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Biogeosciences Discussions

Interactive comment on "Micro- and mesozooplankton community response to increasing CO_2 levels in the Baltic Sea: insights from a large-scale mesocosm experiment" *by* S. Lischka et al.

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RC: Referee comment #2

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Micro- and mesozooplankton community response to increasing CO2 levels in the Baltic Sea: insights from a large-scale mesocosm experiment

General comments

Ref #2: The ms. is interesting since it is one of the few studies where CO2 effects on whole plankton communities have been studied in ca. 55 m3 mesocosms. This provides a more realistic setting than single species experiments in smaller experimental units and allows for community effects to be realized. At the same time, the large mesocosm approach used provides some interpretation problems. With no replicate mesocosms in each of the manipulations, statistical analysis is difficult. The fact that the temporal variability of most species during the experiment greatly exceeds the minor differences between the CO2 manipulations makes difficult to detect any patterns caused by CO2. This problem has been partly but not wholly circumvented by using GAMM and GLM models. Also, as with many community studies, it is very difficult to distinguish between direct and indirect (food web) effects, and many of the conclusions remain speculations. The strongest evidence is found for (statistically significant) effects of temperature on microzooplankton abundance, and CO2 effects on certain microzooplankton taxa. Indirect effects on cladocerans, instead, remain on a weak ground. Also, the suggested changes in the food web efficiency (enhanced carbon transfer to higher trophic levels) due to increase of cladocerans are not fully warranted and are not supported by data (see detailed comments).

Author response: We thank referee #2 and appreciate the constructive criticism and comments very much that will certainly help to improve our manuscript substantially. As a general response from our side, we just like to point out that we are aware of the complexity and limitations of such community mesocosm studies in particular the difficulty to assign certain changes to specific factors. Please find our detailed response to all points raised including suggested modifications in the following.

Detailed comments

Abstract Ref #2: The abstract is clear, but some of the conclusions are speculative and probably do not merit mentioning in the abstract (see below).

Author response: The abstract will be modified in consideration of all revisions applied on the manuscript.

1. Introduction

Ref #2: The Introduction is generally well laid out and informative. It gives a proper justification for the study. Where is “Storfjarden” and “Tvarminne”? (page 20029 / line 2, line 6)

Author response: Tvärminne and the Storfjärden area is an open archipelago area on the eastern side of the Hanko peninsula on the south-west coast of Finland. A map showing the study site and mesocosm moorings is included in Paul et al. (2015). We will include this information in a revised version of the mansucript.

2. Methods

Ref #2: The field, laboratory and statistical methods are generally valid. Lack of replicates however creates difficulties in statistical analysis of data.

Author response: We are aware of this problem, however, a rash of particularly logistic, financial and time constraints make a more elaborate experimental design to allow disentangling multiple factor effects on a community level almost impossible to conduct in practice. Despite these potential shortcomings, we think that our approach allows for some valuable insights into possible effects of increased pCO2 concentrations on the plankton community level under at least close to in situ conditions that were otherwise not possible to obtain under at least semi-controlled conditions.

3. Results

Ref #2: The results are presented in a clear manner, but are a bit too exhaustive. The most interesting phenomena are swamped under a load of detailed descriptions of population variations, many of which are impossible to explain.

Author response: This comment is more or less consistent with referee #1. We will

consider this comment carefully and rephrase the text to focus better on the most interesting and important results and shorten the amount of too detailed description of population variations.

Ref #2: To clarify the temporal patterns, and relate them to the minor differences between CO2 manipulations, it would be useful to show the CO2 development in each of the mesocosms.

Author response: This is a similar comment as given by referee #1 who suggested to include temperature, chlorophyll a and Shannon diversity, respectively into Fig. 1, 3 and 4. We would like to point out again, that this will increase the number of (sub-) plots. We will try out if including the CO2 development results in an adequate gain of data visualization and based on this decide whether to show such plots or stick to the original plot.

Ref #2: 3.1.4: It would also like to see the temporal development in the Shannon index H.

Author response: Same reply as already given to referee #1: Fig. 4a is meant to visualize the significant change in Shannon diversity with the daily change in fCO2. In Fig. 3, percent contribution of specific groups is plotted against the mean fCO2 in a treatment. Including H values over the course of the experiment into the individual graphs by adding an additional y-axis wouldn’t result in the same resolution of change in H, therefore we would like to keep Fig. 4a as it is. But we will try out what gain the addition of H values in a new Fig. 3 would bring and, if meaningful, present H values over time in Fig 3 also.

Ref #2: 3.1.5: Please add a short written summary of the most important findings of the statistical tests. At least those that you will also deal with in Discussion and mention in the Abstract

Author response: We will do that.

4. Discussion

Ref #2: 4.1.1: Page 20044, lines 16-20. ("While... respectively") - An unclear sentence

Author response: To make it clearer, we will rephrase this sentence towards: "We found no significant relation between microzooplankton total abundance and fCO2 concentration but total abundance was significantly affected by temperature. Moreover, there seemed to be a trend with respect to species diversity H towards a higher dominance of single species with increasing temperature and fCO2, respectively."

