Ocean-based Negative Emission Technologies

OCEAN NETs

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Abstract: This report summarizes the stakeholder engagement work conducted in the Canary Islands prior, during and after the conclusion of OceanNETs mescosm research on the impacts of ocean alkalinity enhancement. In addition to providing a description of our approach, the report summarizes key themes emerging from this work, including views on the mesocosm studies, perspectives on the role of marine carbon dioxide removal in regional climate/energy transitions, discussions on potential economic prospects associated with ocean alkalinity enhancement, and plans for future stakeholder engagement in the region.

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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 summarizes the stakeholder engagement activities conducted in conjunction with the mesocosm studies carried out in the island of Gran Canaria in the autumn of 2021. It analyzes key insights gathered from the stakeholder workshop carried out in October 2021, and the individual meetings with stakeholders convened before, during and after the conclusion of the mesocosm studies. The report also offers a summary of local media coverage of the studies and auxiliary public outreach activities.

1.3 Relation to other deliverables

The deliverable informs further stakeholder engagement work across OceanNETs, including current work in conjunction with the mesocosm studies in Norway. 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 should 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 deliberative workshop with stakeholders on mesocosm research in the Canary Islands

2.1 Background

Research on the public perception of novel technologies for carbon dioxide removal (CDR) tends to rely on schematic descriptions of the concept in question, or on highly-stylised versions of what future CDR systems might look like. In the past, this work has relied on the elicitation of views from members of the public who typically had little knowledge or experience of the CDR method in question prior to their participation in a deliberative event.

As CDR methods, or negative emissions technologies (NETs), begin to acquire more concrete socio-technical configurations, it becomes easier to identify actors with a direct investment in their development – and, by the same token, with specific reasons to oppose or at least express caution about this development. The picture that emerges from this work is a complex set of challenges, involving not only different views on the merits of one or another particular form of CDR, but specific stakes around every single step in any industrial-scale process to remove and sequester CO_2. Recent research with stakeholders on bioenergy with carbon capture and storage (BECCS), for example, reveals the complex trade-offs and multiple points of contestation that emerge when the whole supply-chains are taken into account (Clery et al 2021), or when a range of nationally specific policy, economic and political factors are considered in deliberative exercises (Bellamy et al 2021). Stakeholder engagement around carbon capture and storage (CCS) or afforestation, two fields with a significant track record of technological projections and public contestation, are similarly expanding of our imagination of which actors, and which issues, may be relevant to real-world actors and will impinge on the public legitimacy of different CDR options (Thomas et al 2018). Crucially, this work considers the views, expectations and concerns of local residents and other actors who are affected by the siting of the relevant infrastructures, bringing into relief local histories of environmental degradation and economic development that are essential if we want to understand public attitudes towards new CDR methods and the infrastructures they imply (Cox et al 2020; Thomas et al. 2022). These local and regional factors complement other dimensions of the problem illuminated by social-scientific research, such as perceptions of the potential of CDR to deter or defer action to reduce greenhouse gas emissions (Markusson et al 2022), or the gaps in international frameworks for the governance of the transnational dimensions of some proposed CDR methods (McDonald et al 2019).

OceanNETs is conducting contained mesocosm studies to assess the ecological and biogeochemical impacts of one of these novel methods of carbon dioxide removal: ocean alkalinity enhancement (OEA). Experimental field research represents a small but significant step in the development of this method. First, because it will produce detailed picture of the potential risks and benefits of artificial alkalinisation, and this will inform public debate on this option, which up to this point has relied on idealized mathematical models and simulations. Second, because by virtue of their location in a particular geography, this research offers an opportunity to *localize* discussions of ocean alkalinisation, and of ocean-based NETs more generally.

This opportunity to localize public debate on marine CDR methods is particularly welcome become discussions of the governance of these options have so far focused on its international dimensions (for example via the London Convention/London Protocol), but has generally been detached from locally specific histories, concerns and expectations. Our understanding of potential local responses to these interventions has been hampered by the lack of field research assessing geographically specific impacts, and by our over-reliance on mathematical models with low spatial resolution.

The OceanNETs project seeks to address these two shortcomings, and to use the conduct of mesocosm studies to generate local discussion and debate on the development of new ocean-based technologies for carbon dioxide removal, and their alignment or misalignment with the plans and priorities of local stakeholders. This report summarizes the stakeholder engagement work carried out in relation to the conduct of a first set of mesocosm studies in ocean alkalinisation in the island of Gran Canaria in the autumn of 2021.

2.2 Scoping research

Initial scoping work began in September 2020. It included a mapping of relevant policy institutions at the local (Gran Canaria), regional (Canary Islands), and national (Spain) level to identify actors with responsibilities for climate action, environmental protection, energy, and R&D. We reviewed recent policy initiatives in the Canary Islands concerning climate action, energy transitions, and environmental protection; we also identified public events where these initiatives had been discussed, to identify potential stakeholders for our work. Initial scoping work also included a review of marine and oceanographic research conducted by researchers based in Gran Canaria or at the Oceanic Platform of the Canary Islands (PLOCAN), the technical infrastructure hosting the OceanNETs mesocosms. We also reviewed existing social-scientific work relating to marine conservation, marine natural resources, and spatial planning processes in the Canary Islands.

