Biogeosciences Discuss.,
doi:10.5194/bg-2016-131-AC1, 2016

Biogeosciences Discussions

Interactive comment on "Blue carbon stocks in Baltic Sea eelgrass (*Zostera marina*) meadows" *by* Maria Emilia Röhr et al.

Maria Emilia Röhr et al.

mrohr@abo.fi

Received and published: 22 June 2016

June 22 2016

Dear Editor,

Please find our detailed responses to the individual questions posed. We found the referee comments very useful for both correcting details and improving the overall clarity of the manuscript. I have attached a corrected version of the ms as a supplement to this comment, and changes to Tables 1 and 2 can be seen in the supplement. Looking forward to your response,

Sincerely, Emilia Röhr

The manuscript by Röhr et al. presents a potentially interesting dataset on sediment

organic carbon stocks and sedimentation rates in contrasting seagrass meadows in the Baltic Sea region. At this stage, however, I cannot recommend publication as there are a number of fundamental flaws in methodology and presentation of the results which compromise the use and interpretation of the data. I have recommended rejection to indicate that it needs a very thorough overhaul; although I feel that with proper re-analysis of (samples and) data, this could certainly be re-submitted.

My main concerns are outlined below.

1. The authors mention that sediments were not acidified to remove carbonates as the inorganic carbon content in their samples was low but they indicate a range of up to 0.3 % inorganic C. I do not understand why a simple acidification procedure was not followed for all samples – if some samples contain 0.3% inorganic C this could substantially influence the d13C values measured, since OC concentrations are often also low.

Reply: The acidification procedure is not trivial for the sediments examined here. Most of the sediments have, as mentioned by the reviewer, very low OC contents and we need to weigh maximum amount of sediment into the tin capsules making the acidification process difficult. Our approach was therefore instead to measure the inorganic carbon content at the 20 study sites to evaluate if IC was contributing significantly to TC in the sediments. This was not the case, as the IC content was between 0.5- 5% of the TC in the sediments. The error by including IC was considered to be minor considering the heterogeneity in the sediments. Further analysis of 13C signal in IC showed that the value was similar to the TC values within the natural heterogeneity of the sediments. Furthermore, as shown by Schlacher and Conolly (2014) acidification procedure should be used with caution as it could also significantly alter the 13 C signal, in particular in low inorganic carbon sediments such as the sediments in our study area. We prioritized to have 3 replicates of all sediment samples, which allow evaluation of the heterogeneity of the samples, which is often neglected in this type of studies due to the cost of analysis. Accordingly, we have corrected the text in the MS

by referring to IC content of TC (0.5-5 %), rather than providing the absolute values of IC (0.03-0.3%DW).

2. Table 1 shows organic matter contents (is this really %OM, or %OC ? This should also be clarified) and the averages are as low as 0.42 % for some sites. If this is %OC (and even worse, if it is %OM), that would imply that up to half the C measured could be inorganic carbon HOW DO YOU ARRIVE AT 50%??, and this would severely bias the OC stock numbers as well as the d13C data. Acidifying these samples after weighing them takes a few minutes – and avoids any concerns on bias due to inorganic C contributions- hence I do not understand why one would not due this routinely on all samples. The authors should either show more convincing data that the data are not biased by inorganic C contributions, or re-analyze their samples with proper acidification to remove carbonates.

Reply:It is OM % in the tables, which has been further clarified. See answer above regarding the procedures.

3. All d13C data should also be presented somehow in Tables or Figures and not merely in the text as is currently the case.

Reply:The d13 C data of sediment surface, Z. marina leaves and rhizomes has been added to table 1.

4. The authors provide estimates for Corg accumulation but it's very unclear what these actually represent and how they should be intepreted. In their study, they measured sedimentation rates using sediment traps (hence, the downward flux of suspended matter and OC) but this is not the same as OC accumulation rates, since much of the OC reaching the surface is likely to be mineralized rather than buried.

Reply:We fully agree with the reviewer and to address this issue we did not use the sedimentation rates we measured ourselves in the Corg accumulation calculations, instead we used the sediment accumulation rates from literature, that have been ob-

tained from either 210Pb analysis, radiocarbon dating or long term monitoring (see answer for question 6 and below). Using published peer-reviewed values for sedimentation was the only possibility here (as in several other papers, e.g. Duarte et al. 2013, Lavery et al. 2013) as obtaining 210Pb cores was beyond the scope of this investigation.

5.%OC and d13C data should be clearly shown for the sediment trap samples and sediments profiles.

