# Response to Referees' comments

We would like to greatly thank Mats Blomqvist for the comprehensive review and helpful and inspiring comments. We think the manuscript has improved considerably. On the base of the remarks we have edited and corrected the dataset, text file with supplementary and data description text.

Referees' comments:

This is a really useful and important publication. The data published represents a significant amount of work now accessible for all to reuse.

There is a strong dominance of data from SW Baltic waters and to better represent Baltic Sea and North Sea it is my hope that the dataset will be enlarged in the future, possibly in cooperation with other laboratories.

In the supplementary information wordfile with descriptions of the data set column headings there is an error for column Group. Description needs to be changed as it is a copy of the previous column description.

Response to referee's comment No.1: *We have corrected the column description accordingly. It now states: "group the taxa is classified to in order to facilitate summary (these groups are rather functional, i.e. not strictly taxonomic, as they vary in rank ranging from Phylum to Order level)". For consistency all over the text we have also corrected "wet weight", "ash free" and "dry weight" to "wet-weight", "ash-free" und "dry -weight".*

In the actual excel data file there are two records classified as Baltic that are situated in the middle of the North Sea (station OB20 and OB40).

Response to referee's comment No.2: *Indeed, both stations are in the North Sea (Doggerbank). We have corrected the dataset accordingly, and assigned the corresponding factors to the correct Region. We have also edited Tables 1 and 2 by correcting the corresponding values. Moreover, in Table 2 we found and corrected another error – values for Baltic Sea WW to AFDW (CI) factors and North Sea WW to DW (CI) factors were swapped. In the dataset itself we have also corrected the remark on the "Raw_Single_Measurments_Factors" Sheet (Cell A2) to more accurate formulation: "Values only from measurements (individuals or pooled individuals) with wet-weight >= 0.5 mg. The DOI stated in the manuscript was updated (to http://doi.io-warnemuende.de/10.12754/data-2021-0002-01) and points now to the updated version of the dataset (with the remark that it is New Version Of 10.12754/data-2021-0002).*

The manuscript is well written and contains a good and clear description of the dataset. There is a small need to improve the English in order to make some sentences easier to read. Here are line numbers were improvements are needed (in most cases also with suggestions for change):

7-9 this sentence is hard to understand, reformulate

Response to referee's comment No.3: *We have corrected the text accordingly: "Availability of standardized biomass data is essential for studying population dynamics, energy flows, fisheries and food web interactions. To make the estimates of biomass consistent weight-to-weight conversion factors are often used, for example to translate more widely available measurements of wet-weights into required dry-weights and ash-free dry-weights metrics."*

12 The dataset provides a broad

Response to referee's comment No.4: *We have corrected the text accordingly.*

15 The dataset can thereby be used to quantify... Delete ", and refine current ecological theory" since this is a bit too much

Response to referee's comment No.5: *We have corrected the text accordingly.*

18 , and the role of

Response to referee's comment No.6: *We have corrected the text accordingly.*

22-23 Conversion factors... this sentence is not understandable, seems to be incomplete?

Response to referee's comment No.7: *We have corrected the sentence to: "Conversion factors are derived from subsamples to enable data standardisation and determination of dry-weight for large volume of material."*

24 pioneered in publication of compilations

Response to referee's comment No.8: *We have corrected the text accordingly.*

27 though allowing... Move comma from after estimates to after groups

Response to referee's comment No.9: *We have corrected the text accordingly.*

30 includes only a little share

Response to referee's comment No.10: *We have corrected the text accordingly.*

32 the importance of the present compilation

Response to referee's comment No.11: *We have corrected the text accordingly.*

65 36 repository together with basic usage ....  Here in the data description we

Response to referee's comment No.12: *We have corrected the text accordingly.*


 38 biomass has a central role

Response to referee's comment No.13: *We have corrected the text accordingly.*

70

 44-45 this point does not fit in the list of scientific study types. Text can be merged into row 23-24 instead.

Response to referee's comment No.14: *We have corrected the text accordingly.*


 62 In the continous ....  This sentence can be simplified. No suggestion on how.

75 Response to referee's comment No.15: *We have tried to simplify the sentence, that is now written as: "The database is continuously enlarged, with main efforts targeted to obtain sufficient number of measurements for reliable estimates and to cover as many characteristic species per region as possible (Table 2)."*


 74 the data will be done periodically.

