

Response to Reviewer 1:

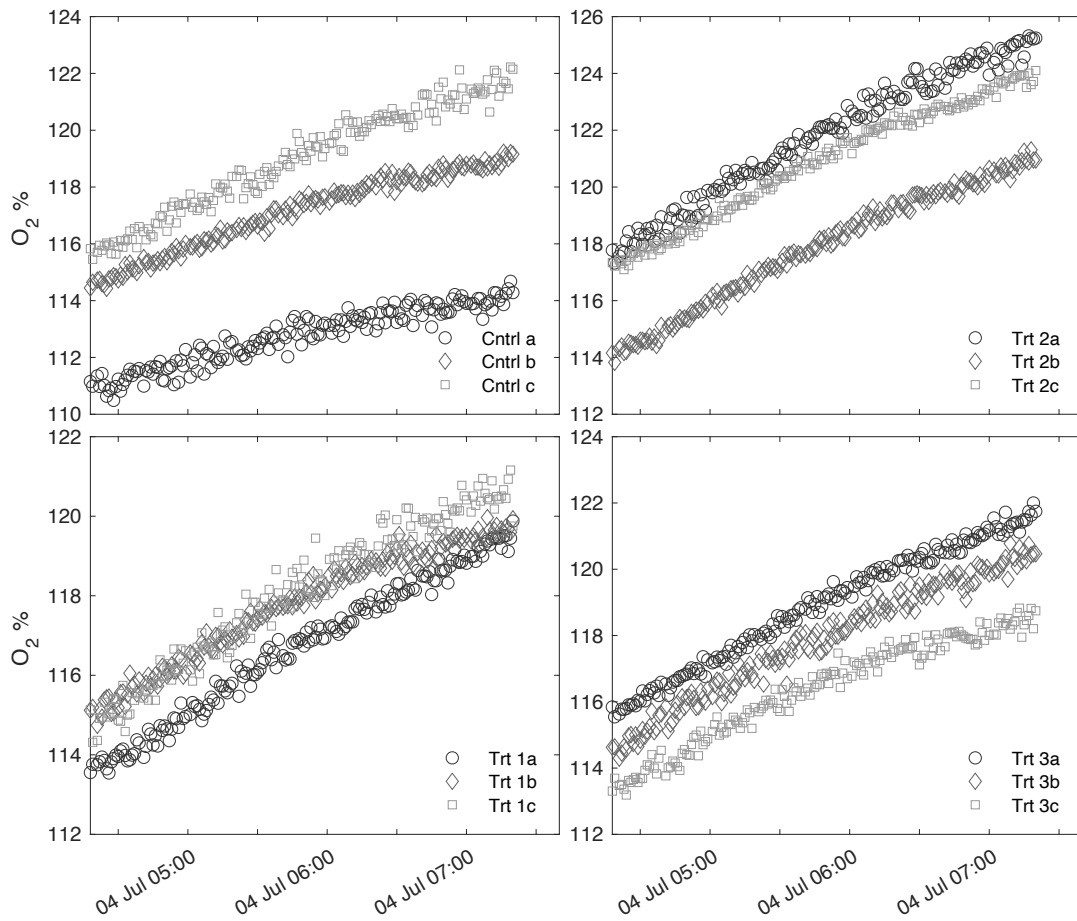
We would like to thank the reviewer for their time and comments. There are many relevant points of concern pointed out and we have tried to address these as best possible by adding clarity and detail. Some concerns by the reviewer we feel are out of scope for a technical paper, however, we have attempted to resolve these points to a degree we feel relevant. We hope that the substantial changes are sufficient as a revision to be considered for publication.

Please find below our response to all comments and concerns raised by the reviewer in bold typeset.

Summary response and major concerns by the reviewer 1:

- 1) The introduction lacks a profound description of the Kongsfjord hydrology **We understand the concern about a lack of detail regarding the location of the setup. Since we focus more on the system which can be deployed in a variety of locations, we feel that a site description is best fit in the Methods section. Please see our added detail regarding site description in the revised manuscript, section 2.2.**
- 2) A referenced figure (S2) is missing: We apologize for not removing this residual figure reference as the original S2 figure was part of a previous manuscript iteration. It was removed due to poor image quality. **We have incorporated a new image of the setup in an updated figure 1.**
- 3) the three graphics in figures 1 and 2 mainly show the same but in detail are all different and inconsistent to an extent that it is almost impossible to really understand the setup. **We thank the reviewer for this comment and agree that the presentations in both these figures don't share coherence due to their schematical orientation. We have now combined figures 1 and 2 which we hope provides better detail about the experimental setup, as well as affording a visual of the system. Please see figure 1 in the revised manuscript.**
- 4) The discussion is mainly complaining about the problems that occurred in the beginning (and that they were solved) while it should show how strong the system is and what makes it special in comparison to other outdoor mesocosm systems (like e.g. Wahl et al. 2015). **We thank the reviewer for this comment and have rewritten the discussion to highlight the novelty and strengths of the system. We hope the newly written discussion projects this orientation.**
- 5) Finally, the structure of the paper as well as the language are not always clear and precise (you may ask a native speaker to review the text) and – as no biological data are shown – the proof is missing that the system can create a biological effect (I don't really doubt this but it has to be shown). **We have gone through the manuscript with finer detail to**

assure lucidity throughout. We respectfully disagree with the reviewer that there needs to be evidence of a biological effect. As per suggestion by reviewer # 2, we have chosen to remove details about the biological component and focus more on the system itself. We agree with this suggestion as the aim of the manuscript is to show the functionality and assess the potential to manipulate environmental parameters, not to assess a biological response. We have, however, provided a figure below showing the continuous measurement of oxygen during an incubation to provide a visual of the biologically induced response. For further evidence of the experimental results that utilized this system we will provide reference to Miller et al. (community level effects) and Lebrun et al. (organismal level effects) as soon as the preprints are available. We will update this interactive discussion with the link to the preprint as soon as possible.



Incubation 1 for the control and treatment conditions.

Response to line comments by reviewer 1:

LL 97-100 “The rapidly changing conditions in...”: Please move this sentence up and add information to write a new paragraph where you roughly describe the abiotic oceanographic conditions in Svalbard fjords including the correlations between temperature, salinity and light conditions. **We have removed this sentence and included a version of the content in a broader description of Kongsfjorden in the manuscript. This new section (as suggested by the reviewer above) has been shifted to the beginning of the Materials and Methods section: 2.2.**

L 107: change to: ‘...treatments that represent expected future conditions...’. **We have reworded and changed this sentence. Please see lines 147 – 150 in the revised manuscript.**

L 109: change to: ‘...present at 7 m depth’ (delete the ‘a’). **This has been corrected.**

L109-110: change to: ‘The treatments were realized by multi-stressor combinations of temperature, freshening and irradiance (Table 1).’ **This sentence has been changed to reflect the reviewer’s suggestion.**

L110-112 “The response of communities...”: I understand that you want to publish your data in a separate paper. However, when you want to publish a technical note on your system, you need to show that your system works and that the treatment has an effect on the biology. Hence, I expect that you show at least some biological results of a pre-experiment or similar... Otherwise, I suggest to use the here presented data in the (extended) method section of the other manuscript - and not as a stand-alone paper. **We understand the concern of the reviewer to show the biological response of the organism(s) exposed to the treatments as a proof of application, however, we respectfully disagree that showing biological data is a standard procedure when describing an experimental system (e.g., Jokiel et al. 2014; Olariaga et al. 2014). We especially believe we can prove that an experimental system can work even if the simulated treatments do not have an effect on biology. The guidelines of a Technical Note also do not mention this within the scope of the journal. We feel that we have appropriately shown that the system can modify and regulate the salinity and temperature as described in the manuscript. To alleviate any concern about being able to stimulate a biological result, we point the reviewer to our response above which includes a plot of oxygen evolution during one of the incubations. We can also provide an update to this interactive discussion once the partner manuscript is published as a preprint.**

Jokiel, P. L., Bahr, K. D., and Rodgers, K. S.: Low-cost, high-flow mesocosm system for simulating ocean acidification with CO₂ gas, *Limnology and Oceanography: Methods*, 12, 313–322, <https://doi.org/10.4319/lom.2014.12.313>, 2014.

Olariaga, A., Guallart, E. F., Fuentes, V., López-Sanz, À., Canepa, A., Movilla, J., Bosch, M., Calvo, E., and Pelejero, C.: Polyp flats, a new system for experimenting with jellyfish polyps, with insights into the effects of ocean acidification, *Limnology and Oceanography: Methods*, 12, 212–222, <https://doi.org/10.4319/lom.2014.12.212>, 2014.

