Carbon to Sea Initiative

September 19, 2024

Congressman Frank Lucas
Chair
House Committee on Science Space Technology
2321 Rayburn House Office Building
Washington, DC 20515

Congresswoman Zoe Lofgren
Ranking Member
House Committee on Science Space and and Technology
2321 Rayburn House Office Building
Washington, DC 20515

Re: *Navigating the Blue Frontier: Evaluating the Potential of Marine Carbon Dioxide Removal Approaches*

Dear Chairman Lucas and Ranking Member Lofgren:

Thank you for the opportunity to submit written testimony. My name is Dr. Julie Pullen and I am a founding partner and chief scientist of Propeller Ventures, an early-stage venture fund focused on ocean climate technology. I am also a member of the Science Advisory Board for Carbon to Sea, the leading nonprofit effort to evaluate the promise of one high-potential marine carbon dioxide removal (mCDR) pathway called ocean alkalinity enhancement (OAE). I serve on the boards of several other ocean science and climate organizations, including Ocean Visions and Waterfront Alliance.

I earned my Ph.D. in physical oceanography from Oregon State University and am an adjunct research scientist at The Earth Institute at Columbia University. I am a member of the U.S. Climate Security Roundtable. I have also served on the leadership councils of the American Meteorological Society and The Oceanography Society.

OUR CLIMATE CHALLENGE

I appreciate the opportunity to discuss the need for increased investment in carbon dioxide removal technologies, particularly in mCDR, which is understudied and underfunded.

I'm grateful for this committee's leadership in building up a domestic green economy. Your support of the bipartisan Infrastructure Investment and Jobs Act and the Inflation

Reduction Act has strengthened America as a leader in climate technology and innovation, helping mitigate climate change while strengthening our economy.

Despite the progress made with those two pieces of legislation, we are still not on track to meet the emissions reduction targets set out in the Paris Agreement. We're also leaving good jobs and economic growth on the table if we don't double down on carbon dioxide removal.

Americans depend on the ocean and coastal waters for the jobs and economic contribution they generate. Unless we find solutions to the challenges that our ocean waters face, the $275 billion fishing and shellfish industry - and the nearly 2 million family-supporting jobs that rely on it - could suffer.

CDR IS A NECESSARY COMPLEMENT TO EMISSIONS REDUCTION

Scaling back fossil fuel use is the top priority to slow global warming and, at the same time, I strongly believe we must develop and responsibly scale CDR to draw down legacy carbon emissions from the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), CDR "is required to achieve global and national targets of net zero CO_2 and greenhouse gas emissions. CDR cannot substitute for immediate and deep emissions reductions, but it is part of all modeled scenarios that limit global warming to 2° or lower by 2100." The International Energy Agency similarly reports that CDR must account for 8 percent of emission reductions in order to meet the goals outlined in the Paris Agreement.

CDR'S ECONOMIC POTENTIAL

Carbon dioxide removal is a burgeoning industry full of economic potential, which could eventually be worth anywhere from $259 billion by 2050 according to Rhodium Group, to $1 trillion by 2037 according to Bloomberg, to $1.2 trillion by 2050 according to McKinsey. The U.S. has the opportunity to lead the way on support for innovation, scientific study, and regulation for this emerging industry, in order to reap the economic rewards over the coming years. Already, investment in carbon capture facilities from the American Jobs Plan is expected to create up to 78,600 jobs by 2035, with the National Oceanic and Atmospheric Administration (NOAA) predicting a total of 300,000 new CDR jobs by 2050.

Major companies such as Microsoft and Stripe have begun investing in this technology. This year, Microsoft announced that they will be purchasing 500,000 tons of carbon removal credits over the next six years, in addition to the company's previous $200 million investment in CDR. Stripe has similarly invested $15 million into CDR, helping companies purchase carbon dioxide removal and bring emerging technologies to the market.

Those numbers signal the market's interest — and they understate it if anything. But the overall focus so far has been disproportionately weighted towards land-based methods of CDR, like DAC, reforestation, and soil regeneration efforts. They're further along, so it makes sense. But we must recognize that these are not our only options and there is more work to be done.