We organised a round of virtual meetings with individual stakeholders to further calibrate the stakeholder engagement work. Participants in these meetings included local and regional policy actors (including the Cabildo, or Island Council, of Gran Canaria), members of civil society organisations, local researchers who had participated in previous oceanographic research projects, members of PLOCAN, groups and individuals dedicated to environmental conservation, local business associations, and economic development agencies. In these meetings, we offered a brief introduction to the topic of marine CDR, presented the OceanNETs research agenda, and described the purpose and design of mesocosm studies. The meetings also included a semi-structured discussion of local factors that the interlocutor thought significant in framing the relevance of ocean-based NETs in the Canary Islands [an example guide for these meetings is included in the Appendix].

These discussions indicated low prior awareness of NETs or CDR, even among actors actively involved in climate and environmental policy debates. Yet the meetings elicited a set of views on a wide range of topics. In contextualizing the relevance of marine CDR and/or ocean alkalinity enhancement in the Canay Islands, our interlocutors often directed the discussion towards the urgency of diversifying the economic base of the archipelago, and the contested local nature of climate and energy transitions. The pressing need to re-think the economic model of the islands, and of Gran Canaria in particular, had recently been brought home by the impact of the Covid-19 pandemic. With a population of 2.2 million, the islands received more than 15 million tourists in 2019 (Gran Canaria itself, with a population of 820.000 residents, received 4.3 million). The tourist sector accounts for 40% of regional GDP, and it profoundly shapes the human and natural environment of the islands.

Although the need of a change in the economic model was a recurrent theme, the direction of change, and its relationship to climate transition, was a matter of debate, as made manifest in a set of intense public controversies over new infrastructures for renewable energy sources, which our interlocutors often alluded to. These themes have important implications for the local framing of negative emissions technologies and marine carbon dioxide removal. We reflect on them in more detail in Section 2.4.

2.3 Approach to deliberative stakeholder engagement

On the basis of this scoping work we made several decisions on the design of further stakeholder engagement work. Our original plan had been to carry out a small deliberative workshop in January 2021. The event would have been organised around a set of English-language presentations on OceanNETs and the mesocosm research, followed by a facilitated discussion with participants on some of the key themes identified through the scoping research. It would have taken place virtually, given Covid restrictions at the time. The format would have been similar to that adopted in WP6 for the development of realistic deployment scenarios for ocean liming, albeit with a greater emphasis on locally relevant factors that might affect the feasibility of alkalinisation scenarios (see Deliverable 6.1 and 6.3 for further details on this approach).

When the mesocosm work was postponed until September 2021 (due to restrictions on internatinoal travel), we decided to adopt a different approach). We continued to hold individual meetings with stakeholders, both to increase awareness of the OceanNETs project among local actors, and to expand the range of topics they considered relevant when they were invited to discuss this topic.

In collaboration with Fundacion Loro Parque, a local institution dedicated to conservation efforts, we organised a public workshop to discuss marine CDR and ocean alkalinisation with a broad range of stakeholders. The workshop included introductory presentations on ocean-based NETs, the design and objectives of the mesocosm experiments, and emerging regulatory and economic dimensions of ocean alkalinity enhancement (See Appendix for presentation materials). The workshop was followed by a round-table discussion focused on the perceive fit (or lack thereof) of ocean-based NETs within existing regional priorities for economic development, conservation and climate action. The event was held at the Poema del Mar aquarium in the capital city of Las Palmas conversation efforts [Figure 1]. In addition to those who attended the discussions in person, the event was watched by around two hundred viewers online.

Figure 1: Roundtable at the stakeholder workshop at Poema del Mar

While the research was underway in Taliarte, the mesocosms were visited by representatives from local institutions. The research attracted extensive attention from local and national Spanish media. This included radio and television interviews with members of the OceanNETs team, and regular newspaper reports on the objectives and progress of the experiments. Local coverage focused on the design of the study, its pioneering role in the assessment of ocean alkalinity enhancement, and the participation of local researchers and institutions in the scientific work. These reports often discussed the potential role of Gran Canaria as a "laboratory" for the development of new approaches to climate change mitigation (see Section 2.4 for a discussion of this theme). The public workshop at Poema del Mar was also extensively covered in local and national media.

The OceanNETs team maintained an active, English-language blog detailing the setting up and progressing of the study. Members of the team also participated in international climate awareness activities, including the Global Climate Strike on 24 September 2021. Local coverage of the project has continued after the conclusion of the mesocosm studies [See Figure 2], indicating ongoing interest in the topics OceanNETs is exploring.

50 Gente y Culturas

MIÉRCOLES, 27 DE ABRIL DE 2022
LA PROVINCIA | DIARIO DE LAS PALMAS

Ciencia

Verónica Pavés
SANTA CRUZ DE TENERIFE

El mar canario acoge las primeras pruebas de secuestro de CO_2 con rocas

La experiencia, que corre a cargo del grupo de investigación alemán Geomar, trata de acelerar el proceso natural de secuestro de dióxido de carbono con minerales

El Archipiélago ha sido el campo de pruebas de los primeros experimentos *in situ* del mundo para medir los impactos de una de las tecnologías más prometedoras en la lucha contra el cambio climático: el uso de minerales en el secuestro de carbono en el mar. Aunque pueda parecer una solución extremadamente simple para mitigar un problema tan complejo como es el calentamiento global; sobre el papel abre un abanico de posibilidades impensables hace apenas unos años.