L114-116: “The salinity offsets...”: This comes here a bit out of nowhere. Needs explanation of the fjord conditions here or (better) in the introduction. **We have simplified this portion of the text and incorporated it into a more comprehensive description of the experimental design**

from lines 156 to 163 in the revised manuscript. Section A1 now discusses the details of this calculation.

L123: Fig. S2 is missing. If you don't have a good picture, please add a proper sketch to show the complete setup including the tanks (important to understand what you did). Also, the readers need to know how the treatments were distributed across the mesocosms... **We apologize for this discrepancy and have removed this figure reference. A photo of the system can now be viewed in the newly created figure 1 in the revised manuscript.**

Paragraph 124-131: Move this paragraph down after the whole system description (as a new paragraph 2.6). **We have removed this section completely as it was determined not to be very relevant to the system performance. This decision was made based on the newly written methods section and comments from reviewer 2.**

L124-125 "...experimental unit (i.e. a single mesocosm)...": What are these? Describe the mesocosms first, and then the organisms you put in. **This description has been removed in the revised manuscript.**

L139-131 "...with total biomass weights ~400 g for urchins and < 150 g for snails and seastars...": Please give the numbers of animals per tank! (very difficult to imagine the community from these weights...)! And: dry or wet weight? **This information has been removed in the revised manuscript.**

L137-138: You give the names and manufacturers of all the other devices in the table (which is actually table A2) also in the text. Why not these sensors, here? Please be consistent! **We have added the names and manufacturers to the in-text reference.**

L138: Its table A2! **We apologize for this discrepancy and have corrected this table reference.**

L146: Was the water temperature in the sub-header tanks also measured / logged? If yes, mention here! **The temperature was not measured in the sub-header tanks, it was only measured *in situ* at the COSYNA station and in each mesocosm. The text has been updated on lines 212 – 223 to clarify this point.**

L147 'constant flow': give flow rate. (or add: 'see below'). **We have reworded this sentence to describe the maximum flow rates rather than the flow rate to each mesocosm. We describe this later in section 2.3 of the revised manuscript.**

L154: What are 'weekly whole-system incubations'. Explain! **Given the comprehensive restructuring of the manuscript and removal of the biological description of the experiment we feel further explanation regarding this point is not relevant in this manuscript. This sentence has been revised to point the reader to these methods and results elsewhere. See lines 314 – 316 in the revised manuscript.**

L157: Can you please give some information on the quality (alkalinity) of the tap water on Swalbard? Is it ground water? Or from melted ice? Background: in some regions the tap water has very high alkalinity and significantly changes the water chemistry when used to reduce salinity... **The tap water in Ny-Ålesund is sourced from the Tvillingvann reservoir. Throughout this experiment we took several alkalinity measurements. For three consecutive weeks the average alkalinity in the control condition was: 2240, 2221, and 2202 and 2049, 2053, 2032 $\mu\text{mol kg}^{-1}$ in the treatment 2 condition, which had a salinity approximately 5 units lower than the control (i.e., 34 to 29). The difference between these three consecutive weeks in alkalinity were 190, 168, and 169 $\mu\text{mol kg}^{-1}$. Recently published data in Gattuso et al. (2023) reports a TA-salinity relationship of $\text{AT} = 47.6 \times \text{S} + 643$ for a salinity range from 32 to 35 with an RMSE of 17 $\mu\text{mol kg}^{-1}$ in Kongsfjorden. Using this equation, we estimate an alkalinity difference of 238 $\mu\text{mol kg}^{-1}$. While this estimate is higher than our observed changes, our measured values were reasonable indicating no need for concern. Further, elevated alkalinity in freshwater is irrelevant for the functioning of the system described.**

Gattuso, J.-P., Alliouane, S., and Fischer, P.: High-frequency, year-round time series of the carbonate chemistry in a high-Arctic fjord (Svalbard), Earth Syst. Sci. Data, 15, 2809–2825, <https://doi.org/10.5194/essd-15-2809-2023>, 2023.

