

Ocean-Based CDR Panel Discussion Summary



INTERNATIONAL ALLIANCE TO
COMBAT OCEAN ACIDIFICATION

 THE OCEAN FOUNDATION

So, What is Ocean Carbon Dioxide Removal Anyway? How Does It Relate to OA?

On March 22, 2022, the OA Alliance and The Ocean Foundation hosted a panel discussion with OA practitioners in the public and private sectors about the research and investment needed to explore the potential utility of Ocean-based Carbon Dioxide Removal strategies and how they relate to OA, including potential benefits or consequences. A summary of the discussion is below.

While reducing anthropogenic carbon emissions is the #1 action needed to combat ocean acidification, additional strategies may be needed to assist carbon sequestration and advance resilience building actions to limit ocean acidification and achieve global climate goals. A new report by the National Academies of Sciences, Engineering and Medicine outlines six ocean-based Carbon Dioxide Removal (CDR) approaches that are in need of further research. These approaches can be understood as part of a broader land and coastal based CDR research agenda to help meet the goals set forth in the Paris Climate Agreement.

Panelists:

- Matthew Eisaman, Co-Founder and CTO, Ebb Carbon and Associate Professor, Stony Brook University
- Dr. Jessica Cross, Research Oceanographer, Pacific Marine Environmental Laboratory, National Oceanographic and Atmospheric Administration
- Romany Webb, Associate Research Scholar, Sabin Center for Climate Change Law, Columbia Law School; Committee on a Research Strategy for Ocean CDR and Sequestration, National Academies of Sciences, Engineering and Medicine
- Brad Ack, Executive Director, Ocean Visions
- Mark J. Spalding, President, The Ocean Foundation
- Dr. Sarah Cooley, Director of Climate Science, Ocean Conservancy

Facilitator:

- Jessie Turner, Director, International Alliance to Combat Ocean Acidification



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Part One: High-level comments regarding the context for and role of CDR in climate change mitigation, adaptation, and messaging.

- As of 2021, atmospheric carbon dioxide (CO₂) levels have reached historically unprecedented levels, higher than at any time in the past 800,000 years. Projections for the end of this century indicate that our global ocean's surface waters could be 150 times more acidified than at the start of the Industrial Revolution as a result of increased CO₂ emissions being absorbed by the ocean.
- The Paris Agreement has set forth a global agreement for limiting warming below 2 degrees, with targets for 1.5 degrees. A recent UN Environmental Program analysis indicates we are on track to reach 2.7 degrees by 2100. The IPCC AR6 Working Group I assessment indicates 2 degrees of warming is most likely by 2050. Pathways to 1.5 C all require 100-1000 Gt removal of CO₂ already in the atmosphere by the end of the century, with annual rates of removal at 10 Gt CO₂ until 2050 and rising to 20 Gt CO₂ through 2100.
- While some ocean CDR strategies could help remediate OA, it's not clear yet whether proposed ocean CDR techniques will meaningfully and certainly drawdown atmospheric CO₂. Verification, durability, and scalability of ocean CDR pose big challenges. We should be working towards resolving which approaches are worth the investment, given the costs and risks.
- Two of the biggest drivers of ocean-climate change are warming and carbon absorption. While limiting the ongoing amount of GHG and CO₂ released into the atmosphere every passing day is critical, effects will be ongoing from the CO₂ that is already in the atmosphere (and being absorbed by the ocean) now. This means, to limit OA and other ocean-climate impacts, we need to reduce the atmospheric concentration of legacy CO₂. We also need to be rethinking what are considered "safe and acceptable" goals. Even if we meet the global goal of 1.5 degrees and 450 ppm, we will see (and are already seeing) incredibly harmful and irreversible environmental impacts. While many ocean CDR solutions are not yet proven, we should be investing now so we are better prepared to harness them moving forward. It is important to do two things at once—transition away from fossil fuels (turn off the tap) and work on strategies that reduce existing carbon concentrations in the atmosphere and the ocean.
- A critical question / challenge is presented around messaging ocean CDR so we can avoid what the literature calls "a moral hazard." This might be created by presenting or messaging "solutions" to climate change that incentivize or perpetuate the notion that we don't need to transition away from fossil fuels, and to stop emitting GHG and CO₂ at the sources—which we do. It is important to ensure that ambition and urgency for reducing further emissions of GHG and CO₂ is not diminished.
- The National Academies of Sciences, Engineering and Medicine formed a committee that was tasked with assessing six approaches to ocean CDR. The biotic approaches are ocean fertilization (adding micronutrients or macronutrients to stimulate phytoplankton growth), artificial upwelling/downwelling (using pipes to bring up cooler, nutrient-dense water to the surface to stimulate phytoplankton growth and downwelling CO₂ rich water), seaweed cultivation, and ecosystem recovery (protect and recover fish, whale, and other animal populations, and restore habitats). The abiotic approaches are ocean alkalinity enhancement and electrochemical



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methods. The committee looked at the existing the knowledge base for each technique, as well as its efficacy, durability of carbon storage, scalability of removal, environmental risk, co-benefits, social considerations, cost of deployment, monitoring, and carbon accounting, and other resource needs, such as energy and material requirements.