80 Response to referee's comment No.16: *We have corrected the text accordingly.*


 74 there is no version tab in the web page (link at row 74)

Response to referee's comment No.17: *We have removed the remark "(under the 'versions' tab)" and reformulated the sentence: "Users are encouraged to use the latest version of the data set according to the 'Related' note published at IOW*

85 *repository."*


Citation: https://doi.org/10.5194/essd-2021-157-RC1

# Weight-to-weight conversion factors for benthic macrofauna: recent measurements from the Baltic and the North Seas

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**Abstract.** ~~Estimates of biomass often involve the use of weight-to-weight conversion factors for rapid assessment of dry weights based metrics from more widely available measurements of wet weights.~~ Availability of standardized biomass data is essential ~~amid research on~~for studying population dynamics, energy ~~flow, fishery~~flows, fisheries and food web interactions.

10   To make the estimates of biomass consistent weight-to-weight conversion factors are often used, for example to translate more widely available measurements of wet-weights into required dry-weights and ash-free dry-weights metrics. However, for many species and groups the widely-applicable freely available conversion factors until now remained very rough approximations with high degree of taxonomic generalization. To close up this gap, here for the first time we publish the most detailed and statically robust list of ratios of wet-weight (WW), dry-weight (DW) and ash-free dry-weight (AFDW). The dataset includes

15   over ~~1700~~17.000 records of single measurements for 497 taxa. Along with aggregated calculations, enclosed reference information with sampling dates and geographical coordinates the dataset provides ~~the~~a broad opportunity for reuse and repurposing. It empowers the future user to do targeted sub selections of data to best combine them with own local data, instead of only having a single value of conversion factor per region. ~~Data~~The dataset can ~~help~~thereby be used to quantify natural variability and uncertainty~~, and assist to refine current ecological theory~~. The dataset is available via an unrestricted repository

20   from: http://doi.io-warnemuende.de/10.12754/data-2021-0002-01 (Gogina et al., 2021).

## 1 Introduction

Research on energy flow, food web interactions, fishery and population dynamics, and the role of biodiversity in ecosystem functioning depend on the estimates of biomass and secondary production. This broad range of studies often involve the use of weight-to-weight conversion factors for rapid assessment of required dry-weights based metrics from less time-consuming

25   and therefore more widely available wet-weights biomass measurements (e.g. Ricciardi and Bourget, 1998 and references therein; Gogina et al., 2020). Conversion factors are derived from subsamples to enable data standardisation and determination of dry-weight for large volume of material. If user-defined sub-selection of database for conversion factors is possible, it can be combined with own local data, instead of relying on single average number per large region. With growing interest in

biodiversity in the second half of the last century, primarily efforts from the Baltic Sea pioneered ~~publishing the~~in publication of compilations of conversion factors for marine macroinvertebrates (Thorson, 1957; Lappalainen and Kangas, 1975; Rumohr et al., 1987), that later expanded to other geographic regions (Petersen and Curtis, 1980; Tumbiolo and Downing, 1994; Ricciardi and Bourget, 1998; Brey et al., 2010). However, though ~~allow~~allowing general biomass estimates~~,~~ for many species and groups~~,~~ the available widely-applicable conversion factors for data standardization remain very rough approximations of weight-to-weight relationships. For example, the global database for meio-, macro- and megabenthic biomass and densities that was recently published by Stratmann et al. (2020) includes only a little share of measured ash-free dry--weights and cites only a handful of publications (including those listed above) that provide such broadly used sets of values for the corresponding conversion. This highlights the importance of ~~presented~~the present compilation.

Here for the first time we publish the taxonomically most detailed and statically most robust list of ratios of wet--weight (WW), dry--weight (DW) and ash-free dry--weight (AFDW) based on over 17.000 measurements for 497 taxa from the Baltic and the North Seas (~~Zettler~~Gogina et al., 2021). All well curated raw and aggregated data is currently stored in the open access repository together with ~~the~~ basic usage information. ~~Here in the~~In this data ~~descriptor~~description paper we describe methods and algorithms used and provide details on metadata, structure and content of the dataset.

