Ocean-based Negative Emission Technologies

OCEAN NETs

Deliverable Title	**Summary report on deliberative workshop with stakeholders on mesocosm research in Bergen, Norway**
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Abstract: This report summarises the stakeholder engagement work conducted with actors in the Bergen region during OceanNETs research activities on ocean alkalinity enhancement. Stakeholder engagement included a series of individual meetings with local actors and an online deliberative workshop where the OceanNETs research agenda in Bergen was presented and discussed. This revised report describes our approach to stakeholder engagement, the structure of the stakeholder workshop, and some key insights derived from this process.

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Document History

Date	Version	Description	Name/Affiliation
29.06.2022	1.0	First submitted version, reviewed and validated David Keller and Judith Meyer	Javier Lezaun/UOXF
30.09.203	2.0	Modifications including expert's reviews.	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

The deliverable summarises the stakeholder engagement activities conducted in conjunction with the mesocosm studies carried out in Bergen, Norway from May through July 2022. It analyzes key insights gathered from individual meetings with the stakeholders and the workshop carried out in June 2022. Following the reviewers' comments, this revised version includes further information on the methodology used for this task and the structure of the online workshop.

1.3 Relation to other deliverables

This deliverable informs further stakeholder engagement work across OceanNETs. It provides insights useful for future WP7 deliverables, including the final report on deliberative stakeholder workshops (D7.8), OceanNETs' work on a sustainable development goals framework for ocean-based NET evaluation (D7.9), and policy briefs assessing the local or regional fit of proposed NETs. It will also inform OceanNETs work on governance, specifically D2.3 (Report on regional and global governance challenges and opportunities for emerging ocean-based NETs) and D2.6 (Policy brief identifying challenges and opportunities for emerging ocean-based NETs in regional and global ocean governance frameworks targeted to EU and global policy makers).

2. Summary report on stakeholder engagement work in Bergen, Norway

2.1 Introduction

As we indicated in our report of the public outreach and stakeholder engagement in Gran Canaria during the first series mesocosm studies, field research on the potential environmental impacts of ocean alkalinity enhancement (OAE) offers an opportunity to deepen discussions with local stakeholders about researching and developing OAE application, and ocean-based negative emissions technologies (NETs) for carbon dioxide removal (CDR) more generally. Similar to the work carried out in Gran Canaria, the main purpose of the stakeholder engagement work conducted in Bergen was to inform local actors of OceanNETs research activities, elicit views on the mesocosm work and on the risks and benefits potentially associated with OAE, and create venues for discussions of ocean-based NETs attuned to local expectations, concerns and priorities. Until recently, much of the discussion on the public acceptability and governance of OAE has adopted an international or at best national perspective. Field experiments, even contained ones like those carried out by OceanNETs, allow us to understand better how local dynamics shape public perceptions of OAE and might be useful in devising appropriate governance processes.

2.2 Methodology: background review and stakeholder mapping

Our stakeholder engagement work in Bergen included 1) a data-gathering phase, where we sought to identify relevant actors, and researched national policy on CDR and local histories of marine spatial governance; 2) individual meetings with local actors involved in regional 'blue economy' initiatives; 3) a deliberative workshop (carried out online) to present and discuss OceanNETs research activities in detail.

We began the stakeholder engagement work by identifying key issues relevant in the Norway/Bergen context. This first involved searching for and reviewing social science literature, grey literature and media coverage relating to issues of marine environments/oceans, coastal areas, CDR, and climate change. Our review uncovered documents relating to public debates, social conflicts, and issues of public perceptions on the following topics: climate change and climate transitions, coastal issues and coastal zone planning, fishers and fisheries, aquaculture, conservation, the blue economy, renewables and offshore wind power, and carbon capture and storage (CCS). We also study the history of alkalinisation in Norway, where this method has long been in use to replenish fish stocks in fresh water bodies.