Los minerales de carbonato y silice llevan millones de años capturando dióxido de carbono de la atmósfera, apoyando al mar en el secuestro de este gas. Esta reacción se produce cuando las rocas, al erosionarse con el agua de la lluvia o las olas en la costa reaccionan con el CO2 atmosférico, precipitando en forma de bicarbonatos que son arrastrados hacia el océano. Con esta actividad, cada año son capaces de sustraer de la atmósfera una gigatonelada de dióxido de carbono de manera natural. En teoría, el proceso natural podría acelerarse depositando grandes cantidades de rocas de silicato o carbonato pulverizadas en el mar. Si los investigadores lo lograran, conseguirían secuestrar unas 100 gigatoneladas de dióxido de carbono cada año. Un revulsivo para la lucha contra el cambio climático, que necesita eliminar 20 gigatoneladas de este contaminante cada año a partir de 2030.

Estos experimentos forman parte del proyecto científico de la Unión Europea denominado OceanNETs está liderado por el centro Geomar Helmholtz Center for Ocean Research in Kiel, con la participación de la Universidad de Las Palmas de Gran Canaria. Ambos centros, en colaboración con la Plataforma Oceánica de Canarias (Plocan) llevan una década haciendo pruebas de estas incipientes tecnologías en el Archipiélago. Tras estudiar varias fórmulas basadas en la actividad natural de los océanos para el secuestro de carbono, la alcalinización o meteorización del océano a través de estas rocas resulta una de las más prometedoras de las que se están estudiando en todo el mundo.

Los estudios que se están haciendo tratan de responder a preguntas como qué influencia podrá tener esta tecnología en los océanos del futuro y si podrá tener un impacto negativo en la biodiversidad. A falta de estos datos, los expertos de todo el mundo ya miran con entusiasmo las posibilidades que desentraña esta posible futura tecnología. Los aspectos teóricos y estas primeras pruebas han sido tan prometedoras que han llegado a los oídos del filántropo y empresario, Bill Gates, quien ha compartido en su Twitter un artículo en el que *National Geographic* relata las pruebas que se están haciendo Gran Canaria, acompañado del comentario, «This rocks» (en inglés, este juego de palabras tiene un doble sentido, dado que, literalmente significa *estas rocas* pero en la jerga popular se traduce como *esto mola*).

«Sobre papel es una técnica que muestra muchos beneficios», resume Javier Arístegui, oceanógrafo de la Universidad de Las Palmas de Gran Canaria (ULPGC), que colabora en este proyecto. El uso de rocas para «alcanilizar» el océano y hacerlo más susceptible a la captura de dióxido de carbono también permite corregir la acidez del mar. La acidificación del océano se produce cuando las concentraciones de dióxido de carbono son tan grandes que resultan inasumibles para el ecosistema, que reacciona alterando el frágil equilibrio del pH y, por ende, afectando a la biodiversidad marina.

No todas las rocas tienen este potencial, son las carbonatadas o con silicatos las más proclives a reaccionar de esta manera con la erosión del agua. En las aguas poco productivas de Canarias se han realizado experimentos en mesocosmos (una recreación del ecosistema natural a menor escala) aumentando la alcalinidad con minerales, de carbonato cálcico y sódico. En dos semanas se realizará el mismo estudio comparándolo con las aguas templadas y productivas de Noruega en la que, además, utilizarán olivino, que pertenece a la familia de los silicatos. El trabajo se encuentra en una cuenta regresiva contra la apisonadora del cambio climático. «Cada vez tenemos menos tiempo», advierte Arístegui, que recuerda que estas tecnologías deben estar en funcionamiento en 2030 reducir las concentraciones de CO2 de la atmósfera y alcanzar el objetivo del acuerdo de París de que la temperatura del planeta no suba más de 1.5-2 grados a finales de siglo, con respecto a los valores pre-industriales.

Para ello se necesitan inversores y, con esta colaboración, las empresas de Canarias tienen una oportu-

> Bill Gates ha mostrado en su Twitter el interés por los experimentos realizados en Taliarte

Un buceador trabaja en uno de los mesocosmos utilizados para controlar las condiciones del agua de mar canario. | GEOMAR

Los investigadores de Geomar toman muestras de agua de la costa de Taliarte, junto a los investigadores de la ULPGC en sus mesocosmos.

Pasa a la página siguiente >>

Figure 2: Example of recent media coverage of mesocosm studies (La Provincia, 27 April 2022)

2.4 Insights from stakeholder engagement work

Perceptions of mesocosm studies

The experimental set-up of the OceanNETs mesocosm studies (the smaller-scale GEOMAR mesocosm system design, with nine cylindrical polyurethane foil bags attached to a pier in the harbour of Taliarte, next to the PLOCAN headquarters) was novel in relation to the assessment of ocean alkalinization, but was seen as part of long trajectory of oceanographic research in Gran Canaria, which is regularly reported in local media. A national research infrastructure administered by the Spanish Ministery of Science and Innovation, PLOCAN is a well-known institution locally, with a strong program of public outreach and communication.

Mesocosm formats very similar to the OceanNETs set-up have been used in the past, in previous research projects led by GEOMAR scientists. The most relevant examples are the KOSMOS GC 2014 and the KOSMOS GC 2019 projects, part of the international BIOACID and Ocean artUP consortia, respectively. KOSMOS GC 2014 assessed the impacts of ocean acidification through a mecosom study in Gando Bay, while KOSMOS GC 2019 assessed the feasibility and associated risk of using artificial upwelling to increase ocean productivity (and potentially raise fish production). KOSMOS GC 2019 in particular used an experimental format nearly identifcal to the one employed OceanNETs.

