Ocean-based Negative Emission Technologies

OCEAN NETs

Deliverable Title	**D7.7 Specialized protocol for responsible research and innovation on ocean-based NETs**
Lead	UOXF
Related Work Package	WP 7
Related Task	Task 7.3
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Prieto Dissemination Level	Public
Due Submission Date	30.04.2024
Actual Submission	30.04.2024
Project Number	869357
Start Date of Project	01. July 2020
Duration	60 months

Abstract: This protocol synthesizes the work of the OceanNETs project on the formulation of a series of principles for responsible research and innovation in the study of ocean-based carbon dioxide removal.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 869357.

Document History

Date	Version	Description	Name/Affiliation
30.04.2024	1.0	First submitted version	Javier Lezaun/UOXF

1 Introduction

1.1 Context

OceanNETs is a European Union project funded by the Commission's Horizon 2020 program under the topic of Negative emissions and land-use based mitigation assessment (LC-CLA-02-2019), coordinated by GEOMAR | Helmholtz Center for Ocean Research Kiel (GEOMAR), Germany.

OceanNETs responds to the societal need to rapidly provide a scientifically rigorous and comprehensive assessment of negative emission technologies (NETs). The project focuses on analyzing and quantifying the environmental, social, and political feasibility and impacts of ocean-based NETs. OceanNETs will close fundamental knowledge gaps on specific ocean-based NETs and provide more in-depth investigations of NETs that have already been suggested to have a high CDR potential, levels of sustainability, or potential co-benefits. It will identify to what extent, and how, ocean-based NETs can play a role in keeping climate change within the limits set by the Paris Agreement.

1.2 Purpose and scope of the deliverable

Form the start, OceanNETs has included a strand of discussions over the principles that should guide research and development on ocean-based methods of carbon dioxide removal (CDR). Task 7.2 has included Knowledge Exchange seminars among project team members, and discussions at annual team meetings, as well as individual interviews with participants in the OceanNETs consortium. This report synthesizes those discussions, and successive updates of principles for responsible research and innovation (MS10, MS27 and MS38).

2 Origin and application of the protocol

2.1 Background

OceanNETs seeks to improve our knowledge of the potential risks and benefits associated with different methods of marine carbon dioxide removal (mCDR), so that societies will be better prepared to make informed choices about any further development or eventual deployment.

OceanNETs does not favour any specific mCDR method, nor does it advocate for a particular scale or timeline of deployment. Its purpose is solely to inform public debate and policy decisions on these issues by providing high-quality scientific data that illuminate the multiple dimensions (technical, political, economic, environmental, legal) of mCDR research and development.

As an interdisciplinary initiative, OceanNETs employs a variety of research methods. This includes models and simulations of different mCDR scenarios, contained field studies of ocean alkalinity enhancement (OAE), life-cycle assessment of different OAE deployment scenarios, social-scientific research of public and stakeholder perceptions, and legal inquiry into potential governance architectures for mCDR development, demonstration and deployment.

In the context of the EC 8th Framework Programme for Research and Technological Development (Horizon 2020), Responsible Research and Innovation (RRI) refers to a commitment to 'anticipate (…) and assess (…) potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation' (European Commission 2017). RRI typically encompasses a series of principles and good practices intended to help researchers reflect on the potential societal impacts of their work, and engage relevant societal actors in a collective examination of the potential consequences of that work.

This protocol adapts this commitment and these principles to the research activities undertaken by OceanNETs. It focus in particular on the two kinds research endeavours where the experience of the consortium may be most relevant: field experiments to assess the potential impacts of ocean alkalinity enhancement, and modelling of future mCDR scenarios.

2.2 Process

These principles are the result of an ongoing series of discussions throughout the life of the OceanNETs project, including a Knowledge Exchange seminar and debate of specific issues at annual OceanNETs project meetings. Additionally, individual interviews were conducted with members of the project team, including WP leaders. Our reflections were further informed by interviews with external researchers involved in other projects researching ocean-based methods of carbon dioxide removals. A detailed qualitative analysis of this corpus of interviews is available in: Nawaz, S., & Lezaun, J. (2024). 'Grappling with a sea change: Tensions in expert imaginaries of marine carbon dioxide removal'. *Global Environmental Change*, 85, 102806.