Drawing upon this review, we worked with OceanNETs colleagues at NORCE to identify a list of relevant actors and institutions to contact across these sectors. We used the networks established through the 'Havlunsj' meetings, a series of events that bring

together actors connected to the maritime economy and marine environments in the Bergen region. (See Appendix 1 for a partial list of contacted stakeholders). We also conducted several in-person meetings with actors in Bergen in order to (1) introduce the OceanNETs research agenda, including the mesocosm experiments, and (2) further identify stakeholders who might be interested in the project.

We met with the following groups:

- Members of an aquaculture industry innovation hub called NCE Seafood Innovation, which comprises many of the key aquaculture companies active in Norway;
- Leadership from a large Norwegian shipping company, Grieg Maritime, which is active in other maritime industries as well;
- Social science researchers at the University of Bergen's Centre for the Study of the Sciences and Humanities who work on topics of environment, climate, and natural resources;
- Leadership from the Bergen Aquarium, which is connected to and collaborates with stakeholders in the Bergen region that range from environmental NGOs to CCS industry to academic marine research projects on related topics like microplastics;
- Interdisciplinary researchers from NORCE and the University of Bergen who work on CCS from legal, public perceptions, biogeochemistry, and engineering perspectives;

We used these meetings to further identify relevant stakeholders or make contact with specific individuals (e.g., contacts at environmental NGOs, marine research institutions, and in maritime finance). These meetings also helped us identify several historical trends that could be relevant to understand local or national perceptions of ocean alkalinity enhancement. For example, several of our meetings flagged the history of river and lake liming in Norway, recent debates over other climate change mitigation policies (e.g., CCS and offshore wind), and the evolution of different sectors of the maritime economy. We come back to some of these themes in the discussion below.

Following these meetings, we reviewed the list of participants and identified several remaining gaps in our coverage of stakeholders, such as smaller fishers' associations and government environment departments. We conducted further internet research to identify additional stakeholders in those spaces.

Ultimately, we used the full list of stakeholders to circulate invitations to an online discussion seminar to discuss the OceanNETs mesocosm studies and ocean-based CDR more generally. We sent invitations to 55 stakeholders across the following areas: aquaculture (both large companies and start-ups), fisheries, CCS, environmental and

conservation NGOs, start-ups working on CDR-related topics, other maritime industries (e.g., shipping, marine minerals, marine technology), water and environmental research institutes, trade organisations, a recreational fishing organisation, government fisheries and environmental departments, a local Bergen governmental body, business advisory organisations, banks, innovation centres in energy and maritime industries.

2.3 Stakeholder workshop

We designed an online seminar specifically tailored to local stakeholders. Conducted in collaboration with colleagues at NORCE and GEOMAR, the seminar was structured around two short presentations. The first one introduced the concept of ocean-based negative emissions technologies, as broadly as possible, and offered initial insights into the overall OceanNETs research agenda. The second presentation introduced the topic of ocean alkalinity enhancement, and explicated the design of the mesocosm studies. Participants first had a chance to ask any questions or raise issues in relation to the themes of the presentation, after which we moved into a moderated discussion organised around key themes on which we sought stakeholder input. Although the presentations were in English, the opening and closing of the seminar were in Norwegian, and participants were offered the chance to speak in Norwegian if they so preferred.

The enclosed appendixes give a fuller account of the workshop.

- Appendix 2 includes the invitation sent to local stakeholders for the June 2022 workshop and describes the structure of the meeting
- Appendix 3 includes the notes used by the facilitators to moderate the group discussion during the workshop.
- Appendix 4 includes the slides used for the two presentations during the workhsop.

2.4 Key insights

Environmental impacts and 'safe operating space' for OAE

Several questions regarding environmental impacts were flagged. Following the discussion of the mesocosm experimental design and its use of compounds to simulate lime and olivine, one participant asked whether the toxicity of trace minerals was evaluated prior to the mesocosm experiments. This was particularly relevant in relation to olivine, which contains nickel, chromium and other trace elements. (There was perhaps an uncommon awareness of olivine, as Norway is by far the largest global producer, and the largest olivine mine, the Gusdal Olivine Pit, is located in the country). It was explained that the mesocosms *simulate* the use of olivine, by including some of its key components, but does not include nickel or any other trace elements.