Our dataset can assist the studies where information on biomass has ~~the~~a central role by helping to more accurately translate WW into the more relevant AFDW. Data presented here are of use for a range of scientific studies, including:

(i)     facilitating spatial and temporal comparison of secondary production and energy flow in marine ecosystems

(ii)    assessment of species contribution to ecosystem functioning; supporting the generation of empirical models and predictive mapping of ecosystem services provided by marine benthic macroinvertebrates, by ensuring the most use of best taxonomic resolution and information on biomass

~~(iii)    enabling user defined sub selection of data, that can be combined with own local data, instead of relying on single average number per large region~~


## 2 Materials and methods

Macrobenthic specimens were collected over the period from 1986 to 2020 in the Baltic and the North Sea (Fig. 1 and Table 1). Following HELOCM guidelines on sampling soft bottom macrofauna (HELCOM, 2017) most samples that were used for measurements included in the dataset were collected using Van Veen grab or 1-m dredge (type Kieler Kinderwagen). From hard-bottom habitats samples where partly derived by divers (Beisiegel et al., 2017). Routinely, samples were stored for at least three months before weighing. Biomass determination was carried out separately for each taxon. All nesting species like polychaetes or hermit crabs were removed from tubes or shells. *Molgula manhattensis*, ~~a species of~~an ascidian species, and phoronids (represented solely by *Phoronis sp.*) require a special remark. As a rule, both taxa can hardly be separated from the glued grains of sand, which is why an exception has been made here. With these organisms the grains of sand were also commonly weighed in the laboratory routine. However, as desired, the AFDW only specifies the organic content, since sand

2

and ash were deducted from that weight. Biomass of molluscs and echinoderms was measured with shells. The database only includes values based on individuals with wet~~-~~ weight exceeding 0.5 mg. The dry~~-~~ weight was estimated after drying the formalin material at 60°C to constant weight (for 12-24 hours, or longer, depending on material thickness). After determination of dry~~-~~ weight, ash-free dry~~-~~ weight was measured following incineration at 500°C in a muffle furnace until weight constancy was reached. AFDW is recommended as the most accurate measure of biomass (Rumohr et al., 1987). Species nomenclature has been standardised in line with the World Register of Marine Species (WoRMS Editorial Board, 2021). ~~In the continuous complementation of the~~The database is continuously enlarged, with main efforts ~~were~~ targeted to obtain sufficient number of measurements for reliable estimates and to cover as many ~~frequent and~~ characteristic species per region as possible (Table 2). The groups used in the dataset in order to facilitate the summary should be rather considered as functional, i.e. not strictly taxonomic, as they vary in rank ranging from Phylum to Order level. A word of caution should also be given regarding mean and confidence interval values reported in Table 2, calculated using R package 'DescTools' (Andri et mult. al., 2021) in R (R Core Team, 2013). Here we display the results based on all values of raw measurements of factors for all taxa included in the group. Alternatively, depending on the aims and desired summary level, users are facilitated to obtain from the dataset mean values of conversion factors per group based on mean values per each taxon included in the group, thereby avoiding to overweight the reported statistics by dominant species, typically represented by high number of measurements.

## 3 Data availability and usage note

All measurements are available from IOW data repository: http://doi.io-warnemuende.de/10.12754/data-2021-0002-01 (Gogina et al., 2021). We have included all quality-assured measurements values without prejudice. Reporting errors and updates of the data will be done periodically ~~issued~~. Users are encouraged to use the latest version of the data set according to the 'Related' note published~~listed (under the 'versions' tab)~~ at IOW repository. This contribution is based on data release 1~~2.0~~. There are no limitations on the use of these data.

# References

Andri et mult. al. S: DescTools: Tools for Descriptive Statistics. R package version 0.99.41, https://cran.r-project.org/package=DescTools, 2021.

Beisiegel, K., Darr, A., Gogina, M. And Zettler: Benefits and shortcomings in the employment of non-destructive benthic imagery for monitoring of hard-bottom habitats, Mar. Pol. Bul. 121, 5-15, doi.org/10.1016/j.marpolbul.2017.04.009, 2017.