OCEAN-BASED CDR IS AN UNDEREXPLORED OPTION

One promising solution scientists are exploring leverages an existing natural resource: the ocean. The ocean is already the world's largest carbon sink, covering more than 70 percent of the planet and holding about 50 times more carbon than the atmosphere. Through a natural geological process, alkaline rocks like limestone wash into the ocean and alter the water to make it more alkaline than freshwater sources. This increase in alkalinity causes a chemical reaction that converts dissolved carbon dioxide into carbonates and bicarbonates, which safely remain locked away for thousands of years. That chemical reaction in turn allows the ocean to absorb more carbon dioxide from the atmosphere. The carbon is stored in the ocean for tens of thousands of years, making this geological process effectively permanent.

If we accelerate this process without creating adverse effects on the larger ecosystem, we could remove billions of tons of atmospheric carbon dioxide. It's important to say that the concept of adding alkalinity to water has been used for decades by shellfish hatcheries and to reduce acidification in rivers.

Recent laboratory[1] [2] [3] [4] studies and controlled outdoor environmental experiments,[5] [6] which simulate real-world conditions[7] on a smaller scale, show that while there are upper limits as to how much OAE should be done in any particular place,[8] [9] OAE can theoretically be done in effective,[10] [11] [12] safe,[13] [14] [15] and responsible[16] [17] [18] ways.

GREATER PUBLIC INVESTMENT IS NEEDED

This early interest and investment in CDR and mCDR from philanthropic, public and private sectors is a strong start to build a nascent field. To support further high-quality research, attract new private sector funders, and encourage greater collaboration and professionalization within the field, greater public investment is needed. The U.S. government must play a catalytic role in strengthening investments and developing a responsible regulatory framework for the mCDR field if we hope to tap into its true market potential.

The U.S. government has already made historic investments, nearly $61.5 million, in mCDR technologies and the ocean-climate space over the last year or so. This includes $24.3 million in grants from the interagency National Oceanographic Partnership Program

to advance mCDR research, which funded 17 projects with partners from 47 institutions. The DOE's ARPA-E program also awarded $35.8 million in grants to accelerate the development of mCDR technology. As just one example of this funding at work, the University of Pittsburgh was awarded $1.4 million from the Office of Naval Research to explore how desalination membranes (special filters used to separate salt and minerals from water) can support mCDR. That's just a part of overall government funding for CDR, which is more than a billion dollars so far.

In addition to funding, the White House has taken steps to build systemic, whole-of-government support for the emerging CDR market. The Ocean Climate Action Plan and Fast-Track Action Committee are specifically designed to support mCDR research and advance mCDR technologies, like OAE. Last month, the Department of Energy (DOE) and National Oceanic and Atmospheric Administration (NOAA) announced a memorandum of agreement to advance mCDR research and development, promote coordination and collaboration between agencies, and create ethical guidelines for this technology. This is an encouraging example of interagency collaboration, bringing together NOAA's ocean science expertise and the DOE's capacity to scale and advance the commercialization of technologies.

These are exciting and necessary announcements, but the U.S. must ramp up funding for mCDR research to help inform decisions about which approaches are most effective and safe for large-scale development. In order for mCDR technologies to deliver safe and effective CDR at scale, NASEM estimates that funding for R&D needs to rise to about $301.5 million annually, for a ten-year investment of $2.41 billion. Already, more than 400 scientists from around the world have called for increased R&D of mCDR to determine its efficacy and safety.

OAE IS A HIGH-POTENTIAL PATHWAY

Given the urgency of the climate crisis and the need for further research into mCDR, the U.S. should invest in a portfolio of marine CDR approaches. There are multiple mCDR pathways that could be used — for example adding alkaline-rich types of sand to the ocean, nutrient fertilization, and other biotic pathways. Each of these methods require different amounts of time, money, and resources and may have varying degrees of success at scale. But there is broad agreement among the ocean-climate scientific community that it's worth exploring these methods to determine their effectiveness, safety, and long-term potential to help mitigate climate change.