One concept that was introduced in the second workshop presentation that captured and addressed some of these concerns was the idea of using contained experimental work to define a 'safe operating space' for ocean alkalinity enhancement. The overarching criterion to define this space would be environmental safety - minimising impact not just on individual organisms, but on marine biological communities. Depending on the materials under consideration for OAE, future engagement work should proactively engage with potential toxicity issues, as these may not be immediately clear to some stakeholders (or public groups), and yet may be key to their evaluation of different OAE methods.

Other exchanges flagged other potential environmental concerns. One participant asked whether OAE might have similar effects of mineral bio-accumulation in sea sponges as those observed in the wake of deep sea mineral mining deep sea minerals (in their words, "the equivalent of 'smokers' lung"). Given that sea mining has generated controversy over environmental impacts,[1] this possibility may require further investigation. Environmental concerns did not always imply an opposition to OAE. The discussion included references to the potential of OAE to reverse acidification (discussed further below), or the potentially positive effects of carbonation.

Uncertainties illuminated by mesocosm studies and timescales for development of OAE

In addition to providing empirical evidence on the impacts of additional alkalinity on marine ecosystems, the experimental work conducted in Gran Canaria and Bergen is revealing new areas of uncertainty. An issue that raised the interest of participants was the precipitation of calcium carbonate observed in the mesocosm studies, which imply a potential net loss of alkalinity and corresponding release of carbon into the atmosphere. Support for further research on OAE appeared widespread, but raises the question of plausible timelines for the evaluation and potential adoption of OAE. One of the participants in the workshop raised the example of carbon capture and storage (CCS), a technology that is currently receiving a great deal of attention and investment in Norway, but which only garnered sufficient support after more than a decade of discussions and debates in the country. The need for extensive research on fundamental aspects of OAE suggests risks in any premature transition to uncontained experiments.

Interactions with existing marine uses and industries

Norway's strong reliance on maritime industries might signal particular scepticism about intervening in marine environments, but stakeholders emphasised the country's particular interest and openness to emerging technologies and innovations, citing examples from CCS to green shipping fuels. The question is whether OAE could include co-benefits,

[1] https://www.iucn.org/resources/deep-seabed-mining
https://www.biologicaldiversity.org/campaigns/deep-sea_mining/pdfs/Deep-seaMiningFAQ.pdf

conflicts or overlaps with existing maritime activities, such as aquaculture, fisheries, and other elements of the regional and national 'blue economy.'

Hypothetically, such a co-benefit might align to address existing priorities that these sectors have identified. Multiple stakeholders cited ocean acidification as an environmental challenge facing Norway, along with related issues like extinction of fish species. One seafood company identified ocean acidification as one of its key sustainability challenges, along with sea lice and creation of anoxic environments. However, whether this overlap serves as a synergy or tension requires further investigation.

In some of the one-on-one meetings, stakeholders had queried the potential synergies with existing economic sectors and infrastructures. Norway has one of the largest shipping industries in the world, and s ideas floated in these discussions included repurposing very large crude carriers (VLCCs) for mineral distribution once they can no longer be used for their original use, retrofitting greywater systems for the on-board conversion of mineral powders to solutions (assuming solutions are a more environmentally sound and efficacious approach to OAE), or using hull sensors as part of a monitoring infrastructure.

These discussions remained speculative, and somewhat disconnected from the specific purpose of the mesocosm studies, but suggest the relevance of potential synergies to local stakeholders (similar discussions took place in Gran Canaria during the first phase of experimental work). They point to the relevance of the policy and economic frameworks, within which OAE might be developed (including the possibility of a market for OAE-derived carbon credits). Participants inquired about matters relating to monitoring, verification and reporting, and this remains a key dimension to gauge stakeholder perceptions of OAE and other ocean-based NETs.