Brey, T., Müller-Wiegmann, C., Zittier, Z. M. C. and Hagen, W.: Body composition in aquatic organisms - A global data bank of relationships between mass, elemental composition and energy content. J. Sea Res. 64, 334–340, 2010.

Gogina M., Zettler, A., and Zettler, M.L.: Dataset of weight-to-weight conversion factors for benthic macrofauna of the Baltic and the North Seas, The Leibniz Institute for Baltic Sea Research, Warnemünde, http://doi.io-warnemuende.de/10.12754/data-2021-0002-01, 2021.

Gogina M., Zettler, M.L., Vanaverbeke, J., Dannheim, J., Van Hoey, G., Desroy, N., Wrede, A., Reiss, H., Degraer, S., Van Lancker, V., Foveau, A., Braeckman, U., Fiorentino, D., Holstein, J. and Birchenough, S.: Interregional comparison of benthic ecosystem functioning: Community bioturbation potential in four regions along the NE Atlantic shelf. Ecol. Ind., 110, 105945, doi: 10.1016/j.ecolind.2019.105945, 2020.

HELCOM: Manual for Marine Monitoring in the COMBINE. Programme for monitoring of eutrophication and its effects. Annex C-8, HELCOM, https://helcom.fi/media/documents/Manual-for-Marine-Monitoring-in-the-COMBINE-Programme-of-HELCOM_PartC_AnnexC8.pdf, 2017.

Lappalainen, A. and Kangas, P.: Littoral benthos of the northern Baltic Sea 11. Interrelationships of wet, dry and ashfree dry weights of macrofauna in the Tvarminne area, Int. Rev. Ges. Hydrobiol., 60, 297-312, https://doi.org/10.1002/iroh.19750600302, 1975.
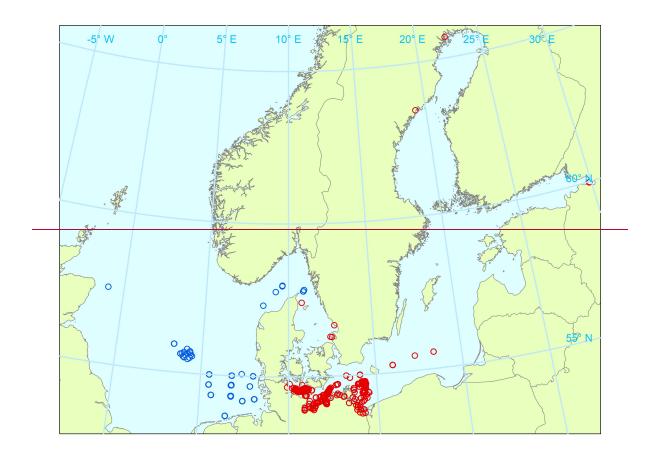
Petersen, G.H. and Curtis, M.A.: Differences in energy flow through major components of subarctic, temperate and tropical marine shelf ecosystems. Dana, 1, 53-6, 1980.
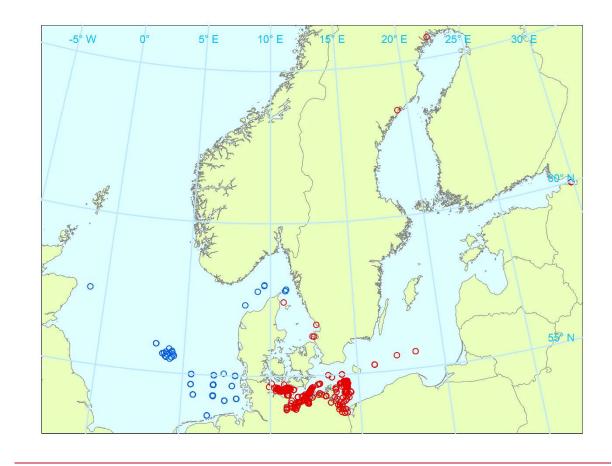
R Core Team: R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R–project.org/, 2013.

Rumohr, H., Brey, T. and Ankar, S.: A compilation of biometric conversion factors for benthic invertebrates of the Baltic Sea. Balt. Mar. Biol. Publ., 9, 56 pp, 1987.

Ricciardi, A. and Bourget, E.: Weight-to-weight conversion factors for marine benthic macroinvertebrates. Mar. Ecol. Prog. Ser. 163, 245–251, 1998.