Leading research organizations like the IPCC and U.S. National Academies of Sciences, Engineering, and Medicine (NASEM) have specifically identified ocean alkalinity enhancement (OAE) as one high-potential approach that demands further exploration. In theory, OAE is a scalable, permanent, and effective way to remove carbon from the

atmosphere. Researchers and scientists from academic institutions, private companies, philanthropies, and government agencies are already working to answer questions around OAE's efficiency, safety, environmental impacts, and costs. Notably, NASEM published research in 2021 advocating for the development of OAE technologies and recently, Isometric (a network of scientists) developed the world's first MRV protocol for OAE.

In order to meet global emission reduction goals and strengthen the U.S. economy, greater federal investment into marine carbon dioxide removal technology is needed. Doing so will address the worsening climate crisis and allow the U.S. to emerge as a global environmental leader.

I appreciate the opportunity to submit this testimony. Please do not hesitate to contact me should you have any questions or need any further information.

Sincerely,
Dr. Julie Pullen
Science Advisory Board Member
Carbon to Sea Initiative

Key Sources

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[1] Gately, J. A., Kim, S. M., Jin, B., Brzezinski, M. A., and Iglesias-Rodriguez, M. D.: Coccolithophores and diatoms resilient to ocean alkalinity enhancement: A glimpse of hope?, Science Advances, 9, eadg6066, https://doi.org/10.1126/sciadv.adg6066, 2023.

[2] Moras, C. A., Bach, L. T., Cyronak, T., Joannes-Boyau, R., and Schulz, K. G.: Ocean alkalinity enhancement – avoiding runaway CaCO3 precipitation during quick and hydrated lime dissolution, Biogeosciences, 19, 3537–3557, https://doi.org/10.5194/bg-19-3537-2022, 2022.

[3] Guo, J. A., Strzepek, R. F., Swadling, K. M., Townsend, A. T., and Bach, L. T.: Influence of ocean alkalinity enhancement with olivine or steel slag on a coastal plankton community in Tasmania, Biogeosciences, 21, 2335–2354, https://doi.org/10.5194/bg-21-2335-2024, 2024.

[4] Ferderer, A., Chase, Z., Kennedy, F., Schulz, K. G., and Bach, L. T.: Assessing the influence of ocean alkalinity enhancement on a coastal phytoplankton community, Biogeosciences, 19, 5375–5399, https://doi.org/10.5194/bg-19-5375-2022, 2022.

[5] Hartmann, J., Suitner, N., Lim, C., Schneider, J., Marín-Samper, L., Arístegui, J., Renforth, P., Taucher, J., and Riebesell, U.: Stability of alkalinity in ocean alkalinity enhancement (OAE) approaches – consequences for durability of CO2 storage, Biogeosciences, 20, 781–802, https://doi.org/10.5194/bg-20-781-2023, 2023.

[6] Marín-Samper, L., Arístegui, J., Hernández-Hernández, N., Ortiz, J., Archer, S. D., Ludwig, A., and Riebesell, U.: Assessing the impact of CO2-equilibrated ocean alkalinity enhancement on microbial metabolic rates in an oligotrophic system, Biogeosciences, 21, 2859–2876, https://doi.org/10.5194/bg-21-2859-2024, 2024.

[7] Dupont, S. and Metian, M.: General considerations for experimental research on ocean alkalinity enhancement, in: Guide to Best Practices in Ocean Alkalinity Enhancement Research, edited by:

Oschlies, A., Stevenson, A., Bach, L. T., Fennel, K., Rickaby, R. E. M., Satterfield, T., Webb, R., and Gattuso, J.-P., Copernicus Publications, State Planet, 2-oae2023, 4, https://doi.org/10.5194/sp-2-oae2023-4-2023, 2023.