Norwegian experience in artificial liming

Some actors mentioned Norway's fairly unique experience in the liming of rivers, lakes and catchments. Since the 1980s, liming has been used to restore fish populations in acidified waters in several southern counties. The key goal of this programme has been to re-establish extinct or nearly extinct populations of Atlantic salmon in many rivers, generally by the deposition of powdered limestone in the relevant catchments or lakes. The operational features of these programs vary, but in some cases approximate (at a smaller scale and in fresh water systems) some of the scenarios that OceanNETs is considering. In some cases liming is carried out directly on lake surfances, in other cases lime dosers for continuous liming of running water are used. A particularly salient aspect of these programs is the extensive monitoring of environmental effects, including the possible impact of trace metals. We are collecting more evidence to assess its relevance of this experience to our research on ocean alkalinity enhancement.

3. Conclusion

Although many local actors appreciated the opportunity to learn more about the research OceanNETs is conducting in Bergen, the mesocosm studies themselves seemed to have limited salience to the stakeholders we approached. This is why, in the group discussion, we aimed to emphasise the *trajectory* of OAE development, rather than immediate *implications* of the experimental studies. Engaging stakeholders on hypothetical trajectories of development proved challenging, given gaps in the scientific evaluation of OAE and the many potential deployment options (e.g., different materials, with their associated industries and life cycles of these materials, uncertain options for dispersal, and lack of clarity on regulatory aspects, including removals certification).

We plan to continue the stakeholder engagement work in the region with further individual interviews. Given the interest of some local institutions to host further discussion we are considering a further workshop when the full results of the mesocosm studies are available. The insights gathered in this follow-up work will inform the final report on deliberations with stakeholders (Deliverable 7.8 [36]).

Appendix 1: Partial list of stakeholders contacted during engagement work

Navn	Type	Nettside	Kommentar
DNV	Advisory	https://wv	Advisory organ/expert organization with it
Norwegian Maritime Author	Authority	https://wv	Administrative and supervisory authority in
The Port of Bergen (Bergen I	Autorithy	https://be	Norway's second largest port. Port of Berge
DNB	Bank	dnb.no	Financing maritime industry. Member of NC
Sparebanken Vest	Bank	spv.no	Financing maritime industry. Largest "local"
Sustainable Energy Catapult	Catapult center	https://su:	"driving force for the green transition and tl
North-Atlantic Seafood Foru	Conference	https://no	NASF is a world-leading executive meeting
Baker Hughes/Compact Carl	Industry	https://wv	Aquired Compact Carbon Capture (carbon c
Hydro	Industry	https://wv	Aluminium and energy
Kystrederiene	NGO	https://ky:	An interest organization within short sea sh
GCE Ocean Technology	NGO	https://wv	Develops and supplies innovative ocean tec
NCE Maritime Cleantech	NGO	https://ma	A world-leading cluster for Clean Maritime
NCE Seafood Innovation	NGO	https://se:	NCE Seafood Innovation aims to contribute
Maritime Bergen	NGO	https://wv	Maritime Bergen is a platform of cooperatic
Akvariet i Bergen	NGO	https://wv	The Aquarium aims to spread knowledge ab
Greenstat	Renewable energy co	https://gre	Founded in 2015 by NORCE, now a stand al
The Institue of Marine Rese	Research	https://wv	Largest center of marine science
Grieg Maritime Group	Shipping	https://gri	Shipping company fleet of high-quality mult
Akvareforma	Startup	Akvareforr	Startup with focus on growing among other
Ocean Forest	Startup	Ocean For	Joint Venture between Lerøy and Bellona w
Aquapro	Startup	http://ww	Aquapro aims to build and develop a mobile
Western Norway University	University	https://www.hvl.no/en/studies-at-hvl/	
TechnipFMC (Deep Purple™)	Industry	https://wv	Technology provider to the traditional and
CCB Subsea	Industry	https://wv	Provides subsea and drilling services
TESS Teknisk Faghandel	Industry	https://tes	More and more focus on innovative teknolc
UNITECH	Advisory	https://un	UNITECH sees potential in utilizing their tec
Corvus Energy	Industry	https://co	State-of-the-art battery factory in Bergen. T
SINTEF	Research	https://wv	Has a local office in Bergen. SINTEF is one o
Lerøy	Industry	https://wv	Fish Farmer
Mowi	Industry	https://mc	Fish Farmer
Naturvernforbundet (FoE Nc	NGO	https://na	Norway's oldest environmental and nature
Klimastiftelsen	NGO	https://kli	Google translate from webpage: The Norwe
Equinor	Industry	https://wv	Giant energy company (earllier called Statoi
Gassnova	Industry	https://ga:	Also involved in Longship. No office in Berge
Bellona	NGO	https://be	The Bellona Foundation is an independent r