Stratmann, T., van Oevelen, D., Martínez Arbizu, P. et al. The BenBioDen database, a global database for meio-, macro- and megabenthic biomass and densities, Sci. Data 7, 206, https://doi.org/10.1038/s41597-020-0551-2, 2020.

Thorson, G.: Bottom communities (sublittoral or shallow shelf). In: Hedgpeth JW (ed) Treatise on marine ecology and paleoecology, Geol. Soc. Am. Mem., 67, 461-534, 1957.

125    Tumbiolo, M.L. and Downing, J.A.: An empirical model for the prediction of secondary production in marine benthic invertebrate populations, Mar. Ecol. Prog. Ser., 114, 165-174, https://doi.org/10.3354/meps114165, 1994.

WoRMS Editorial Board, World Register of Marine Species, VLIZ, https://doi.org/10.14284/170, 2021.

**Figure 1: The geographical locations of sites where individuals that reported measurements values are based on were collected. Colour of symbols indicate habitats of the Baltic Sea (in red) and the North Sea (in blue). Data points may represent multiple observations at that locality. Projection: ETRS89 Lambert Azimuthal Equal-Area.**

**Table 1: Years of material collection and number of corresponding measurements per region included in the dataset.**

| Year | 1986 | 1987 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baltic Sea | | 1 | 243 | 517 | 662 | 428 | 13 | 234 | 134 | 279 | 219 | 328 | 193 | 301 | 387 | 247 | 417 | 398 | 336 | 385 | 392 | 492 | 1315 | 649 | 442 | 760 | 419 | 452450 | 377 | 1351 | 439 | 12810 |
| North Sea | 1 | | | | | | | | | | | | | | | | | | 803 | 1103 | 1445 | 1657 | | | 29 | 7 | 8 | 2 | | | | 5053 |

**Table 2: Weight-to-weight conversion factors for 29 major functional groups, differentiated by region, based on all raw values per taxa included in the group: AFDW = ash-free dry-weight, WW = wet-weight. DW = whole dry-weight, CI = 95% confidence interval, N = number of values, SPP = number of species (taxa) per group.**

