

Interactive comment on “Free Ocean CO₂ Enrichment (FOCE) systems: present status and future developments” by J.-P. Gattuso et al.

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This is a nice and well-written paper describing FOCE systems, their advantages and drawbacks, technical challenges, and current use. I have no doubt that it will be very useful for potential users and to organize the FOCE community.

I only have a few comments and suggestions for minor changes.

1. Of course, FOCE can be used in the context of ocean acidification. However, it could also be considered for other CO₂ related questions. As mentioned in the manuscript, it may be interesting to increase pH to answer some evolutionary questions or test hypothesis regarding artificial alkalization. I suggest to extend the focus of the paper by replacing “ocean acidification” by something like “pH/CO₂ changes” (e.g. page

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4003, line 3; page 4005, line 10; page 4006, line 3; page 431, line 10).

2. Authors justify the use of FOCE by the fact that it allows working at the ecosystem level and compare with laboratory based experiments focusing on single-species. Something that is not very well presented in the manuscript is that you can also work at the ecosystem level in the lab (land-based mesocosms). This is a very important approach that can allow overcoming some of the drawbacks of the FOCE (but with other limitations): more replication, more controlled conditions (e.g. artificial or simplified ecosystems), etc. This approach has been used in the context of ocean acidification and should be better presented in the text.

3. The text is well-balanced but sometime tends to oversell the FOCE system.

For example, - Page 4006, line 26, delete “Although ideal in concept”. No experimental approach is ideal. - Page 4011, lines 10-16. This argumentation sounds a little desperate and is not needed. I suggest deleting. Sure there is value in using FOCE. All experimental approaches have value and no need to try to rank them (“more useful”). - Page 4016, line 16. “more realistic” than lab. This may not always be true if you consider large scale lab-based mesocosms. - Page 4029, line 7 “will deliver”, this is pushing it too far. “will contribute” would be better.

It is important to mention somewhere that all approach are important and that not a single approach is ideal when it comes to project future environmental changes. It is the combination of information collected in single-species perturbation experiments, monitoring, mesocosms, modeling that will allow to provide the needed mechanistic understanding and predictive power that is needed (we tried to make this point in our opinion paper Dupont & Pörtner 2013).

For example, our group developed some physiological models that allow making prediction for the response of a given species in a multiple and fluctuating world. We then validated this model in mesocosms (real world but only a limited set of conditions).

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One of the major limitations of the FOCE is that you can only test a few scenarios (due to low replication) and that it is then difficult to make strong generalization of mechanisms across a gradient. It is also true for the limitation in multiple sampling points (point 2.5). It is then important to keep the link and collaboration with the lab based work.

A table summarizing pros and cons (e.g. costs, replication, realisms, etc.) of different approaches may be interesting as well as a discussion on how these different approaches can help each other. This can be integrated in the conclusion and highlight the key role of FOCE in a multidisciplinary context.

4. For the point 7.4. you may also want to add that FOCE are charismatic experiments that can be used to attract public attention and contribute to ocean and climate literacy in the society.

Other comments:

- page 4004, line 6 “decreased availability of carbonate ions, used by many species to build calcareous shells”. Many species are actually independent from carbonate ions in seawater for their calcification are rather use HCO_3^- or metabolic CO_2 as a source. Maybe delete this?

- page 4011, line 29, Barry et al. (2010) was not putting a lot of emphasis on the importance to take into account natural variability when designing experiments. I suggest to delete this sentence.

- page 4012, line 9, “In contrast to many laboratory experiment...” I agree that using constant conditions is not realistic and that one of the exciting features of FOCE is to offset the natural variability. However, it is equally possible to mimic variability in the lab and many laboratories are not including variability in lab-based experiments. So i would avoid this comparison.

- Page 4020, line 9, “ocean acidification is detrimental to the precipitation of calcium

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carbonate”. In many example, it is not the precipitation in itself that is the problem but the maitenance of adequate internal conditions for calcification due to energy disturbance and increased dissolution. The paragraph is about net calcification so rather say that net calcification is often impacted by OA (very well documented).

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