fig. 2c and Fig. 3c have been relabeled from '(c) latitudinal depth distribution' to '(c) latitudinal distribution'

References.

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