Appendix 2: Invitation to OceanNETs deliberative stakeholder workshop in Bergen

OCEAN NETs

Ocean-based carbon dioxide removal in Norway
The European OceanNETs research project

Stakeholder seminar (online)

Tuesday 28 June
09:00 – 11:00 (CET)

HOSTS
Siri Veland
NORCE

Javier Lezaun
Sara Nawaz
Jose Maria Valenzuela
University of Oxford

OceanNETs (ocean-based negative emissions technologies) is a project funded by the European Union to explore methods to increase the ability of the oceans to absorb atmospheric CO_2.

OceanNETs is conducting both modeling and experimental work to assess the feasibility, risks, and possible co-benefits of different marine negative emissions technologies, also known as carbon dioxide removal (CDR). It is increasingly likely that, over the next few decades, CDR will come to play a significant role in climate stabilization efforts.

OceanNETs is currently conducting contained mesocosm studies outside Bergen to evaluate the environmental effects of one of these proposed methods of marine CDR: increasing the alkalinity of seawater to enhance the ability of the oceans to absorb and sequester CO_2.

This online seminar will introduce the OceanNETs research project to a wide range of actors in the Bergen region, and in Norway more broadly. The event will give participants the opportunity to learn about our research activities, including the mesocosm studies, and to discuss the prospects of developing marine CDR in Norway.

OceanNETs seeks to produce scientific evidence to support responsible public decisions on the further development of marine CDR options. This seminar, together with other public outreach activities, will help the project assess broader societal considerations that should be considered in those decisions.

The seminar is co-hosted by researchers from NORCE and the University of Oxford, two of the institutions participating in the OceanNETs project.

We would be delighted if you would join the event, which will follow the agenda below. We will be circulating additional materials prior to the workshop.

Send confirmation of participation to:
Dr. Sara Nawaz
sara.nawaz@insis.ox.ac.uk

ACTIVITIES	TIME
Welcome, introduction to carbon dioxide removal and the OceanNETs project	20 min.
Presentation on OceanNETs' field studies on ocean alkalinity enhancement	20 min.
Q&A and Discussion: Prospects for development of marine carbon dioxide removal in Norway	70 min.
Wrap-up	10 min.

NORCE

Institute for Science, Innovation and Society
University of Oxford

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869357.

www.oceannets.eu

Appendix 3: Discussion guide for stakeholder seminar on OAE in Norway

1. [Follow up on any questions or comments made during the Q&A session that might deserve further discussion]

2. Norway has declared an intention to reach 'climate neutrality' by 2050. [The Parliament adopted a resolution in 2016 that Norway should be 'climate neutral' in 2030, but this has not been enshrined in law]. There is, however, no specific policy to develop NETs (as far as we can tell).

- What role could you imagine ocean-based NETs playing in Norwegian climate policy?
- Can you imagine OAE being part of climate change mitigation strategies in Bergen/Norway? Why/why not? How does it compare to other kinds of ocean-based NETs tackled by the project?
- Could you imagine this being done in the fjords, or only far off the coast?
- Can you imagine potential synergies, or tensions, with other uses of marine space?

3. At this point [as the presentations have suggested] it is unclear whether OAE can play a significant role in meeting carbon neutrality targets, or which particular type of OAE will offer the best risk-benefit profile.

- The first priority is to conduct further research on the impact of OAE on marine ecosystems, and on its potential as a method of carbon dioxide removal. Do you see the Bergen region playing a role in further research efforts, or are there aspects that should be clarified before further research is conducted.
- Bergen has a thriving set of economic sectors related to the ocean economy. What do you think is the role of ocean-based NETs in this context?