This lineage of mesocosm studies in Gran Canaria indicates the continuities that exist, from the perspective of experimental designs and their localization, between emerging research on ocean alkalinity enhancement, and previous research programmes focused on climate change impacts (ocean acidification), or on interventions on biogeochemical cycles not directly related to carbon dioxide removal (KOSMOS GC 2019 and Ocean artUP were focused on assessing the sustainable development of marine fisheries and aquaculture, and did not measure the potential use of artificial upwelling as a form of carbon dioxide removal).

Local stakeholders from research organisations and policy-making institutions often discussed this long history of oceanographic research in terms of the potential for Gran Canaria to become a "test bed" or "laboratory" for the development of marine technologies, including those oriented towards climate change mitigation. Technologies for marine carbon dioxide removal were often grouped together with other coastal or offshore interventions. The most relevant examples of emerging economic activities discussed in the meetings were the development of offshore wind platforms, and the further development of aquaculture, two areas where local research actors (PLOCAN and the University) are highly active. Policy-makers often framed these sectors as part of an emerging 'blue economy' that could mitigate the island's current reliance on mass tourism. Both the regional government of the Canary Islands and the Cabildo of Gran Canaria have active programmes to incentivize the development of these economic alternatives.

The idea of the island as a "laboratory" for climate or blue economy solutions is, however, contested. Local environmental groups have criticized some of the proposed blue economy initiatives, and this conceptual framework more generally. Ben Magec/Ecologistas en Accion, the largest and most active environmental campaign group in the islands, criticised the orientation of many of these policies towards new cycles of economic exploitation of local waters, leading to the further destruction of marine ecosystems (ref. Schutter et al 2021). Offshore wind, a sector that enjoys broad support from local, regional and national institutions, as well as multinational corporations, is the most active front in these debates. The "high quality" of local winds and water is discussed as an untapped asset, but general agreement on the need to move away from Gran Canaria's current reliance on fossil fuels and to incentivize renewable energy generation breaks down as soon as specific technical options are put on the table. Current plans to build offshore wind farms off the coast of Gran Canaria crystalize radically different views on the direction of local energy and climate transitions.

References to these disputes emerged often in stakeholder meetings, and provide some insights into the contested nature of dominant imaginaries of climate and energy transition (see following section for a further discussion). Even if prior knowledge of, or interest in, proposed methods of carbon dioxide removal was often low, the fact that stakeholders referred to these controversies as relevant for framing any potential development of ocean-based NETs in the island suggests some of the most relevant governance challenges. While contained experiments to characterize the impact of additional alkalinity on marine ecosystems and determine the durability of carbon sequestration were generally welcome as a way of increasing our understanding of this NET, stakeholders were often surprised at the scale of deployment (Gigaton level) that was mentioned in some of the most speculative scenarios. The introduction, at the workshop, of the life-cycle of some of the proposed methods of ocean alkalinization brought into focus the range of technical and material requirements of this form of carbon dioxide removal, and the environmental footprint of the terrestrial activities necessary for deployment at scale.

Attending to the infrastructural dimensions of oceanographic research illuminates, at a small scale, what conflicts over the use of marine space looks like. Even if the specific design of the OceanNETs mesocosm study appeared largely uncontroversial, there is a local history of debate and contestation over the expansion of marine research activities in Gran Canaria. Fishermen, for example, have complained in the past about the expansion of offshore experimental infrastructures, arguing that they interfere with their exploitation of local resources. The small harbour at Taliarte, the location of the OceanNETs mesocosm bags, is also a site of public debate, in connection with the proposed expansion and upgrading of port facilities. While the Gran Canaria Cabildo, which administers the harbour, justifies the changes as a means of improving the provision of services (including additional support for scientific and research activities seen as key to the island's economic future), some local residents argue that the expansion would negatively impact local amenities, such as the beach. These are local disputes, unrelated to the specific scientific content of the OceanNETs studies or marine CDR in general, but relevant if we want to identify the sorts of trade-offs and choices that are made when a particular technological option is developed. They bring NETs and their development "down to earth" (ref. Clery et al 2021), and illustrate the local complexity of governance decisions. In the conclusion we reflect on how to extend our understanding of CDR governance to encompass these local conflicts.

Role of marine CDR in regional climate transitions

Preparations for the OceanNETs mesocosm studies coincided with the final stages in the development of a new climate action strategy for the Canary Islands, and several of our interlocutors expressed interest in whether, and how, marine CDR might fit within these regional goals. The regional government's climate action strategy contemplates reaching carbon neutrality by 2040. It contemplates a radical reduction of emissions this decade (cutting 2018 emissions levels by almost half by 203), to be achieved via a rapid transition towards renewable energy sources, sustainable mobility, and greater energy efficiency in key economic sectors. The strategy also contemplates a gentle increase in greenhouse gas removals via natural carbon sinks, mainly through a better management of nature reserves (which currently encompass 40% of the Islands' territory) and the introduction of sustainable and carbon farming practices within the agricultural and forestry sectors.

NETs, including ocean alkalinity enhancement, are mentioned in the strategy. Although a door is left open to incorporating NETs into future climate strategies, the current policy makes clear that increases in carbon removal and sequestration between now and 2040 will rely primarily, if not exclusively, on the conservation and expansion of 'natural sinks' (soils, forests, wetlands, and oceans).