Reply:We have presented the POC depth profiles for all our study sites (Fig. 3). We found it uninformative to present the d13C depth profiles for all of the study sites. This is because we analyzed d13 C depth profiles for 8/10 Danish sites and saw no significant change in the isotope signal with depth. For that reason, and due to costs of analysis, we decided not to analyze the d13 C depth profiles from the remaining sites.Instead our focus is on comparing changes of d13 C signal from the sediment surface layer.

6. On L225-230 the authors explain how "Corg accumulation" was calculated: Results for carbon burial (applied by multiplying the Corg stock, regional seagrass area and sedimentation rate estimate from literature) in each area are given as Corg accumulation (t y-1)". This does not make sense, since (i) this formula does not match in terms of units (Corg stock: g C m-2; area: m2; sedimentation rate: g DW m-2 y-1; so you end up with gC x g DW m-2)

Reply:We have clarified this part in the MS. We used sediment accumulation rates from the literature that were presented in mm y-1, not our own sedimentation rates that were expressed in gDW m-2 y-1,and only represent a snapshot of the sedimentation and not the sediment accumulation rate (see further details below).

7.Why use sedimentation rates from the literature when you measured these with your sediment traps?

Reply:Sediment traps were deployed for short period of time (48 hours), and represent

temporally a snapshot of the sedimentation and not the actual sediment accumulation rates. The sediment traps were used for comparison of sedimentation rates between Finland and Denmark, as well as to evaluate the input sources of material to the sediments through the sedimentation process.

The sediment accumulation rates from literature were either based on 210Pb profiles, radiocarbon dating or long-term sediment trap deployments (Duarte et al. 2013,Serrano et al. 2014, Miyayima et al. 2015). The accumulation rates applied here vary from 0.32 mm y-1 to 4.2 mm y-1. Notably these numbers are very conservative estimates for sediment accumulation in coastal areas as higher rates can be expected.

8.The literature sources referred to here for sedimentation rates are not from these sites, hence they are unlikely to be very meaningful.

Reply:See previous answer. In addition, there are very few publications (Duarte et al. 2005, Fourqurean et al. 2012, Lavery et al. 2013, Geiner et al. 2013, Serrano et al. 2014a, Serrano et al. 2014b, Miyayima et al. 2015) that have reported sedimentation rates/ sediment accumulation rates in seagrass meadows and even less for Zostera marina on the northern hemisphere (Greiner et al. 2013, Miyayima et al. 2015). We made multiple literature searches and reviewed a number of papers, and are confident that the values used in our context (0.32, 2.02 and 4.2 mm y-1;Duarte et al. 2013,Serrano et al. 2014, Miyayima et al. 2015) are relevant.

As sediment accumulation data is generally very sparse, using literature data is often the only option for providing estimates for Corg accumulation in seagrass ecosystems. A similar approach to estimating Corg has been used in several influential research papers (e.g. Duarte et al. 2005 (cited 500 times), Lavery et al. 2013 (cited 50 times).

9. In order to obtain Corg accumulation rates for your study sites, the %OC profiles should be combined with sediment dating techniques (e.g. 210Pb) or site-specific sedimentation rates.

Reply:See answers above.

10.Authors mention a few times that sediment density is a factor that partially explains the OC stocks. This is not a causal factor – density and %OC are expected to be inversely related in sediments since organic matter has a much lower density than the mineral fraction. See for example the supplementary information in Donato et al. (2011) Mangroves among the mostcarbon-rich forests in the tropics. Nature Geoscience, doi:10.1038/ngeo1123.http://www.nature.com/ngeo/journal/v4/n5/extref/ngeo1123-s1.pdf

Reply:We do not understand this comment, as our data showed exactly this: high organic matter content sediments had the lowest sediment dry density as sediment dry density decreased with increasing OM content.

11.L233: be more specific in terminology: how do you define “eelgrass carbon sequestration rate”: carbon burial ? net primary production ?

Reply:To clarify this, we have now added a definition for carbon sink capacity in line 57 and for carbon sequestrtaion in line 60.

