Ocean-based Negative Emission Technologies

OCEAN NETs

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Lead	GEOMAR
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Author(s)	Ulf Riebesell
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Abstract:

In this report the on-line data workshop that relates to the mesocosm experiment conducted in the subtropical, oligotrophic waters off Gran Canaria in September/October 2021 is described. All participating groups presented their final (and in some cases still preliminary) results. At the meeting a list of intended manuscripts was prepared and for each manuscript lead authors were identified. Additionally, a publication strategy was discussed and decided.

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Document History

Date	Version	Description	Name/Affiliation
30.03.2024	1.0	First submitted version.	Ulf Riebesell/GEOMAR

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 Centre 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

The aim of this WP is to investigate the potential risks and benefits of ocean alkalinity enhancement (OAE) for ecosystem integrity and biogeochemical functioning. In a 5-weeks mesocosm experiment conducted in the subtropical, oligotrophic waters off Gran Canaria in September/October 2021, the potential biogeochemical and ecological impacts of ocean alkalinity enhancement (OAE) were tested. The aim of this experiment was to investigate the potential risks and benefits of CO_2-equilibrated OAE for ecosystem integrity and biogeochemical functioning. In this context, the results of this study provide the first insight on the effects of OAE at the community level in a natural system. They will feed into developing guidelines for safe and responsible implementation of ocean alkalinity enhancement.

1.3 Relation to other deliverables

This mesocosm study off Gran Canaria tested one possible approach for alkalinity enhancement, namely CO_2 equilibrated alkalinization, in subtropical, oligotrophic waters. In the framework of OceanNETs a complementary mesocosm experiment has been conducted in temperate, mesotrophic water off the Norwegian coast. The latter study tested for non-equilibrated alkalinization with two different minerals, a silicate-based mineral (simulating olivine addition), and a calcium-based mineral (simulating slack lime addition). Comparison of the two data sets will provide further insights into the ecological and biogeochemical consequences of alkalinity enhancement, in particular site- and mineral-specificity of potential OAE impacts.

The data set generated in this experiment will be shared among various research groups for in-depth analysis of potential OAE effects on a wide range of ecosystem and biogeochemical processes. The results of this will be used to parameterize ecosystem-biogeochemical models simulating ocean alkalinity enhancement.

2. Experimental design

In the nine mesocosms, each with a volume of about 10 m^3, inhabiting a natural plankton community, alkalinity enhancement was achieved through addition of a mix of sodium bicarbonate and sodium carbonate, simulating CO_2-equilibrated alkalinization in a gradient from control up to twice the natural alkalinity. The response of the enclosed plankton community to the alkalinity addition was monitored in over 50 parameters which were sampled or measured *in situ* daily or every second day. In addition to the mesocosm experiment, a series of side experiments were conducted, focusing on individual aspects of mineral dissolution, secondary precipitation and biological responses at the primary producer level. This campaign, in which 47 scientists from 6 nations participated, generated the most comprehensive data set collected so far on the ecological and biogeochemical impacts of ocean alkalinity enhancement.

3. Data workshop

An on-line data workshop was held on 12 April, 2023, during which all participating groups presented their final (and in some cases still preliminary) results. At the start of the workshop the OceanNETs data manager, Lisa Paglialonga, presented the project's data policy and data management services. This was followed by presentations on:

- Carbonate chemistry (Julietta Schneider)
- Inorganic nutrients, profiles of temperature, salinity, pH, oxygen, light (Michael Sswat)
- Oxygen-based primary production and community respiration (Laura Marin-Samper)
- ^{14}C-based size-fractionated primary production and Chlorophyll *a* (Joaquin Ortiz)
- Flow cytometry and Flow CAM (Aja Trebec)
- Phytoplankton photophysiological response (Steve Archer)
- Cell stress (Librada Ramírez)
- Phytoplankton and microzooplankton microscopy (Xiaoke Xin)
- Mesozooplankton composition and development (Nicolás Sánchez)
- Water column biogeochemistry – particulate organic matter (Jan Taucher)
- Chromophoric dissolved organic matter (Nauzet Hernández)
- Dissolved organic carbon and nitrogen (Minerva Espino)
- Element fluxes and composition, sinking velocities and remineralization (Kristian Spilling)
- Side experiments - abiotic and biotic responses to OAE (Niels Suitner)

Each presentation was followed by a Q&A session.

At the meeting a list of intended manuscripts was prepared and for each manuscript lead authors were identified. It was further discussed which data sets will best be combined for the intended manuscripts. The final decision was left to the lead authors and was to be taken once the story lines of the manuscripts were established. Additionally, a publication strategy was discussed and decided.

Meanwhile the following manuscripts were published, submitted or are in preparation:

Published

Hartmann J., Suitner N., Lim C., Schneider J., Marín-Samper L., Arístegui J., Renforth P., Taucher J., Riebesell U. (2023) Stability of alkalinity in Ocean Alkalinity Enhancement (OAE) approaches – consequences for durability of CO_2 storage. Biogeosciences, 20, 781–802, https://doi.org/10.5194/bg-20-781-2023

Submitted

Paul, A. J., Haunost, M., Goldenberg, S. U., Hartmann, J., Sánchez, N., Schneider, J., Suitner, N., and Riebesell, U.: Ocean alkalinity enhancement in an open ocean ecosystem: Biogeochemical responses and carbon storage durability, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-417, 2024

Marín-Samper, L., Arístegui, J., Hernández-Hernández, N., Ortiz, J., Archer, S. D., Ludwig, A., and Riebesell, U.: Assessing the impact of CO_2 equilibrated ocean alkalinity enhancement on microbial metabolic rates in an oligotrophic system, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-2409, 2023.

Suessle, P., Taucher, J., Goldenberg, S., Baumann, M., Spilling, K., Noche-Ferreira, A., Vanharanta, M., and Riebesell, U.: Particle fluxes by subtropical pelagic communities under ocean alkalinity enhancement, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-2800, 2023.

González-Santana, D., Segovia, M., González-Dávila, M., Ramírez, L., González, A. G., Pozzo, L. J., Arnone, V., Vázquez, V., Riebesell, U., and Santana-Casiano, J. M.: Ocean alkalinity enhancement using sodium carbonate salts does not impact Fe dynamics in a mesocosm experiment, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-2868, 2023.

Suitner, N., Faucher, G., Lim, C., Schneider, J., Moras, C. A., Riebesell, U., and Hartmann, J.: Ocean alkalinity enhancement approaches and the predictability of runaway precipitation processes – Results of an experimental study to determine critical alkalinity ranges for safe and sustainable application scenarios, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-2611, 2023.

Ramírez, L., Pozzo, L. J., Vázquez, V., Trebec, A., Díez, J. L., Arístegui, J., Riebesell, U., Archer, S. D., Segovia, M.: Ocean Alkalinity Enhancement (OAE) does not cause cellular stress in phytoplankton of the sub-tropical Atlantic Ocean. Biogeosciences, Special issue: Environmental impacts of ocean alkalinity enhancement.

Sánchez, N., Goldenberg, S. U., Brüggemann, D., Jaspers, C., Riebesell, U.: Plankton food web structure and productivity under Ocean Alkalinity Enhancement. Science Advances

In preparation

Xin, X., Goldenberg, S. U., Taucher, J. Stuhr, A., Arístegui, J., Riebesell, U.: Impacts of ocean alkalinity enhancement on the stability of phytoplankton and microzooplankton communities. To be submitted to Biogeosciences, Special issue: Environmental impacts of ocean alkalinity enhancement.