The tensions and trade-offs implicit in this strategy have become apparent in a series of recent controversies, which our interlocutors returned to often when discussing the potential role of NETs in future climate action. Most relevant in the island of Gran Canaria is the ongoing debate over the planned construction pumped-storage hydropower plant. The project is led by Red Eléctrica de España, partly state-owned utility company that operates the national electricity grid in Spain, and is supported by both the island Cabildo and the regional government. The project, justified by its advocates as a means to transition towards renewable energy sources and achieving greater 'energy sovereignty,' has generated intense opposition, as the plant is to be built in one of the most remarkable nature reserves on the island, the Barranco de Arguineguín. A citizen movement (Salvar Chira Soria), and several environmental and civil society organisations, are actively campaigning against the project, and seek to halt its development via administrative routes.

The controversy, mentioned often in meetings and interviews, serves as a lynchpin to crystalize diverging positions on the energy and climate transitions under discussion in the island. It materializes alternative views on the economic and energy future of the island, and more specifically on how to strike a balance between actions justified by the need to achieve carbon neutrality by 2040, and the imperative to protect natural habitats, ecosystems, and landscapes.

This holds an important lesson for the development of ocean-based CDR methods. No method of removing or sequestering carbon is likely to enjoy broad local legitimacy if it is seen as threatening valuable natural habitats or landscapes. When it comes to marine and coastal environments, a long history of destruction in the service of economic development, and poor stewardship of protected areas makes this a particularly sensitive topic in the Canary Islands. Ocean alkalinity enhancement brings these issues into sharp relief. Not only is the *idea* of adding large quantities of alkaline materials to seawater a problematic proposition for the general public, as work in WP3 suggests. If we move beyond the abstract concept of ocean alkalinity enhancement and consider all the industrial processes that would be required to generate, process, transport and deposit those materials at scale, as WP6 is doing at the moment, the local footprint of OAE becomes very significant and is bound to affect public acceptability of this method of carbon dioxide removal. Mathematical models and simulations might indicate that OEA has a significant potential as a means of removing CO2 from the atmosphere, or even as a way of reducing ocean acidification, but these are global calculations that reveal global or planetary-scale benefits, and do not determine how OEA will be perceived by local actors on the basis of regionally-specific considerations. As our stakeholder engagement work in Gran Canaria suggests, seen from a local or regional perspective, there are always better and more sustainable climate change mitigation alternatives on offer. Even if the discussion is narrowly focused on CDR methods, actors will always have other approaches at their disposal – in our case, better protection and expansion of natural sinks, which are seen as fully compatible with local sustainability, environmental protection, and climate resilience goals.

<u>Economic development prospects of ocean alkalinization</u>

Several interlocutors were interested in the economic prospects of ocean alkalinity enhancement. This was partly trigered by one of the presentations at the public workshop, which drew on research from OceanNETs WP6 to discuss possible life-cycles of ocean alkalinity enhancement applications (ocean liming and electrochemical weathering), and to outline some hypothetical deployment scenarios. In particular, the potential use of desalination reject brines as a source of sustainable material for alkalinization attracted the attention of the actors in the desalination sector, including the public water utility. Desalination is key to the economic life of the Canary Islands, and is a key componet of the regional R&D system. A follow-up meeting with the regional water utility, Canaragua, was arranged to discuss in more detail some of the scenarios being developed in WP6 and explore opportunity for future engagement.

Discussion of these hypothetical scenarios brought the discussion back to the key determining factors of regional climate transitions, particularly to changes in the fossil fule-intensive energy mix that currently sustains the islands' economic activities. The life-cycle assessments that are being carried out in WP6 make clear the significant energy requirements for any large-scale production of alkaline materials from desalination waste.

Any hypothetical scenario for incorporating ocean alkalinization into existing desalination infrastructures is thus conditional on the wholesale transition of those infrastructures towards renewable sources, but that transition is likely to be contested if it involves significant alteration of local landscapes and ecosystems (as discussed under the previous sub-heading).

Another hypothetical economic dimension of ocean alkalinity enhancement that attracted interest at the stakeholder workshop is the possibility of securing carbon credits that could be traded or used to meet corporate or regional carbon neutrality targets. At the meeting in Poema del Mar, the discussion focused on the lack of a technical infrastructures to measure or verify carbon removal via ocean alkalinization, and the absence of regulatory frameworks at the EU level that would allow a certification (and potentially trading) of those removals.

Although tentative and speculative, discussing potential economics of ocean alkalinity enhancement was useful to exploring a neglected dimension of the problem. When they were introduce to OceanNETs and its research agenda, several local actors were keen to learn more about the potential economic benefits – the local returns of any further development or potential deployment of this CDR option – perhaps imagining OAE as another piece of the "blue economy" puzzle. We had little to go by in fleshing out these discussions, other than reflecting on the scientific, technical and political uncertainties that currently define speculations over the potential transformation of ocean alkalinisation into a source of economic revenues or carbon credits. One option to extend this line of work would be to invite local stakeholders to discuss further iterations of the desalination case study in WP6, and in the process test emerging imaginaries of ocean alkalinisation as a climate solution that can be promoted through market incentives.

3. Conclusions and plans for future work

The localization of field research on ocean alkalinization in Gran Canaria helped trigger a set of discussions with local stakeholders on regionally specific considerations that should be taken into account when further experimentation and potential deployment of this method of marine CDR is considered. What these discussions indicate, is that actors will expect an alignment of this or any other CDR method with local priorities for sustainable economic development and climate action. By the same token, they will contest local application of this NET if it thought to compromise these priorities, no matter what the hypothetical planetary benefit of OEA might be.

