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Earth System Science Data Discussions

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Interactive Comment

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 thank Anonymous Referee #2 for taking the time to point out places where the manuscript could be improved. We hope that our responses, and clarifications below and in the manuscript may address in part the issues raised.

Referee #2: The way I understand the purpose of the paper is to collate abundance and biomass observations on marine macrozooplankton (> 2 mm as adults) for contributing data on Plankton Functional Types (PFT) for use in global biogeochemical models (Dynamic Green Ocean Models, DGOMs)). I regret observing that macrozooplankton is not a natural group but a man-chosen size fraction. It comprises herbivores (salps), as well as carnivores (two PFTs).

Author Response: Indeed macrozooplankton as a group are arbitrarily defined and we have referenced the variety of classifications that exist within the literature (Introduction: Page 4, lines 76-80). However, if you examine macrozooplankton from a Plankton Functional Type (PFT) perspective you can see that macrozooplankton, whether herbivore or carnivore, they play a similar role in carbon export (see Le Quéré et al 2005). This is why we have grouped macrozooplankton together in this database and publication. It is their functional role in the carbon cycle as opposed to their functional role in the food web that this definition is based upon. A classification of, and introduction to macrozooplankton has been included in the introduction with the relevant references for readers to begin to understand how biogeochemical PFT modelers view macrozooplankton (Page 4, lines 86-101). Splitting the macrozooplankton further into herbivores and carnivores would compound the challenges the reviewer notes in acquiring enough coverage for the database; and is has not yet proven necessary in PFT modeling. The taxonomic classification in the original data were retained in the raw database collections, to make sure that future developments could split the data in different fractions once enough data becomes available to justify doing so.

Referee #2: Also, the models to my knowledge do not use abundance, but biomass (carbon) values.

Author Response: We have added a justification for including abundance in the new Section 2.4 "We have included abundance data in the dataset for a variety of reasons (1) most macrozooplankton data is recorded in abundance terms and abundance data is often used in the calculation of biomass, (2) abundance may be used as an indication of where the animals are, and in what quantities, i.e. it may be used in a qualitative sense, (3) additions to both the abundance dataset and the conversion dataset will make it possible to convert more abundance data to biomass in the future, and (4) we have carefully separated the data collection and data processing steps, so that the data would be easily adaptable for other purposes than biogeochemical model validation."

Referee #2: Granted these conceptual weaknesses, I am surprised about the omission of biomass/carbon observations for copepods, among which many dominant species of the upper layers in cool-temperate and subpolar seas are 2-5 (8) mm long.

Author Response: 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 large copepods are included in meso- or macro-zooplankton 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 μm < mesh size < 330 μm; 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”.

Referee #2: On the other hand, the biomass data for the HOTS and BATS stations represent mesozooplankton (Landry et al., Madin et al., and Steinberg et al., as cited), but not macrozooplankton as in the ms. and the figures.

Author Response: As noted in the response to the previous comment, we have clarified that we have only used the > 2 mm and 2 - 5 mm fraction from the HOTS and BATS datasets. Thus, while we have excluded the mesozooplankton data from HOTS and BATS, we have added a qualifier (Page 11, lines 298-305) in the manuscript to indicate that we cannot say at present whether there is double counting or a size range gap between the meso- and macrozooplankton databases.

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Referee #2: Quite dismaying are the large blank regions in Fig. 1b. [and] Referee #2: Excepting the thorough study of the Southern Ocean, the authors have not found the existing macrozooplankton data for most of the open sea in all three oceans, which are emphasized by the most of the current DGOMs. These biomass observations may not be in the databases used by the authors but they should have looked for them.

Author Response: For the large blank areas, this is not due to a lack of observations per se, but that the observations are not specific enough to allow conversion to carbon. We have changed Section 3.2.2 (Page 12, lines 313-318) to make this clearer: "This is a direct result of only converting abundance to biomass using species-specific conversions. This approach was necessary as bulk conversions of abundance to biomass as yet are not sophisticated enough to account for many of the variables, e.g. region, season, life history, food concentration and food quality, that are important in the amount of carbon in any particular individual or species".

Also see also our reply to Referee #1 where we show that using a bulk conversion does not give reasonable results where specific conversion factors are not available at present. We have compiled a large database of conversion factors and we are convinced that in a large majority of cases where we could not find a conversion factor this is truly because these measurements have not been made and not for want of looking.

This work may help to clarify the information that needs to be reported during sample collection and preserved throughout the lifetime of the data in order that the data might be useful in studies that employ global biogeochemical models (see Le Quéré and Pesant, 2009).

Referee #2: I do not think that the conclusion in the third-fourth lines of section 4, p.13, ('an insight in the distribution of macrozooplankton from the poles to the tropics has been gained') is justified.

Author Response: I have removed this sentence.

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Referee #2: Also, I do not see the relation of specimen numbers to studies of biodiversity as alluded to.