[8] Hartmann, J., Suitner, N., Lim, C., Schneider, J., Marín-Samper, L., Arístegui, J., Renforth, P., Taucher, J., and Riebesell, U.: Stability of alkalinity in ocean alkalinity enhancement (OAE) approaches – consequences for durability of CO2 storage, Biogeosciences, 20, 781–802, https://doi.org/10.5194/bg-20-781-2023, 2023.

[9] Moras, C. A., Bach, L. T., Cyronak, T., Joannes-Boyau, R., and Schulz, K. G.: Ocean alkalinity enhancement – avoiding runaway CaCO3 precipitation during quick and hydrated lime dissolution, Biogeosciences, 19, 3537–3557, https://doi.org/10.5194/bg-19-3537-2022, 2022.

[10] He, J. and Tyka, M. D.: Limits and CO2 equilibration of near-coast alkalinity enhancement, Biogeosciences, 20, 27–43, https://doi.org/10.5194/bg-20-27-2023, 2023.

[11] Hartmann, J., Suitner, N., Lim, C., Schneider, J., Marín-Samper, L., Arístegui, J., Renforth, P., Taucher, J., and Riebesell, U.: Stability of alkalinity in ocean alkalinity enhancement (OAE) approaches – consequences for durability of CO2 storage, Biogeosciences, 20, 781–802, https://doi.org/10.5194/bg-20-781-2023, 2023.

[12] Moras, C. A., Bach, L. T., Cyronak, T., Joannes-Boyau, R., and Schulz, K. G.: Ocean alkalinity enhancement – avoiding runaway CaCO3 precipitation during quick and hydrated lime dissolution, Biogeosciences, 19, 3537–3557, https://doi.org/10.5194/bg-19-3537-2022, 2022.

[13] Marín-Samper, L., Arístegui, J., Hernández-Hernández, N., Ortiz, J., Archer, S. D., Ludwig, A., and Riebesell, U.: Assessing the impact of CO2-equilibrated ocean alkalinity enhancement on microbial metabolic rates in an oligotrophic system, Biogeosciences, 21, 2859–2876, https://doi.org/10.5194/bg-21-2859-2024, 2024.

[14] Gately, J. A., Kim, S. M., Jin, B., Brzezinski, M. A., and Iglesias-Rodriguez, M. D.: Coccolithophores and diatoms resilient to ocean alkalinity enhancement: A glimpse of hope?, Science Advances, 9, eadg6066, https://doi.org/10.1126/sciadv.adg6066, 2023.

[15] Ferderer, A., Chase, Z., Kennedy, F., Schulz, K. G., and Bach, L. T.: Assessing the influence of ocean alkalinity enhancement on a coastal phytoplankton community, Biogeosciences, 19, 5375–5399, https://doi.org/10.5194/bg-19-5375-2022, 2022.

[16] Boettcher, M., Chai, F., Conathan, M., Cooley, S., Keller, D. P., Klinsky, S., Lezaun, J., Renforth, P., Scobie, M., and Webb, R. M.: A Code of Conduct for Marine Carbon Dioxide Removal Research, The Aspen Institute, Energy and Environment Program, 44, 2023.

[17] Dupont, S. and Metian, M.: General considerations for experimental research on ocean alkalinity enhancement, in: Guide to Best Practices in Ocean Alkalinity Enhancement Research, edited by: Oschlies, A., Stevenson, A., Bach, L. T., Fennel, K., Rickaby, R. E. M., Satterfield, T., Webb, R., and Gattuso, J.-P., Copernicus Publications, State Planet, 2-oae2023, 4, https://doi.org/10.5194/sp-2-oae2023-4-2023, 2023.

[18] Cyronak, T., Albright, R., and Bach, L. T.: Field experiments in ocean alkalinity enhancement research, in: Guide to Best Practices in Ocean Alkalinity Enhancement Research, edited by: Oschlies, A., Stevenson, A., Bach, L. T., Fennel, K., Rickaby, R. E. M., Satterfield, T., Webb, R., and Gattuso, J.-P., Copernicus Publications, State Planet, 2-oae2023, 7, https://doi.org/10.5194/sp-2-oae2023-7-2023, 2023.