12. Why do you need this (a rate) to calculate the total Corg pool (= a stock)?

Reply:We have changed this part in the ms and used Corg sequestration estimate calculated from our own data. In the calculation the Corg sequestration estimate is added to the POC we measured from above- and belowground biomass of Z.marina and the mean Corg of sediments to obtain a value for total Corg in the study area. Calculation is shown below. Carbon components for calculation of value or price:

DENMARK FINLAND 1. Annual C sequestration 0.35 ton/ ha 0.05 ton/ha Lost C sequestration each year over 100 yrs in Denmark 0.35 ton/ha x 100 = 35 t/ha

2. C in living eelgrass Denmark: Finland: Mean proportion aboveground POC in Zm 35% 38% Mean Proportion belowground POC in Zm 29% 36% Average aboveground

biomass 145 gDW m-2 101 gDW m-2 Average below ground biomass 148 gDWm-2 79 Proportion POC aboveground 50.7 g m-2 = 0.51 t/ha 38.4 g m-2 = 0.38 t/ha Proportion POC belowground 43 g m-2 =0.43 t/ha 28.4 gm-2= 0.28 t/ha Tot. abgr + belgr POC in living Zm 0.94 t/ha 0.66 t/ha 3. C in sediments Corg mean of n=10 sites 43.6 t/ha 6.27

TotC DEN= 0.35+0.94+43.6= 44.9 t/ha or 4490 t/km2 TotC FIN= 0.05+0.66+6.27= 6.98 t/ha or 698 t/km2

13. L326: how can the Corg stock be as low as <0.001 mg C cm-3 ? Please check these numbers. You refer to Figure 3 here but I don't see these low numbers on Figure 3.

Reply:These values are correct, but represent the mean from each site with standard error of mean. Many sites had replicates with POC (mg C cm-3) concentration below detection limit (0.001).

Minor comments:

14.L17: account –>accounts Reply:Corrected.

15. L17: oceanic carbon burial : organic ? total ? Reply:Corrected.

16.L19: organic carbon Reply:Corrected.

17. L20: accumulation rates Reply:Corrected.

18.L24: organic carbon Reply:Corrected.

19. L27-28: these should be expressed in areal rates (or in areal rates + integrated over the relevant areas)

Reply:The lines the reviewer is referring to (L 24-25) are areal estimates. A conservative estimate of the total organic carbon pool in the regions ranged between 6.98-44.9 t ha-1. Our results suggest that the Finnish eelgrass meadows are minor carbon sinks compared to the Danish meadows, and that majority of the Corg produced in the

Finnish meadows is exported. Similarly, the estimates for Corg accumulation in eelgrass meadows in Finland (< 0.002- 0.033 t C y-1) were over two orders of magnitude lower compared to Denmark (0.376-3.636 Corg t y-1).We have added a column to Table 2, in which we present the Corg sequestration rates calculated individually for the different study regions.

20. L29-30: see comment above regarding density

Reply:See answer 10.

21. L31: DistLm: explain

Reply:Explanation added.

22. L44: Atmospheric carbon dioxide

Reply:Corrected.

23. L59: 10ËĘ-10 : something wrong here. Express this is e.g. PgC

Reply:Corrected.

24.L66 and further: salinity has no units – avoid using psu

Reply:Corrected.

25.L73-74: 7% decline per year – but a total 29% loss since 1879; these numbers are indeed often cited but they are somewhat at odds – if the 7% per year is consistent, that would lead to >29% loss in 4 years.

Reply:These numbers are directly from Waycott et al. PNAS. 29% of the known global areal extent has disappeared since seagrass areas were initially recorded in 1879. Rates of decline have accelerated from a median of 0.9% yr-1 before 1940 to 7% yr-1 since 1990. According to one of the authors, this is calculated as 7% of the total remaining at the end of each year, which means that the actual amount of seagrass area lost decreases each year because the total decreases each year.

26.L96: “typically faster”: ambiguous: do you mean that seagrasses have faster turnover rates, or other sources ?

Reply:Corrected.

27.L98: use the correct terminology: “isotopically heavier in d13C” is not correct: “enriched in 13C”, or “have higher d13C values”

Reply:Corrected.

28.L103-106: explain how identifying/constraining sources can lead to more reliable estimates of the capacity of the meadows to store and sequester carbon. I don’t think this is the case – they allow you to budget the fate of seagrass C more accurately, but to determine the organic C stores or sequestration rates, you don’t need the source information ?

Reply:We agree with the reviewer′s comment and have rephrased this part in the ms.

29.L333: “ranged from”: but then you provide an average +/- stdev.

Reply:Corrected.

30.L385 and elsewhere: when presenting a range of d13C values, provide the lowest (most negative value) first.

Reply:Corrected.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/bg-2016-131/bg-2016-131-AC1-supplement.pdf

---

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-131, 2016.