Ref #2: 4.1.1: Page 20045, lines 2-3. Mentioning that "significant relations were determined for all factors" is not very helpful. rather pinpoint the most significant and meaningful findings.

Author response: We will consider this comment carefully in a revised version and better detail the most significant and meaningful findings.

Ref #2: 4.1.2: May Myrionecta... This chapter is very speculative. I would condense this to minimum – or reject it totally.

Author response: This comment is consistent with referee #1 and we agree in principal (see our response to referee #1). In a revised version we suggest to cut this section to a minimum but keep the main statements that we think could provide some likely explanations.

Ref #2: 4.2: mesozooplankton. There is not much relevant discussion on the cause-effect relationships in this chapter. If no significant relations were found, I would not expand the discussion by adding a chapter on each of the Results chapters. E.g., you can easily delete chapter 4.2.2 Mollusks.

Author response: We agree with referee #2 that this section has some potential for shortening. We suggest the following for a revised version of the manuscript: We would like to keep the more general part that puts the mesocosm community in relation with the natural succession of MZP in Tvärminne/Storfjärden as this parts helps the

reader to classify our study compared with the natural succession. As we are not presenting accompanying field data, we think this is helpful information for the wider context. Further, we will condense section 4.2.1 (copepods) to the most important points and omit section 4.2.2 (Mollusks).

Ref #2: 4.2.3: The long speculation on the "Cladocera-OA effect" is also far too stretched. The data do not show any effect of chl a on cladoceran abundance. Finding evidence in some imaginary phenomena ("missed peaks between samplings") is not a good strategy either. (Page 20052, lines 6-9).

Author response: We agree and will cut this section substantially. But in the same line as we argued above with respect to the discussion on Myrionecta rubra, we think that our considerations are not completely unfounded and shouldn't be completely neglected pointing out. The abundance differences in at least 3 of the elevated CO2 mesocosms were substantial and together with the considerations on the reproductive biology and food preferences of Bosmina suggest for some most likely indirect cause-effect patterns related to CO2 conditions that our experimental approach could not reveal. Therefore, in a revised version we would like to keep a revised part of the discussion and agree to substantially cut it down and focus on the most important and most justified statements.

Ref #2: 4.2.3 The finding of correlation between empty-filled brood chamber ratio and CO2 and chl a is interesting, but, again, too many variables covary. All in all, if all phenomena on cladocerans are mediated through food, it is very speculative to say that CO2 will have any effect. There are simply too many open issues between the relationship between CO2 increase and Bosmina food conditions in the Baltic Sea.

Author response: We agree with the reviewers concern of being too speculative here (again). In line with our argumentation above, we suggest to substantially tone down our statements and underline the more speculative nature where appropriate.

5. Conclusions

Ref #2: The authors suggest that an increasing amount of filter feeding cladocerans (Bosmina) enhances carbon transfer to higher trophic levels due to enhanced usage of organisms of the microbial loop. Yes, filter feeders, like Daphnia, use bacteria and nanoflagellates for food, but Bosmina are not non-selective filter feeders, and many copepods also feed on flagellates. This complicates the picture. Also, Wikner & Andersson (2012, Global Change Biology 18: 2509-2519) claim that channeling more energy through microbial loop decreases the food web efficiency, and, hence, transfer of energy towards the higher trophic levels, including fish. If the authors want to retain this part, they should at least back up their conclusions with references, and include a description of the food web, clarifying who is eating whom, and how carbon will be channeled in each case. Actually, it is not obvious that Bosmina are much eaten by fish. Instead, it is possible that small cladocerans are suitable food for mysids and predatory cladocerans, like Cercopagis pengoi. Studies exist for the Baltic Sea for such interactions. How does this affect the conclusions on the trophic efficiency?

Author response: We will carefully consider the reasoning above and re-evaluate our logic. In particular we will take into account influence of other environmental drivers on carbon flux and the balance between auto- and heterotrophic processes in dependence on the mentioned publication by Wikner and Andersson (2012) and further consolidate the conclusions we will finally arrive at with references and a more detailed food web description.

Ref #2: However, despite some shortcomings, there are valuable parts in this ms. If nothing else, the study shows that some CO2 effects can be seen at community level, but that the effects are complex and difficult to study in any type of experiment. This is useful information as such.

References:

Paul, A. J., Bach, L. T., Schulz, K.-G., Boxhammer, T., Czerny, J., Achterberg, E. P., Hellemann, D., Trense, Y., Nausch, M., Sswat, M., and Riebesell, U.: Effect of elevated

CO2 on organic matter pools and fluxes in a summer Baltic Sea plankton community, Biogeosciences, 12, 6181-6203, doi:10.5194/bg-12-6181-2015, 2015.

Interactive comment on Biogeosciences Discuss., 12, 20025, 2015.