Our engagement with stakeholders in Gran Canaria has informed our understanding of the local dimensions of marine CDR governance. This was a gap in our approach, as most of our previous work focused on international or at best national dimensions of the problem (see Lezaun 2021 for a longer discussion of these lessons).

When it comes to ocean-based NETs, these local governance challenge generally involve conflicting claims over the use of marine spaces and resources. Gran Canaria offers a paradigmatic example of these conflicts, as the development of infrastructures for seaside tourism monoculture and the expansion of port facilities have been prioritized over virtuallly any other use of the coastal environment. Our interlocutors drew on a rich history of precedents to articulate these conflicts over marine space. They also pointed to local experiences of marine spatial planning (MSP) that might offer a model for adjudicating the inevitable trade-offs that would be generated by the development of ocean-based NETs (Abramic et al 2021; García-Sanabria et al 2021). A key advantage of MSP is that it operates at the ecosystem level, takes into account land–sea interactions, and makes explicit the tensions (and potential synergies) between alternative uses of marine space. In most European jurisdictions, MSP is supported by legally-binding frameworks that include explicit mandates for transparency, participation, and accountability (as in the EU Marine Spatial Planning Directive). Placing discussions of marine CDR development in this context will help articulate many of the choices and trade-offs between alternative uses of marine spaces, which remain hidden when public debate remains focused on individual technologies, or on the international challenges raised by ocean-based NETs.

Public and stakeholder interest in ocean alkalinization of marine CDR grew as OceanNETs work in Gran Canaria unfolded. It became clear that stakeholder engagement should continue beyond the conclusion of the mesocosm studies. The completion of the second round of mesocosm studies in Norway will offer an opportunity to return to Gran Canaria and discuss experimental results with local actors. Those results will offer a fuller picture of the potential risks and benefits of ocean alkalinization, and a better sense of the uncertainities that still define the field. A further round of stakeholder engagement work will also give us an opportunity to discuss recent regulatory moves at the regional level (e.g. the regional strategy for just transition and climate justice, currenlty under development) and in the EU (e.g. further developments in the European Commision's regulation of carbon farming and sustainable carbon cycles). In parallel, we will involve local actors in further work in WP6 on the development of scenarios for the use of desalination brines in ocean alkalinization applications. Our intention is that this line of work will continue throughout the duration of the OceanNETs project.

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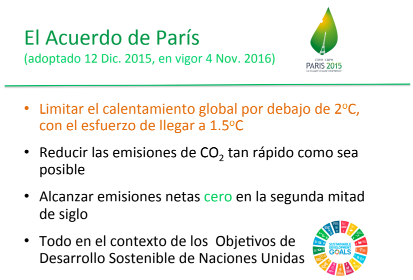
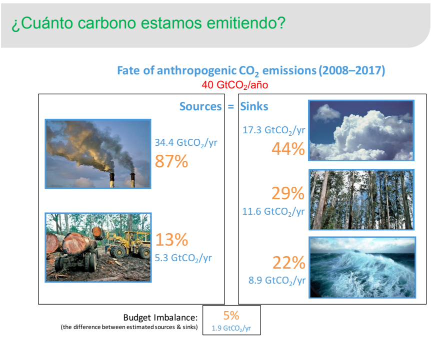
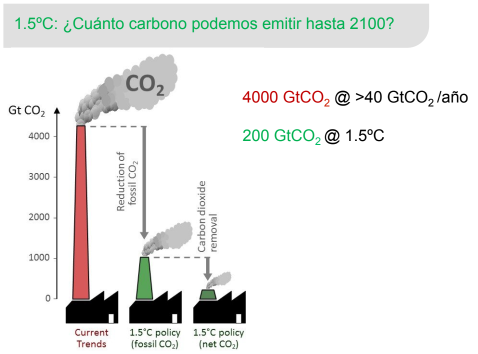
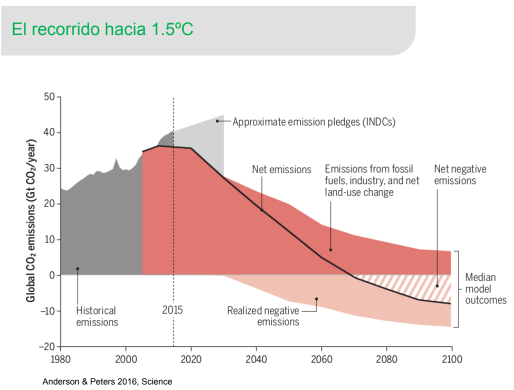
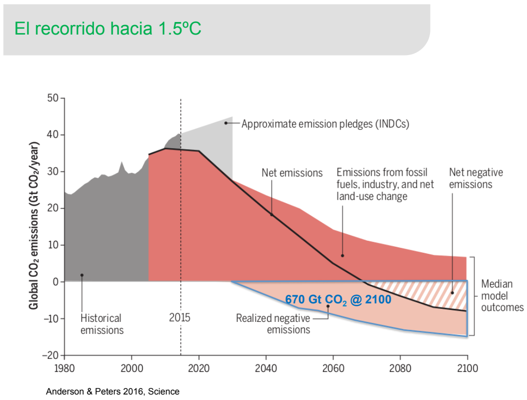
Appendix: Materials used in the stakeholder workshop