The protocol has benefited from discussions with colleagues in the context of several international initiatives to develop principles or a code of conduct for marine carbon dioxide removal. This includes work sponsored by the Aspen Institute to produce a Guidance for Ocean-Based Carbon Dioxide Removal Projects (2021), and the recently completed Code of Conduct for Marine Carbon Dioxide Removal Research (2023), also sponsored by the Aspen Institute (Energy & Environment Program). Three members of the OceanNETs team (David Keller, Javier Lezaun and Phil Reforth) are authors of that Code of Conduct, which articulates at more length some of the principles included in this protocol. Principles relating specifically to OAE research have been published in an extended form in Nawaz, S., Lezaun, J., Valenzuela, J. M., & Renforth, P. (2023). 'Broaden

research on ocean alkalinity enhancement to better characterize social impacts'. *Environmental Science & Technology*, 57(24).

3 Principles guiding field experimentation in ocean alkalinity enhancement

The following principles apply to research activities undertaken in the marine environment with the purpose of advancing our scientific understanding of the risks and benefits of ocean alkalinity enhancement (OAE), but could be extended to field studies of other mCDR options.

Field studies are essential for a proper assessment of OAE. They require a special consideration of potential environmental, social, ethical and geopolitical consequences. By virtue of their geographically situated nature, they bring research activities into contact with specific communities and environments, creating obligations and opportunities for public engagement. The principles are organized around three main phases: planning & scoping, execution of research, and cessation & decommissioning.

3.1 Planning and Scoping

- *Conduct research in jurisdictions with the capacity to perform appropriate environmental risk assessment (including public consultation)*
- *Identify local stakeholders concerned with environmental conservation, climate action and sustainable development*
- *Socialize the objectives of the research project by informing stakeholders of the design and purpose of the study before the start of activities*
- *Establish a plan to monitor potential unintended impacts that could arise as a result of research activities*
- *Identify adjacent marine activities that might be affected by research practices and infrastructures, and establish a mechanism to file grievances*
- *Create a community liaison group to discuss the evolution of the project*

3.2 Execution of research

- *Inform local stakeholders of any changes in the design, scale or level of containment of the project*
- *Facilitate visits by local residents to research sites and facilities*

3.3 Cessation and Decommissioning

- *Identify any ecosystem in need of restoration at the project's conclusion*
- *Share with local stakeholders the evidence gathered in the study and discuss its regional significance*
- *Define protocols for post-study monitoring of relevant environmental impacts*
- *When research is conducted away from home the institution, review with local researchers opportunities for further knowledge/data exchange, tech and equipment transfer*

4 Principles guiding modelling work on ocean-based CDR

Modelling work is central components in the assessment of mCDR options. OceanNETs includes several types of models, including Earth System models and Integrated Assessment models. Although they do not present immediate environmental or social risks, models do shape trajectories of field experimentation and future deployment, and as such can determine social and environmental outcomes. Increasingly, RRI principles have been applied to modelling work, with different methods of 'collaborative' or 'participatory' model development suggesting ways of engaging external actors in discussions over what conceptual frameworks to use, which variables to include or exclude from the model, how to parametrize those variables, and how to assess and interpret modelling results.

- *Articulate and justify choices regarding scale and timeline of mCDR being modelled*
- *Clarify assumptions about future climate action trajectories (level of emission reductions; nature and scale of residual emissions) used in modeling processes*

- *Specify durability of sequestration in reporting removal potentials*
- *Make explicit current limits on our ability to simulate CDR, and to measure, verify and monitor removals*
- *Discuss model outputs with stakeholders to test the socio-political feasibility of different CDR pathways*
- *In discussions with policy makers, clarify that modeling outputs do not represent policy recommendations*

5 Conclusion

These principles have not been endorsed by all participants in the OceanNETs consortium, but they reflect the key issues raised in discussions throughout the life of the project. The protocol is intended as a tool to inform further debate on the principles that should guide research and development on ocean-based carbon dioxide removal. As the field of mCDR R&D grows, these ideas should be further refined in relation to the specific nature of the R&D activities in question.