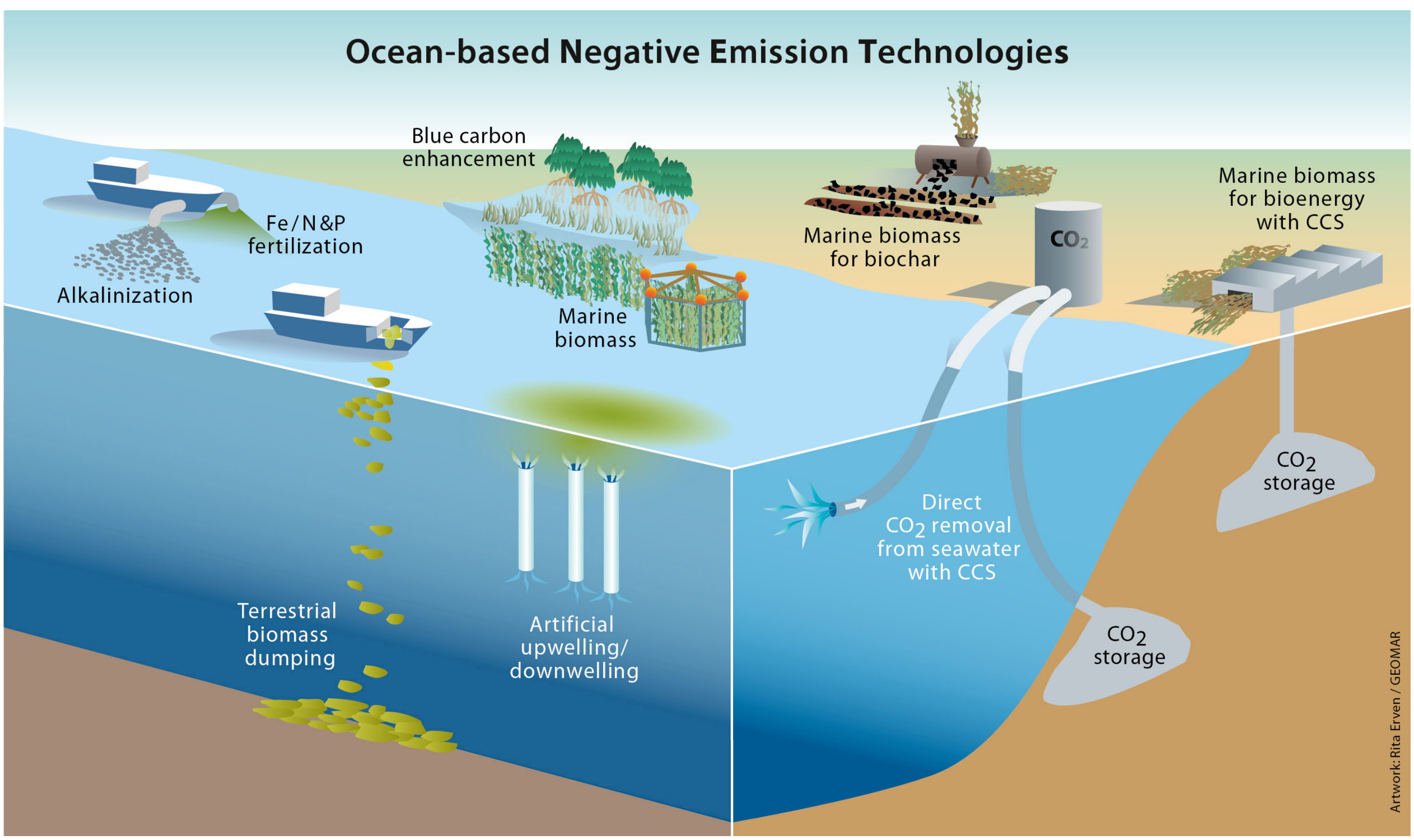
What Is Ocean Carbon Dioxide Removal?