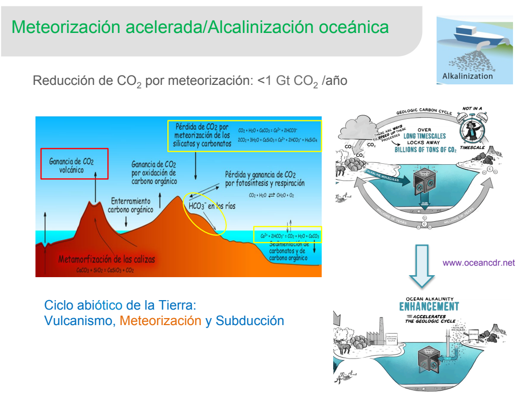


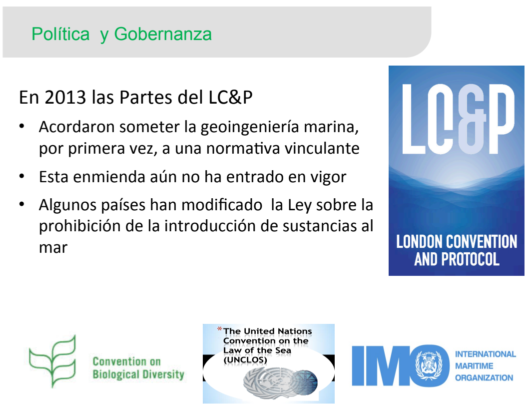






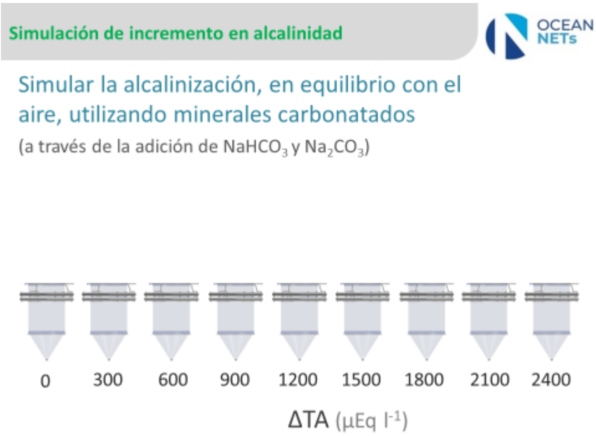







OceanNETs
Experimento de mesocosmos
Foto: U. Riebesell
Socios
GEOMAR
Helmholtz Centre for Ocean Research Kiel
UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA
PLOCAN
HERIOT WATT
UH
Financiación
OCEAN NETs
Ocean CDR
AQUACOSM plus


Alcalinización oceánica
OCEAN NETs
Winners
Losers
Bach et al. (2019) fclim

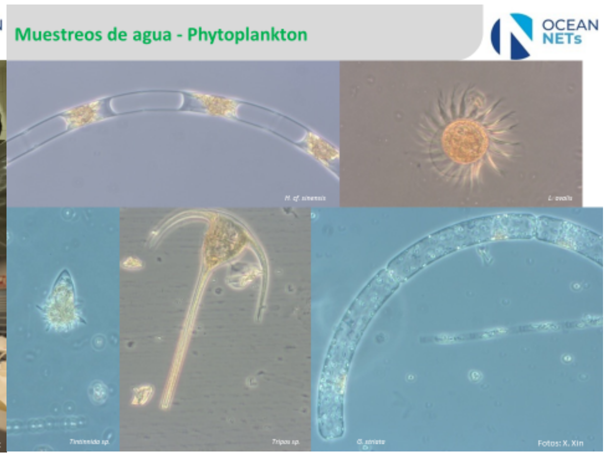

Simulación de incremento en alcalinidad
OCEAN NETs
Simular la alcalinización, en equilibrio con el aire, utilizando minerales carbonatados
(a través de la adición de $NaHCO_3$ y Na_2CO_3)
0
300
600
900
1200
1500
1800
2100
2400
ΔTA (μEq l^{-1})


Montaje y tratamiento
OCEAN NETs


Sedimentos y fluorescencia
OCEAN NETs
Fotos: M. Sswat

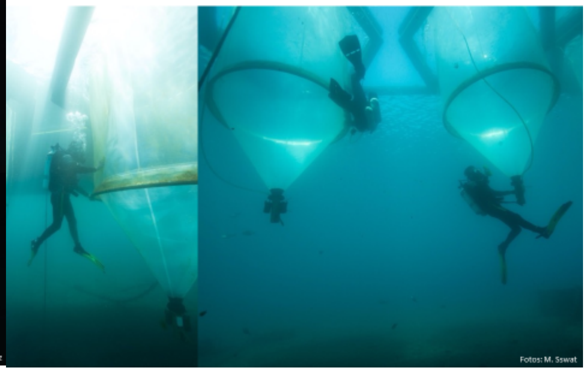

Muestreos de agua
OCEAN NETs
Fotos: M. Sswat


Muestreos de agua
OCEAN NETs
PLOCAN
Fotos: M. Sswat


Muestreos de agua - Phytoplankton
OCEAN NETs
Fotos: X. Xin

Muestreos de agua - Zooplankton

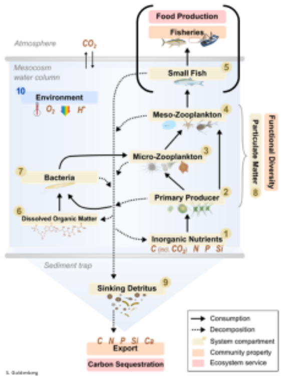
Mantenimiento



Análisis completo del sistema

- Para **identificar** la potencial respuesta de la comunidad al incremento de alcalinidad se deben monitorizar:
  - Parámetros **bióticos**:
    - Composición de especies via análisis de imagen, ADN,..
    - Producción primaria con análisis de materia orgánica, oxígeno, clorofila...
    - Otros
  - Parámetros **abióticos** (entorno fisicoquímico):
    - Alcalinidad y pH
    - Nutrientes inorgánicos
    - Otros
- Y **relacionar** los resultados

Análisis completo del sistema



Abarcamos **cerca de 50 parámetros** diferentes con el objetivo de cuantificar, con confianza, el potencial impacto al medioambiente e informar correctamente sobre este.