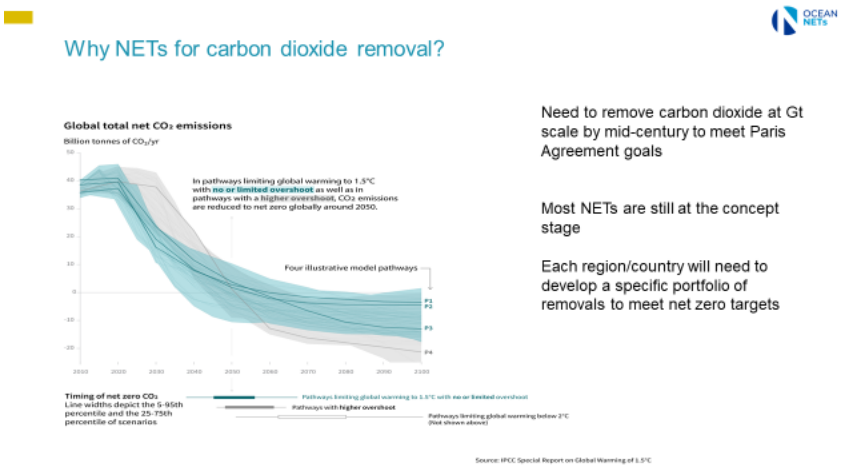
4. At the moment [as mentioned in the presentations] the regulation of OAE is uncertain. How removals could be verified and certified (for example as a way of generating carbon credits) is also highly uncertain. In your view, what are the key questions that would need to be resolved before this type of ocean-based NETs is developed further.

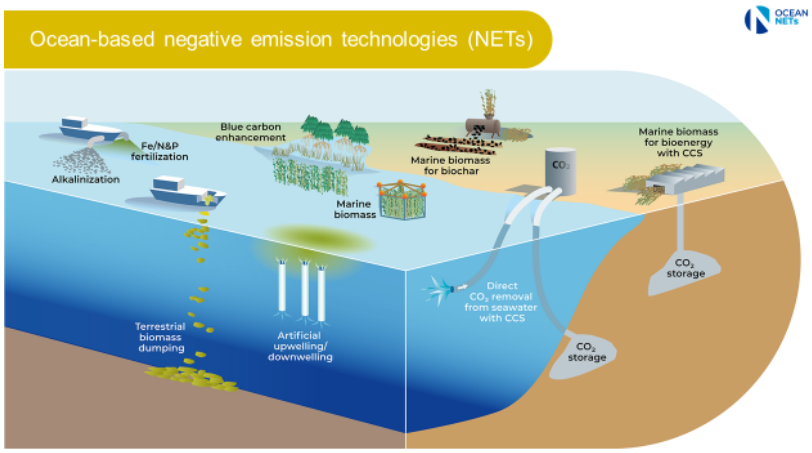
5. Who should be involved in future discussions about the prospect of OAE and its governance? Can you think of relevant stakeholders that should be part of this conversation?

6. In our preliminary research we have noticed a history in Norway of liming lakes and rivers in the 1970s and 1980s to reverse the effects of acidification and replenish fish stocks. Are you aware of that history, and do you see that experience as relevant to the research OceanNETs is conducting?

7. Norway has a tradition of upholding the "polluters pays principle". Considering the presentations and discussions thus far, is this a relevant principle that should be applied to the governance and financing of OAE and/or other approaches discussed in this session?

Appendix 4: Materials shared with workshop participants (presentations)





Some general characteristics of ocean-based NETs

- Limited empirical evidence about their removal potential and risks associated with large-scale deployments – evaluations are generally derived from models
- Uncertainties regarding governance
  - Regulatory constraints on deployment (e.g. EIA)
  - Lack of clarity on monitoring, reporting and verification of removals (e.g. EC Communication on sustainable carbon cycles & certification of removals)
- Limited thinking on how they might fit within regional strategies for climate action and economic development
  - Compatibility with fishing & aquaculture
  - Synergies with energy transitions (offshore wind)
- Particularly true of ocean alkalinity enhancement