| Group | Baltic Sea | | | | North Sea | | | |
|---|---|---|---|---|---|---|---|---|
| | WW to DW (CI) | WW to AFDW (CI) | N | SPP | WW to DW (CI) | WW to AFDW (CI) | N | SPP |
| Amphipoda | 0.145 (0.142-0.149) | 0.143121 (0.138118-0.148124) | 585 | 48 | 0.121143 (0.118138-0.124148) | 0.128 (0.123-0.133) | 443 | 42 |
| Anthozoa | 0.187 (0.177-0.197) | 0.19313 (0.181123-0.206137) | 103 | 8 | 0.13193 (0.123181-0.137206) | 0.141 (0.128-0.155) | 77 | 4 |
| Arachnida | 0.242 (0.218-0.267) | 0.215 (0.19-0.239) | 20 | 1 | 0.215 (0.19-0.239) | | | |
| Ascidiacea | 0.178 (0.14-0.215) | 0.15 (-045 (0.14604-0.44605) | 108 | 4 | 0.045 (15 (-0.04146-0.05446) | 0.012 (0.006-0.018) | 4 | 3 |
| Bivalvia | 0.489 (0.484-0.494) | 0.473073 (0.465072-0.482074) | 43914390 | 4241 | 0.073473 (0.072465-0.074482) | 0.084 (0.081-0.087) | 10631064 | 3940 |
| Bryozoa | 0.161 (0.146-0.176) | 0.073 (0.064-0.082) | 30 | 2 | 0.073 (0.064-0.082) | | | |
| Caudofoveata | | 0.269 (0.246-0.293) | | | 0.269 (0.246-0.293) | 0.189 (0.133-0.245) | 11 | 1 |
| Cirripedia | 0.495 (0.474-0.516) | 0.649052 (0.575046-0.723058) | 60 | 4 | 0.052649 (0.046575-0.058723) | 0.083 (0-0.171) | 5 | 3 |
| Cumacea | 0.156 (0.153-0.158) | 0.15212 (0.134117-0.169122) | 541 | 3 | 0.12152 (0.117134-0.122169) | 0.13 (0.112-0.147) | 54 | 9 |
| Decapoda | 0.192 (0.182-0.201) | 0.181142 (0.167137-0.195147) | 106 | 10 | 0.142181 (0.137167-0.147195) | 0.119 (0.113-0.126) | 127 | 20 |
| Echinodermata | 0.35 (0.33-0.37) | 0.404071 (0.392067-0.417076) | 197 | 6 | 0.071404 (0.067392-0.076417) | 0.077 (0.071-0.082) | 382 | 13 |
| Gastropoda | 0.463 (0.452-0.473) | 0.617106 (0.601103-0.63211) | 787 | 55 | 0.106617 (0.103601-0.11632) | 0.096 (0.089-0.102) | 260 | 14 |
| Hirudinea | 0.193 (0.103-0.284) | 0.178 (0.089-0.267) | 6 | 5 | 0.178 (0.089-0.267) | | | |
| Hydrozoa | 0.164 (0-0.512) | 0.099 (0-0.235) | 2 | 2 | 0.099 (0-0.235) | | | |
| Insecta | 0.149 (0.127-0.171) | 0.12 (0.098-0.141) | 31 | 5 | 0.12 (0.098-0.141) | | | |
| Isopoda | 0.176 (0.167-0.185) | 0.235119 (0.164112-0.307125) | 154 | 12 | 0.119235 (0.112164-0.125307) | 0.221 (0.149-0.294) | 7 | 3 |
| Leptocardii | | 0.143 (0.13-0.157) | | | 0.143 (0.13-0.157) | 0.134 (0.121-0.147) | 12 | 1 |
| Mysida | 0.15 (0.145-0.155) | 0.167131 (0.154125-0.18138) | 128 | 8 | 0.131167 (0.125154-0.13818) | 0.154 (0.141-0.168) | 29 | 2 |
| Nemertea | 0.159 (0.154-0.164) | 0.174142 (0.166138-0.182147) | 282 | 6 | 0.142174 (0.138166-0.147182) | 0.158 (0.15-0.166) | 199 | 5 |
| Oligochaeta | 0.154 (0.148-0.159) | 0.28129 (0.125-0.134) | 363 | 11 | 0.129 (0.125-0.134)28 | 0.256 | 1 | 1 |
| Phoronida | 0.74 (0.723-0.757) | 0.544027 (0.513016-0.574038) | 33 | 1 | 0.027544 (0.016513-0.038574) | 0.069 (0.061-0.077) | 69 | 1 |
| Platyhelminthes | 0.165 (0.151-0.178) | 0.105144 (0.08131-0.131157) | 27 | 1 | 0.144105 (0.08-0.131-0.157) | 0.095 (0.07-0.121) | 11 | 1 |
| Polychaeta | 0.168 (0.166-0.17) | 0.189119 (0.185117-0.192120) | 44904489 | 9392 | 0.119189 (0.117185-0.12192) | 0.148 (0.145-0.15) | 22932294 | 9394 |
| Polyplacophora | 0.465 (0.434-0.497) | 0.105 (0.09-0.12) | 6 | 1 | 0.105 (0.09-0.12) | | | |
| Porifera | 0.109 (0.097-0.122) | 0.057 (0.049-0.065) | 51 | 3 | 0.057 (0.049-0.065) | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Priapulida | 0.118 (0.115-0.122) | 0.106 (0.103-0.109) | 269 | 2 | 0.106 (0.103-0.109) | | | |
| Pycnogonida | 0.142 (0.127-0.157) | 0.~~186~~107 (0.~~112~~092-0.~~261~~121) | 22 | 2 | 0.~~107~~186 (0.~~092~~112-0.~~121~~261) | 0.166 (0.097-0.235) | 3 | 1 |
| Sipuncula | | 0.166 (0.091-0.24) | | | 0.166 (0.091-0.24) | 0.148 (0.057-0.238) | 3 | 1 |
| Tanaidacea | 0.196 (0.16-0.231) | 0.151 (0.12-0.183) | 18 | 4 | 0.151 (0.12-0.183) | | | |
| Overall | | | ~~12810~~ 12808 | ~~339~~ 337 | | | ~~50535~~ 50555 | ~~257~~ 259 |

140

8