And: If the mixture with the tap water was done after the temperature adjustment: Why did this not change the temperature? **The tap water was warmer than the fjord water. The freshwater was mixed alongside the incoming temperature adjusted water. However, the system would regulate the inflow of warmed water to compensate for any temperature change induced by the freshwater supply. We have added a brief explanation of this in the revised manuscript. Please see line 200 – 202 in the revised manuscript.**

L158: add ‘by’ between ‘rates’ and ‘using’. **This section has been rewritten.**

L166-167 “The inlet which is located...”: Please describe better in detail or give a map. It should be possible to understand the position of the Ferrybox relative to the point where water is sucked-in for this experiment without the need to click a link... **We have added a detailed description of the flow-through system which is now easily trackable in the new figure 1 and section 2.3. We specifically report the position of the FerryBox (see lines 215 – 216 in the revised manuscript) and make clear the inlet reference is referring to the header tanks.**

L171-172 “Regulation was maintained via regulation flow valves utilizing...”: change to ‘Nominal values were maintained with regulation flow valves by utilizing ...’ **This part has been eliminated and a variation is now present in the newly written 2.3 section.**

L176: Explain ‘PID’. Never use abbreviations without explaining them at 1st mention! **We apologize for this discrepancy and have added an explanation of the abbreviation as proportional integral derivative.**

L178 "...using a software PID controller": replace 'a' by 'the' **This has been changed from "a" to "the"**.

L179-180 "...in PoE mode (proportion on error).": Explain what it does, e.g.: '(proportion on error), which...' **We have corrected this to state 'Power over Ethernet' and have added a description as suggested by the reviewer. See lines 647 – 649 in the revised manuscript.**

L180: replace 'measure' by 'measured value' **This has been corrected.**

L181: replace 'setpoint' by 'nominal value' **This has been changed to 'nominal value'.**

L191 "...to the mesocosms.": Add: (Fig. 1 and 2) **We have added the figure reference.**

L193: This is confusing: the three sensors are the pressure sensors of the three lines (ambient, cold and warmed), right? And Kp, Ki, Kd are the coefficients which are described above and which are realized on the software level for each sensor (I guess). Clarify! **We have clarified this in the text to make clear that reference to the sensors are different than the coefficients described earlier. See lines 650 – 654 in the revised text.**

L196 'hand-crank valves': can these be seen in Fig. 1? Figure 1 is missing a proper figure legend describing all different valves. The hand-crank valves are missing in figure 2(?) **We made a new figure 1 where the hand-crank valves can be seen and are labeled accordingly.**

Figure1: In figure 1, the flow sensors (I guess) are placed AFTER the hand-crank valves. There are two pressure regulation valves for the ambient seawater...? The temperature regulation valves are labeled 'control' and 'treatment'. Harmonize! **We have made a new figure 1 to align with the flow of the system.**

Figure2: I believe you mixed-up the labels for ambient water and warmed water inlet. **This figure has been eliminated.**

Figures1 and 2: Overall, figure 1 and the two pictures in figure 2 don't fit very well together. EG in the photo one can see that the ambient seawater line in reality came from the other side. And not all valves are seen in all pictures and they are labeled differently and have even some errors. This makes it very difficult to understand your setup. The reader gets the feeling that you rather show the pictures because they are beautiful and not to help us to understand what you did. One even may think you didn't understand the figures yourself...

I recommend to maybe show only 2 of the 3 pictures and absolutely make sure they show the same (with same labels).

We have made a new figure 1 which shows a more detailed diagram of the flow of the system.

L 203: replace 'a single' by 'an individual' **This has been replaced.**

L203: 1 – 3, respectively. **This has been added.**

L206: branched (no capital B) **This has been corrected.**

Figure A2: The color of the digital communication is different in the legend (red) than in the figure (black). The lines are too thin to easily see the colors. **We have corrected this and made the lines bolder.**

L209: sending it to an FTP server. **The word “it” has been added.**

L210: replace ‘made’ by ‘ensured’ **This change has been made.**

L211: End sentence after ‘cables’: ‘...cables. The communication between the PLCs...’ **We have made this correction.**

L212-214: ...using a half duplex RS485 (2 wires) protocol, with an analog 4-20 mA and an analog 0-10 V signal, respectively.’ **We have made this correction.**

L215 “...security switch”: Add ‘(Fig. A7)’ **We have made this change.**

L220-224: I'm not familiar with C++ and, hence, cannot comment on this section. **We have kept this description; however, this portion of the text has now been moved to the appendix.**

L234: replace ‘valve-open percentage’ by ‘valve opening percentage’ **This section has been rewritten and now states “valve opening position”**

L242-244 “The microSD...”: Delete sentence. **This sentence has been rewritten. Please see lines 239 – 240 in the revised manuscript.**