Author Response: We have clarified our argument about the potential usefulness of our dataset for studying biodiversity by changing the relevant sentence (Page 16, lines 427-431) in the conclusion from ‘’The species level abundance data will be useful for understanding biodiversity, both globally and regionally”, to “Species level abundance data will be useful for understanding biodiversity, both globally and regionally and will be of interest to researchers outside PFT and biogeochemical modeling. Although the dataset it not yet fully comprehensive, in terms of taxonomic data or temporal and spatial distributions, it is a foundation upon which a comprehensive dataset may be based”.

Referee #2: Other weaknesses of the ms. are citing authors in Table 1d without listing them in the References, . . .

Author Response: The metadata in Table 1d (e.g. Brodskii 1950, Minoda 1967) are not references, but the name of a dataset as it is used within the COPEPOD database. It was and is very important to us to attribute and accredit those who have created datasets that have been used in this analysis. Many of these datasets are old enough that the originators are now retired or have passed away, i.e. most of the NMFS/BCF data, which COPEPOD is now the contact point for. The NODC accession number can be cross-referenced on the COPEPOD website and this brings up all the available metadata associated with each of the datasets.

Referee #2: . . .mislabeling Fig. 2c, . . .

Author Response: Both Fig. 2c and Fig. 3c have been relabeled from ‘(c) latitudinal depth distribution’ to ‘(c) latitudinal distribution’.

Referee #2: . . .and including the in my view useless juxtaposition of the Northern and Southern hemispheres in Figs. 2e and f, which moreover clearly show non-

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significance.

Author Response: As part of the special edition authors have agreed to describe data in a similar manner. Some figures have been included so that data can be compared across datasets easily. We do not claim there is a significant difference between the hemispheres in either the legend or the text.

Referee #2: What are we to do with the global annual median of epipelagic macrozooplankton of 0.02 Pg C, which comprises herbivores and carnivores?

Author Response: PFT models treat macrozooplankton as a generalist group that are linked together by their common function in the removal of carbon from the sunlit waters of the global ocean to the deep ocean. As stated above (in response to the first comment) macrozooplankton demonstrate incredible diversity when it comes to feeding preferences, feeding on minute particles, bacteria, detritus, phytoplankton and other zooplankton. The gridded dataset where all macrozooplankton, regardless of their position in the food web, are 'lumped together' is designed for application in the study of global ocean ecosystems from a plankton function or PFT perspective. PFT modeling uses a coarse division of the ecosystem, breaking the plankton into functional groups or Plankton Functional Types (PFTs). A global annual average value for macrozooplankton biomass allows us to validate how well our models are performing on an annual average basis. Currently validation of PFTs in PFT models is basic but it is necessary. Validation data and the models are constantly improving. We hope that the dataset we have presented here can act as a foundation for continual improvement in the future and that one day it will be useful for more than just the validation of PFT models. Until then it will serve the PFT and ocean biogeochemical modeling communities as a useful tool against which they can validate models and free up the geochemical data that is currently used to constrain models.

We have added to the Origin of Data (Sections 2.1 (Page 7, lines 162-167) & 2.4 (Page 9, lines 226-233)) in order to clarify that we are also supplying the taxonomic data

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that might be useful in different types of studies, and we have reiterated this in the Conclusions section. The taxonomic component of the original datasets may be useful as a foundation for a global dataset of macrozooplankton biodiversity.

Referee #2: What lessons are modelers or other readers to draw from the paper? Referee #2: I recommend against publication.

Author Response: We have added new descriptions in Sections 2.1, 2.4 and 4 to clarify the use that we think this database may be put to, while also emphasizing that we tried to make it easy to put the database to uses we have not thought of. Throughout the manuscript and especially in the conclusions we have referred to the specific uses of this data product, in particular its usefulness to PFT modelers as a validation dataset. We have added to the manuscript to explicitly state who this data product is useful to those outside of PFT modeling and have discussed the limitations of the data and how currently, in terms of biodiversity, it can be seen as a foundation dataset upon which something more comprehensive can be built upon.

Perhaps the most significant contribution of this data product to the scientific community is that for the first time a global macrozooplankton dataset has been collected and synthesized into one coherent and gridded data product. This was a difficult and immensely time-consuming task. Only when it was absolutely necessary to compile this dataset, and the other datasets presented in the special edition to which this manuscript belong, to validate PFT models was this work carried out. This reflects both the difficulty of the task and lack of impetus within the biological oceanography community to create such a product. With the collection, synthesis and presentation of this and other global PFT datasets there is an impetus within the scientific community to build on these datasets and share data that will lead to greater dissemination of data and resultant publications for those who collect the data at sea. We have therefore also included a reference to the submitted manuscript by (Le Quéré et al., in preparation) who show that macrozooplankton are more important than iron limitation in shaping the ecosystem in the Southern Ocean, from which we conjecture that this impetus will

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not stop here.

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