All future climate scenarios that hold planetary warming close to 1.5 °C by 2050 will require massive cuts in greenhouse gas emissions, supplemented by the use of carbon dioxide removal (CDR) methods to clean up leftover heat-trapping carbon dioxide (CO_2) from the atmosphere.[1] The ocean has already naturally absorbed almost 30 percent of all CO_2 emissions caused by humans between 1800 and 1994, and many people are interested in deliberately increasing this uptake using ocean CDR techniques.[2] These techniques seek to protect or enhance natural biological and geochemical processes in order to manipulate the Earth's carbon cycle and counteract this primary driver of climate change (Figure 1). Approaches include conservation or restoration measures to increase natural stores within blue carbon ecosystems—for example, by restoring coastal wetlands—as well as technological approaches that increase the ocean's carbon storage capacity. However, with the exception of the blue carbon methods described in this booklet, most ocean CDR techniques have not been tested at scale, and a few are essentially still on the drawing board.[3]

There is insufficient evidence to determine if most ocean CDR techniques can substantially and durably draw down anthropogenic CO_2, if the societal impacts of these actions would be equitably distributed, and, in the case of technological approaches, if ocean CDR would pose fewer risks for natural and human systems than CDR in atmospheric or terrestrial locations. The research or deployment of technological CDR in the ocean, which is shared by billions of people, could pose significant risks for equity, environmental justice, ecosystem health, food security, and human livelihoods.

Figure 1: Several of the ocean CDR techniques being advanced[4]



Multidisciplinary research is needed to explore all technological ocean CDR methods. Research must go beyond examining simply how much additional CO_2 can be captured and stored in the ocean and what it will cost; it must also include an evaluation of environmental and social risks and co-benefits.[5]

Additionally, given the potential social and environmental risks associated with field research, a research code of conduct should be developed and all recipients of federal grants should be required to adopt it. There should also be incentives for scientists performing CDR research supported by private funding to do the same.[6] This code of conduct should address fundamental principles of scientific integrity (e.g., transparency and dissemination of results), fairness and equity (e.g., public consultation), and responsible research (e.g., minimization of potential harms and assignment of responsibility) across all ocean-based CDR methods.

Ocean-based CDR is a nascent field and is garnering a lot of attention. However, CDR cannot substitute for rapid and deep cuts in greenhouse gas emissions. The development and potential use of these techniques can be only one piece of a comprehensive and equitable climate strategy. This booklet provides a primer on various ocean CDR strategies, summarizing the theory behind each technique, the current state of knowledge of their carbon storage potential and associated costs, technical readiness, and potential environmental and social impacts.

Endnotes

1 Myles Allen et al., “Summary for Policymakers,” in *Global Warming of 1.5 °C: An IPCC Special Report on the Impacts of Global Warming of 1.5 °C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, V. Masson-Delmotte et al., eds. (Cambridge, UK, and New York, NY: Cambridge University Press, 2018), 3–24, doi: 10.1017/9781009157940.001.

2 Nicolas Gruber et al., “Oceanic Sources, Sinks, and Transport of Atmospheric CO_2,” *Global Biogeochemical Cycles* 23, no. 1 (March 2009), https://doi.org/10.1029/2008GB003349 ; Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, *High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques,* 2019, http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques.

3 National Academies of Sciences, Engineering, and Medicine (hereinafter NASEM), *A Research Strategy for Ocean-Based Carbon Dioxide Removal and Sequestration* (Washington, D.C.: National Academies Press, 2022), https://doi.org/10.17226/26278.

4 Reproduced from Miranda Boettcher et al., “Navigating Potential Hype and Opportunity in Governing Marine Carbon Removal,” *Frontiers in Climate* 3, art. 664456 (June 2021), file:///C:/Users/Owner/Dropbox/PC/Downloads/fclim-03-664456.pdf.

5 NASEM, *A Research Strategy*.

6 Aspen Institute Energy and Environment Program, *Guidance for Ocean-Based Carbon Dioxide Removal Projects: A Pathway to Developing a Code of Conduct*, December 2021, https://www.aspeninstitute.org/publications/ocean-carbon-dioxide-removal/; Rebecca Loomis et al., “A Code of Conduct Is Imperative for Ocean-Based Carbon Dioxide Removal Research,” *Frontiers in Marine Science* 9 (May 2022), https://doi.org/10.3389/fmars.2022.872800.