

September 13, 2023

Dear Editors

We wish to state at the outset our overall pleasure with the detailed and quality reviews provided. Please see below our response to this robust sets of comments. Following each discussion point, we reply in *italics* with line and section references noted in all but minor typographic changes.

Sincerely,

Terre Satterfield  
Sara Nawaz  
Miranda Böettcher

## REPORT 2

This paper brings understanding from public risk perception and engagement research to the problem of how research on OAE (ocean alkalinity enhancement) as a tool for CDR (carbon dioxide removal) can be both societally responsible and successful. The paper argues that this can (only) be accomplished through a program of methodologically sound social research and public engagement and lays out key priorities and methodological approaches to accomplish this. The paper is fundamentally anticipatory in its stance—it is looking ahead to problems and issues on the societal side that scientists and engineers, as well as policymakers, are unlikely to be considering at this early stage of OAE development, but should be. Thus, the paper situates its recommended approach to OAE within the anticipatory frameworks of responsible research and innovation (RRI) and anticipatory engagement that have been/are being used successfully in the deployment of other new technologies. This paper first presents a literature review on what is known about public perceptions of OAE and contextualizes this limited data in relation to views on (some) other conceptually adjacent? emerging technologies. It then discusses specific methodological challenges and tools for requisite public engagement across the different stages of development. And finally suggests how the integration of this social research should take place, for increased success of OAE research and innovation.

The audiences for this guidance are seen primarily as OAE natural and engineering scientists/researchers, developers, policy makers, and funders. The paper aims to provide these different audiences with suggestions for conducting and incorporating

necessary social science research and public engagement for responsible (and successful) development. The chapter concludes with specific tailored recommendations for both social scientists and scientists and engineers working together in this research space.

This paper in its aims and its execution aligns well with much current research and policy recommendations on responsible research and innovation. It is written in a highly accessible mode for its intended audiences, and provides careful definition and consideration of how the problem of how OAE (ocean alkalinity enhancement) research (as tool for CDR-carbon dioxide removal) can be both societally responsible and successful through a program of methodologically sound social research and public engagement. The authors propose the study of public perceptions of OAE as potentially risky or controversial is “worthy of exploration” and they draw particular attention to the diversity of views likely to emerge across relevant social groups, a critical issue for the innovation system to address with care. The need for social science research on public perceptions and public engagement that the paper advocates should not require this careful defense, but it absolutely does. So, the paper is making a necessary and useful intervention. The methods and approach they propose are also directly applicable to the larger marine-relevant and terrestrial CDR fields, within which OAE is just one approach, so there is potential broader application of this work. They rightly point out (141) that this is not a promotional piece.

A major strength of the paper is the depth of knowledge and understanding by the authors of perceptions of specific other adjacent fields to OAE and the wider marine and terrestrial environments for CDR, as well as energy, justice and climate mitigation fields, and the risk perception field itself. The paper thus can serve as both a detailed introduction to risk and benefit perception of technologies and consideration of the specifics of OAE as a technological risk object and a governance issue, across geographic scales.

*We are very pleased to hear that the purpose and audience for this paper is clear and well understood by this reviewer. They have understood us well, and summarized that succinctly here.*

### **Specific comments**

#### Section 2-Literature review(s)

The authors note, correctly, that just providing accurate scientific information and improving public literacy are unlikely to resolve public concerns, and the evidence they provide of some indications already of negative public views on OAE is important.

In approaching the review of the extant literature on OAE perceptions and arguably related other areas, they cite 8 'initial propositions' that provide more analytic rigor to this literature review. And then they discuss these across 3 main areas of public perception—OAE (and related) as risk objects; how risk perceivers' characteristics drive or shape perceptions; and how regulatory and risk management contexts are likely to affect people's judgments about OAE.

226) The argument re: controllability as a key factor in risk perception of OAE is important and rightly placed high in the argument.