GEOMAR – Coordinator – GEOMAR Helmholtz Centre for Ocean Research Kiel
AWI – Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research
CSIRO – Commonwealth Scientific and Industrial Research Organisation
HERIOT WATT UNIVERSITY – Heriot-Watt University
FMI – Finnish Meteorological Institute
ifw – Kiel Institute for the World Economy
IASS – Institute for Advanced Sustainability Studies
NORCE – Norwegian Research Centre
NTNU – Norwegian University of Science and Technology
OXFORD – University of Oxford
Universidad de Las Palmas de Gran Canaria (ULPGC)
Universität Hamburg
Leipzig University
UiO – University of Oslo

Partners

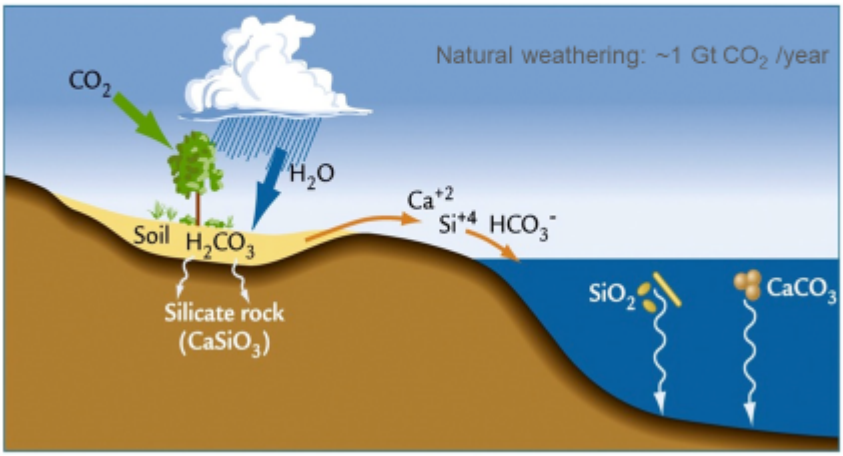
GEOMAR Helmholtz Centre for Ocean Research Kiel
UH
HERIOT WATT UNIVERSITY
UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

Funders

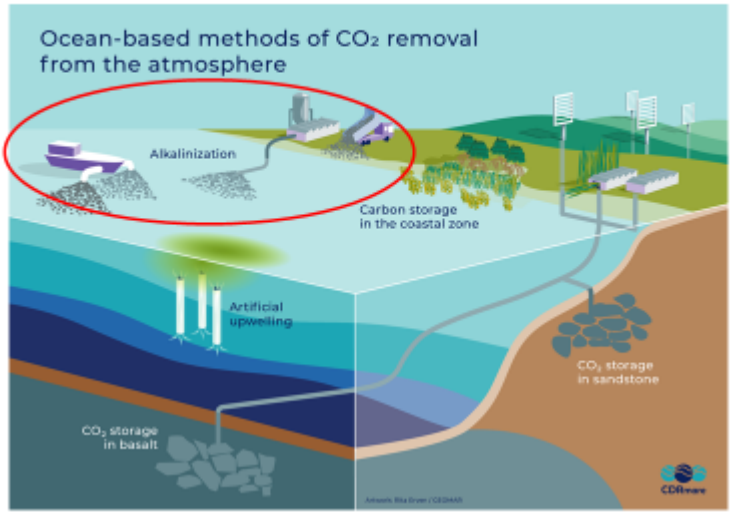
OCEAN NETs
Horizon 2020 European Union Funding for Research & Innovation
plus AQUACOSM

Ocean alkalisation: a natural process

$$CaSiO_{3(solid)} + 2\,CO_{2(g)} + H_2O_{(l)} \rightarrow Ca^{2+}{}_{(aq)} + 2\,HCO_3^-{}_{(aq)} + SiO_{2(aq)}$$



