

Reply to comment of Anonymous Review #1

Reviewer comment:

The manuscript by Oschlies et al. is the introductory chapter in a Best Practices Guide to OAE Research. The full guide will contain seven chapters, which compare and synthesise previously published methods, and offer guidance for future research. Given that Oschlies et al. have only written the introduction chapter it does not present new results or new research. The manuscript is very well written and presents a comprehensive overview of the need for climate dioxide removal (CDR), and the role the ocean can, or should, play. The description of ocean alkalinity enhancement (OAE) is detailed and comprehensive, yet the nuances are easy to follow and understand. The referencing is comprehensive, and I have not identified key publications that have not been, but should be, referenced here. I commend the authors on their overview.

The only issue, and the reason I suggest minor revisions, is about the timeline of our climate goals and how this affects the realism of the suggested CDR methods. The authors correctly state that the goals are to reach net-zero emissions by mid-century. We are now in 2023 so mid-century is quite close in time. Yet the technology necessary for CDR, and marine CDR in particular is in its infancy or non-existent (as noted by the authors of this manuscript). I have just read the introductory chapter so this topic may be covered elsewhere in the Best Practices Guide. But a (brief) section should be added to discuss the necessary timeline, and how realistic/unrealistic it is to achieve operational technology and methods to successfully implement marine CDR. Even if covered elsewhere this aspect deserves mention in the introductory chapter.

Response:

We thank Anonymous Referee #1 for the positive and supportive comment and the suggestion to include a brief section to discuss the necessary timeline for eventual implementation should OAE ever be deployed in a manner helpful for meeting current climate targets to reach net-zero emissions by mid-century.

We propose the following addition:

“The very few (a single-digit number according to the authors’ knowledge) field trials that have been carried out so far, or are being discussed in the year 2023, have the potential to take up a few tons of CO₂ per trial. For the various OAE approaches, technology readiness levels (TRLs) are relatively low, generally rated as 1-2 by Smith et al. (2023), 3-4 for specific approaches (Foteinis et al., 2022) and possibly approaching 5 for methods with first field trials in preparation or under way. Scaling up CO₂ uptake by several orders of magnitude to many million tons per year or possibly even a billion tons per year by mid-century is extremely ambitious. It would require all instruments, measures and policies put in place that can advance every option forward from its current readiness level. In their State of CDR report Smith et al. (2023) estimate that so-called novel CDR methods, which include OAE would need to be scaled up about by a factor 30 by 2030 and a factor of 1300 by mid-century in order to meet the demand expected for reaching promised climate goals.

Required average annual OAE growth rates will have to be around 50%, which is extremely ambitious compared to, for example, an average 9% annual increase in the global capacity of renewable energy (IRENA 2021). Whether or not CDR and OAE specifically can be scaled up sufficiently by mid-century will depend on progress over the next decade, which Smith et al. (2021) call ‘novel CDR’s formative years’. A possible advantage of most OAE methods is that, technologically, they appear relatively simple and rely, to a substantial degree, on technology that exists already for processing different mineral resources at annual rates similar to those that may be required by OAE by mid-century. A possible roadblock for rapidly scaling up OAE is a lack of public acceptance (Bertram and Merk, 2020; Nawaz et al. 2023).

In addition to technological challenges and acceptability issues that would need to be resolved, appropriate governance schemes will be needed if OAE is to be deployed at climatically relevant scales (Böttcher et al., 2021). The 2013 amendment to the London Protocol offers an approach for governing marine CDR, with a focus on ocean fertilization, but would need to be developed further with regards to OAE (see Steenkamp and Webb, 2023, this Guide). Interactions between OAE and other ocean-based activities will also need to be considered (e.g., via marine spatial planning), and any climate-relevant OAE deployment would require new or significantly expanded climate policies and financing schemes. Inclusion of OAE in carbon markets will require the establishment of robust MRV procedures.

All these issues need to be resolved before OAE could be implemented at large scale. Achieving this by mid-century is challenging, but not impossible. Research is urgently required on all aspects that are addressed in the various papers of the OAE guide 23.’

References

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