- The geochemistry of ocean-based CDR pathways can be complex. The successes or potentially negative consequences of different ocean CDR strategies will vary by method and region. In some areas, small changes to the system may create big reactions. In other areas, bigger inputs may be needed for small changes. Until there's a lot less CO₂ in the atmosphere than the global surface ocean, the ocean will continue to absorb CO₂ and OA will continue to worsen.
- A promising method is ocean alkalinity enhancement (OAE). OAE uses alkaline liquid or solid material to then soak up more CO₂ from the atmosphere, which has the co-benefit of raising the pH in the surface ocean. This is essentially a speeding up of the natural carbon cycle, which would happen naturally over 1000s of years. This is a relatively durable method, meaning that the results will be stable for some time, and the reactions are relatively well understood. However, there are unknowns about scalability and the associated energy use for electrochemical OAE or in mining alkaline materials and transporting them to sites in the ocean.
- Should we be targeting local or global? The local scale correspondingly has less surface area to resolve CO₂ but could result in OA remediation very effectively in a certain area. If we're thinking about removing CO₂ from the atmosphere, efforts must be done on a much larger scale. It depends on the timeframe too; do we want to quickly remediate OA or more slowly draw carbon out of the system? To do both, we must reduce emissions extremely quickly and implement terrestrial and ocean CDR extremely quickly over the next 10 to 20 years.
- Some companies (like Ebb Carbon) are working to accelerate OAE to mimic the earth's natural process, weathering, to remove CO₂. The problem is that earth's natural weathering happens on geological time scales (thousands – millions of years), and we don't have that kind of time to mitigate climate change on human-relevant scales. Ebb is using effluent streams or processing seawater directly. Their processes separate salt into acid and base streams. The base is mixed with the effluent to a pH of 8.5 and returned to the ocean, while acid is used on land. The result is CO₂ removal with the co-benefit of reducing OA. Ebb Carbon's approach is electrochemical ocean alkalinity enhancement. Like each of the CDR approaches, this is not a silver bullet, but rather a potential part of an important network of strategies.

Part Two: Thoughts and perspectives regarding research priorities; regulatory, cost and equity aspects of CDR schemes; role of governance and policy makers.

Facilitator: *As we've heard, the National Academy report provides a springboard for governments and stakeholders to outline a process for prioritizing the next phase of research needs based upon several factors.*



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Jessica, what factors do you think need to be prioritized or considered to help direct ongoing research and development?

Three things: (1) monitoring, reporting, verification (MRV) is the next big challenge we face as scientists (understanding how much carbon is actually and stably pulled from the atmosphere). (2) we need to better resolve open questions about governance (understanding who is making decisions, who is deciding on off-ramps if things are too hazardous/not working); and (3) a clear code of conduct (ensure responsible research and measurements that support operational governance).

Mark, I am curious to hear your thoughts on timescales and how timeliness might inform research and development priorities?

As mentioned, we need to talk about ppm CO₂ in the atmosphere and pull that number down fast. Reducing GHG and CO₂ emissions is something we can all work on now. In terms of removing CO₂ from the atmosphere and the water column, we have nature-based solutions, and we know how they work—so we should invest in those and run with them. Regarding other biotic strategies, timescale for meaningful storage is still an important question. Regarding the mechanical abiotic strategies, we can invest in better understanding. The timeline for getting some of these proposed ocean CDR approaches verified (from concept, to pilot, to research, to implementation) can take a very long time, which means we might decide not to invest a lot of up-front money in those approaches first. That said, we can—and should—invest strategically in research and development of nature-based solutions, and in efficacy testing and research of other lesser understood approaches.

Sarah, can you elaborate a bit on the social considerations of weighing ocean-based CDR approaches?

I have a paper in review on this topic alongside three social scientists. Because there's not a lot of evidence on social considerations of ocean CDR, we had to look at other ocean uses and technologies. Relevant factors are the physical characteristics of techniques (where they are, what they look like). Financial factors or incentives of techniques could create less urgency to address CO₂ reductions, further exacerbating a moral hazard. We need more information on how communities may react to ocean CDR technologies that impact nature, what is a community's tolerance for risk across natural environments especially in the ocean environment. Finally, ethical dimensions are—to date—almost completely unexplored.