Ocean alkalinity enhancement



Minerals for alkalinity enhancement

Slaked lime 1.19 g CO_2 / g mineral

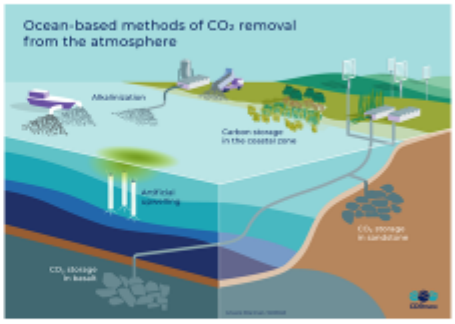
$$Ca(OH)_2 + 2\,CO_2 \rightarrow Ca^{2+} + 2\,HCO_3^-$$

Mg-Olivine 1.25 g CO_2 / g mineral

$$Mg_2SiO_4 + 4CO_2 + 4H_2O \rightarrow 2Mg^{2+} + 4HCO_3^- + H_4SiO_4$$

Objectives

Determine the safe operating space for Ocean Alkalinity Enhancement (OAE) applications for long-term CO_2 removal wrt ...

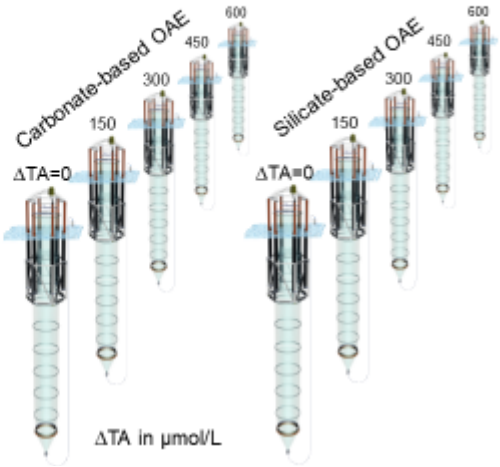


- Effectiveness → CO_2 removal capacity
- Permanence → duration of CO_2 storage
- Environmental safety → maintaining ecosystem health
- Co-benefits → counteracting ocean acidification

Location and approach

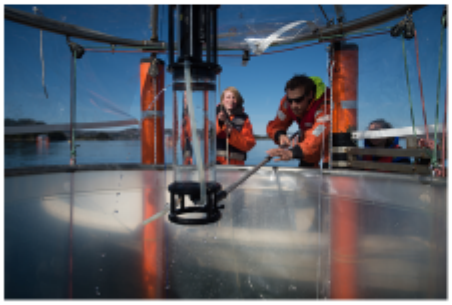
Raunefjord, south of Bergen, Norway

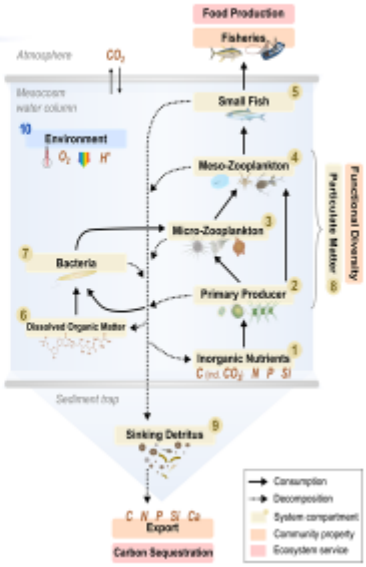
KOSMOS mesocosm experiment



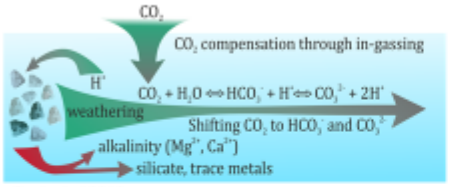
Approach

Ecosystem compartments, transformations and exchange processes covered in this study





Potential biological impacts



Bach et al 2019

Driver	Possible impacts
pCO_2	Photosynthesis → PP, food web
pH	Metabolic performance (co-/dis-benefit)
Ω_{CaCO_3}	Calcification → loss of alkalinity
Silicate	Fertilizing diatoms → food web, bio-C-pump
Fe	Fertilizing phytoplankton & N-fixation
Ni, Cr …	Toxic

Impact strength is likely to depend on:
- Level of alkalisation
- Mineral type (carbonate vs. silicate-based)
- Mineral impurities (trace metals)
- CO_2 equlibrated vs. non-equilibrated
- …..

Any questions?