L246: “2.5.1 Menu bar”: Delete, as there is no 2.5.2: **This has been reassigned its proper section number.**

L247: add ‘of the PC application’ (or similar) after ‘menu bar’ **We have added this suggestion.**

L249-250 “There is also an exit button...”: Commonplace: Delete. **This sentence has been removed.**

L266-267 “Loading should be done...”: ??? Weird sentence that causes more irritation than that it helps. Delete (I guess)... **This sentence has been deleted. We agree with the reviewer that this does not aid the reader.**

L285-289 “The control condition..”: Sentence doesn’t work. Rephrase. **This has been rephrased.**

And: Actually, I would prefer to see the figure of the true temperatures in the system (fig A5) first (and have it discussed) - and then the figure with the deviations from control (fig. 3). **We**

recognize the reviewer's suggestion but disagree with where this figure should appear. We feel that the logical flow of the results section in the manuscript is appropriate as is: presentation and discussion of the regulation of the control condition followed by the performance and regulation of the treatment conditions in the following section. We have however, moved the figure out of the appendix and placed it into the main part of the manuscript and refer to this figure sooner in the text.

L191-305: Problems with the FerryBox and the 10m pump should Imo be placed into the discussion (separate section on technical problems (which you solved)). Also, as I see it, your experiment only started after you fixed the problem with the 10m pump. Instead of complaining about all the technical problems you had, you should show some biological data, here. **We agree with the reviewer regarding the placement of the technical issues and have moved them to the discussion while cutting extraneous detail. We disagree, however, that the experiment started after the 10 m pump came back online as conditions were actively being regulated before this time. Importantly, there was a stepwise increase for the treatment conditions during this period, which we feel is very much a part of the performance and experimental design.**

Given the newly written methods section and the removal of the biological portion of the experiment, we do not see the benefit to include this in the manuscript as it will be published elsewhere. We refer the reviewer to our response above regarding this initial concern as well as to the above plot showing an example of an incubation ground truthing the biological response of the experiment.

L310-311: 'the entirety of the planned experiment.': Repetition (in the bracket of the same sentence)! **The repetition has been removed.**

L316 "Due to technical..." : Same as above: move these technical issues with the temperature and salinity regulation to discussion section on technical problems! I mean: as can be seen in your figures, after you fixed the problem with the 10m pump, the system overall worked pretty well. But in your results, you are mainly complaining about technical problems. This is not very nice to read and almost completely hides what you achieved. **We agree with the reviewer's comment and have rewritten portions of results as well as moved descriptions of most technical issues to the discussion.**

L323: '...(Table 2) were due to various anomalies: In the event...' **This sentence has been removed.**

L385: '...are examples of how improvements that were made during the experiment will allow for a more robust deployment in future.' **This sentence has been removed in the new version of the manuscript.**

L388-389: I suggest that you show some biological data from deployment 1 in this paper to show that your system had an biological effect - and use the 2nd deployment for your 2nd paper which then deals with your actual biological questions... **We feel that the suggestion by the reviewer regarding the biological data is not pertinent to the description of the system in this**

manuscript. We have made many changes to this manuscript which focus on the deployment and operation of the system while significantly reducing any component of the biological experiment performed.

L390: attempts **We have changed ‘attempting’ to ‘attempts’.**

L390: ‘mixing 'chilled' with 'ambient' seawater’ **We have changed the placement of ‘seawater’ in this sentence as per the reviewer’s suggestion.**

L425-428: Who programmed the software? **The second author Pierre Urrutti programmed the software. We have added this to the contributions section**

Figure 3: ‘Regulation of the temperature offset from the set control value during...’ **We have rewritten this caption for clarity: ‘Regulation of the mean temperature offset for all conditions, including the control offset from the FerryBox, and the three treatment offset values from the control condition.’**

Figure A1: Replace scenario numbers by treatment numbers/names and add scenarios in only in the figure caption. **This figure has been remade with a new corresponding caption. Please see Figure A1 in the revised manuscript and the associated caption.**

Table A2: I understand that you don't want to mention the city and country of the manufacturer in the table as this might take a lot of space. However, I think this information is important as companies sometime change names are bought by other companies etc. - and this can cause confusion. Therefore, please give the city and country of each company in the table, in the table caption or in a separate table...**We agree with the reviewer on the importance of providing detailed information on the origin of manufactured products used in the system. The city and country of the manufacturers has been added to the table.**