280) Their provision across these areas of a summary 'key message' is excellent, especially for this intended audience, many of whom may be unfamiliar with the work cited and its implications for this study.

Overall, the reviews are comprehensive and cover all expected topics. This is well done.

*Thank you, we went around on this section several times, very glad that it works.*

The section (2.2.3) on moral hazard conditions could also draw attention to the parallels of these phenomena in the wider energy system change literature with notable contestation over principles of using fossil fuels as a necessary transition to renewables versus more hardline views opposing continued extraction in any form.

*Yes, this is quite true. There are a lot of claims to draw on here, but the most robust example in our opinion is [Green's](#) explanation for the rise of anti-fossil fuel positions in and across nation states. We have added wording and reference to this effect on lines 403-412.*

Section 2.3 on the effects of risk management and governance contexts on public views is absolutely critical and provides a suitable (though brief) summary of the key questions around issues of governance (monitoring; financing; addressing global responsibility; and assuring re: clean up/removal), environmental justice (in its multiple aspects), and the pivotal factor of trust in risk management.

One note, the summary of EJ views does not cite the ever-rising issue of recognition justice, although it is arguably related to reparative justice, which they do discuss.

*We have added recognition justice to this, thank you for that advice, apologies for the omission. See lines 471-472*

In Section 3, they then go on to discuss methods for engagement of “interested and affected groups.” Here they articulate the goals and methods for gaining understanding of public views, laying down a number of key preparatory steps, and finally providing summaries of the main social science engagement methods at different stages of technology development and scales of effort. Table 1 (p 39) summarizes this, providing a useful snapshot and linking each method to RRI aims.

Comments: In general, the content in these sections is excellent, but there is some unevenness. Many other sources could be cited for the summary advice, but at least 1-2 per point, for example, in section 3.2 would clarify from whom they’re drawing this advice. There’s inexplicably more citation and detail in reference to approaches 3 and 4 than 1 and 2. This creates a sense that some are more recommended than others, so a more consistent and systematic pattern would be helpful (especially since the number of citations in each does not at all index the number of relevant studies, or other metrics). Related to this unevenness effect, the authors later state that the review focuses “primarily on early-stage research” (984), but that’s not entirely clear from this section as presented.

*Thank you, we have corrected both points. We don't mean to indicate that 1 and 2 are less important in any way, they all are and are all 'stage of work' and context specific. References and some additional wording have been added to methods 1 and 2.*

*See lines 747-830.*

Section 4 on post-engagement activities provides a brief summary of the ideals of how and in what form these activities should take place (e.g., effective two-way communication, importance of early [and though they don’t say so, often] consultation). They cite the importance of informing modeling efforts, although this advice needs more explanation than they provide to make it fully coherent in this paper and for this audience.

*Thank you, we are not experts in this area, but we are familiar enough to speculate as to possible modelling inputs. We have thus revised that section, adding both upstream and downstream modelling examples based on a recent paper addressing the potential social implications of OAE. And we have added the early and often point you make. Lastly, we have also provided an additional citation to introduce citizen science engagement in modelling work. See lines 1111 to 1136 for these points.*

Technical corrections

*Thank you for catching these items below, close edits much appreciated. All of these have been corrected*

P 3) inconsistent font in para 1

166) 'fertilization approached' is unclear?

252) ibid reference? in note ref per journal format?

329) ibid in note ref again? Consistent w/ journal format?

335) ditto (and elsewhere in the paper, but assuming it's probably okay w/ this journal?)

393—this part (a) is not followed by a parallel part (b) (maybe 399?)

435—why is this one reference dynamically linked?

447—delete double end parens

532 - add # after (2008)

637- change 'run' to 'runs'

795- add vertical space

936 -'a good review' should be 'good reviews'

1320-extra vertical space should be removed

1592—(6), column 2, in table 1 re: deliberative polling doesn't actually specify what stage this would be—for consistency would be good to add (narrative 622 relative to this calls this 'late-stage')