Aun así esto es solo un comienzo. Con el apoyo de las instituciones habría gran potencial en Gran Canaria para sacar adelante la investigación en este campo que está en auge!

--

UNIVERSITY OF OXFORD

Dimensiones económicas de la captura marina de carbono

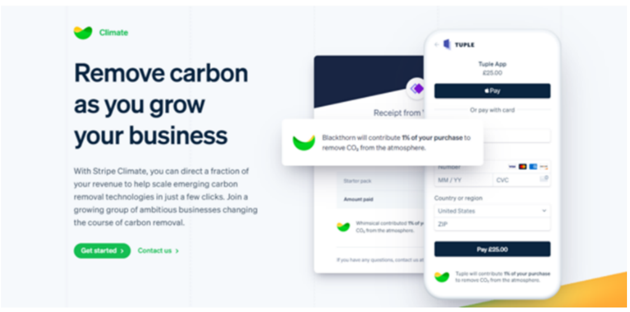
Javier Lezaun, Universidad de Oxford

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

¿Cómo se puede pagar la remoción de dióxido de carbono?

- "El que contamina, paga"
  - útil para reducir emisiones, no tanto para crear nuevas tecnologías o infraestructuras de captura
- Créditos de captura de carbono:
  - Ejemplos en la captura terrestre de carbono (planes de empresas para la neutralidad de carbono; UK Woodland Carbon Code);
  - Difícil de aplicar al entorno marino: las tecnologías aun no están maduras, y la medición de las capturas es técnicamente complicada

Primeros mercados y contratos privados de créditos de remoción



Project Vesta: 3.333 tn a $75/tn

ClimeWorks: 322 ton a $775/tn

CarbonCure: 2.500 tn a $100/tn

Charm Industrial: 416 tn a $600/tn

Orca, Islandia

CLIMEWORKS
Capturing CO₂ from air

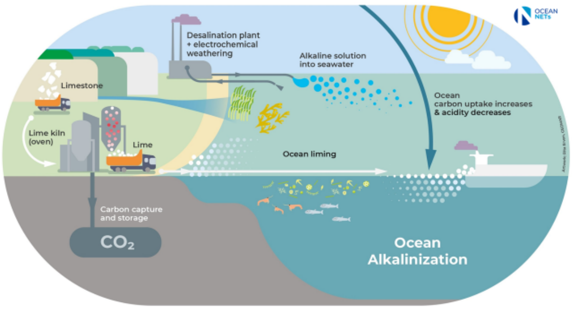
Swiss Re

US$10 millones/10 años

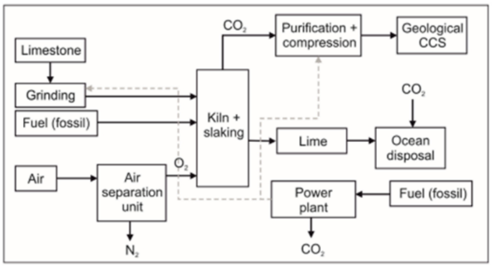
Captura de carbono a escala industrial

- ¿Qué industrias ya existentes pueden participar directamente al proceso de remoción de dióxido carbono?
- Alcalinización artificial: producción de materiales alcalinos
- Como minimizar el impacto medioambiental de estos procesos (extracción de mineral; uso de energía)

- Mercados voluntarios y, de momento, muy pequeños – apenas nada en el entorno marino
- Sin un sistema para certificar capturas, estos mercados seguirán siendo testimoniales
- Propuesta de ley de La Comisión Europea (2022):
  - exclusión de los métodos oceánicos de captura?



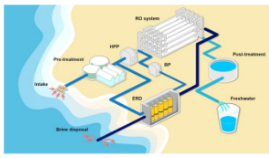
Producción de cal para su deposito en el océano

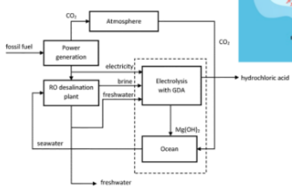


Cómo asegurar que este proceso produce un resultado negativo neto en emisiones?

Cómo minimizar otros impactos ambientales del proceso productivo

Uso de salmueras de desalinización





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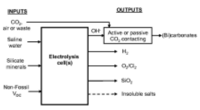
Alcalinización del océano y producción de hidrogeno

Proyecto piloto en Nueva Escocia, Canada



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Conclusiones

- Hay que explorar los co-beneficios, económicos y medioambientales, con actores y actividades económicos ya existentes o emergentes
- El desarrollo de estas oportunidades tiene que ir unido a la descarbonización de esos sectores – si no, es imposible alcanzar la neutralidad de carbono & estabilidad climática
- Necesitamos un marco regulatorio que permita certificar la remoción segura y a largo plazo de dióxido de carbono en entornos marinos