Romany, your work has largely focused on the legal, regulatory and policy landscape. Can you share your thoughts on how these factors inform research, development, and deployment considerations?

There is currently no international or, in the U.S., domestic legal framework specific to ocean CDR. There are existing laws that could apply, but those laws were developed with other activities in mind so often aren't well suited to ocean CDR. Some might impose unnecessary restrictions on ocean CDR research, while others may not adequately address risks. Many people in the research field say that legal complexity and uncertainty is a big impediment to moving forward with projects. On the policy side, building off Jessica's point on monitoring, reporting, and verification, we should be thinking more about how we are going to pay for carbon removal. To rely on markets or carbon credit schemes we need to know the value of the service being provided, which requires an understanding of the extent of storage,



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durability, etc. It's important this is addressed now. While scientific research is necessary and important, we can't wait until we know everything to get started on developing some preliminary policy and legal frameworks which will help us make decisions about different strategies as they progress.

Brad, from Ocean Visions perspective, what makes an ocean-based CDR scheme or strategy successful?

We know that it needs to be safe, cost-effective, and store carbon for 100+ years. That said, it's just too early to have more definitive best practices or guidelines. From my perspective, we need a massive increase in research, development and deployment of ocean pathways with accompanying monitoring, reporting, evaluation for large scale ocean CDR strategies, which means we need government to be part of the research and development process. First thing is to scale up research and development with urgency, as the NASEM report and the EFI report and our Ocean Visions road maps all call for. It's clear that removing atmospheric CO₂—at very large scales—will be required to meet our collective goals.

Matt, we've now heard a little bit about market mechanisms that may be needed to advance this work. At Ebb Carbon, you are thinking about markets for carbon removal / sequestration, but also for the "by-products" created by your approaches to carbon removal. Can you share more about what is needed to facilitate this type of supply chain from your perspective?

In our economic models, the revenue from business is assumed to come from a voluntary carbon dioxide removal market. For the foreseeable future, there's a lot of demand there. Our models assume revenue from CO₂ removal, but currently assume no value for OA remediation. If you look at the area over which OA is remediated per ton of CO₂ removal, a monetary value applied to OA mitigation of just 50 cents per acre of surface ocean would equal the assumed revenue from CO₂ removal at \$100 per tonne of CO₂.

Final question to all: What would you want governments (or the general public) to know about ocean-based CDR strategies? Or inversely, is there a request or call to action?

Brad: Before we get the support for research and development investment at scale, CDR has to be, "a thing," meaning it has to become recognized as a valuable part of the solution equation. We're still placing most of the emphasis on decarbonization, though most of the problem at any moment in time is coming from the CO₂ in the atmosphere and ocean right now. We need to make CDR salient as intensely and proportionately as we're working on turning off the GHG emission tap.

Romany: Agree with Brad. Going back to conversation about moral hazards; we're not talking about a substitute for emissions reduction, but a complement. There's a multifaceted approach to reducing emissions and a multifaceted approach to advancing CDR.

Matt: To governments— look at the advice in the report about funding levels and priorities; develop a permitting process for field research; include these strategies in legislation that's intending to catalyze CO₂ removal.



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Sarah: The climate crisis is way too serious to get this wrong. It's important to remember that if we don't ultimately implement widespread ocean CDR, we're not doing nothing; we're still doing a lot globally to reduce GHG and CO₂ emissions. We must insist on multidimensional research regarding social and technical aspects of CDR, and how they intersect. Meanwhile, we must keep the pressure on for urgent and ambitious mitigation.

Jessica: Scaling CDR is about public trust. To make CDR "a thing," there is a need to collect data that the public can trust, by agencies the public can trust, on a time scale that the public can trust. As a community, we need transparency across the science, market, and governance sides of the equation to help demonstrate that the public, the research community, and decision-makers can trust a process for evaluating CDR strategies.

Mark: We're talking about money. In the United States specifically, we've experienced years of political approaches that have consistently cut taxes and government budgets again and again; this has resulted in a loss of technological advancement, lower levels of research and development, and limited opportunities for the future. Increased funding for climate mitigation and adaptation is an arrow we must have in our quiver moving forward. This includes getting governments to recognize the problem of chronically underfunding research and development. This is the third time the National Academy has issued a report on CDR. Maybe we'll find out some of these CDR strategies don't work; but we need to quickly spend real money very fast to find that out so we can narrow in on the best options.

Jessie: Well, one thing we all have in common is a sense of urgency! For more information about the report, visit the [National Academies of Science, Engineering and Medicine](#).

