Response to Call for input 2022 - Activities involving removals

"Thank you for the opportunity to respond to the process of defining carbon removals - how they should be counted, monitored, and reported. "

Summary of my response: This response directly copies many words from the ocean alkalinity response submitted by Planetary Technologies on 6 October 2022, as our "artificial upwelling" Ocean Microalgae removal approach shares many of the measurement, reporting, and verification challenges.

In the following we have substituted "Ocean Microalgae" for "Ocean Alkalinity Enhancement" and amended a few of the relevant attributes such as years of storage, and we use quotation marks to denote the substance of their submittal (with our modifications):

"Please update Annex 5 to include the possibility that Ocean Microalgae, and perhaps other approaches in the future, will be best verified through modeling, indirect measurement, or other approaches as determined by the best scientific consensus at the time.

Detail: The document A6.4-SB002-AA-A05, titled Draft Recommendation (Annex 5) lays out two primary storage mechanisms for carbon dioxide that has been removed from the atmosphere: land-based (primarily for reforestation and afforestation), and geological formations (see paragraphs 3 and 4 on page 5 of Annex 5, Appendix I and Appendix II and many other locations).

Annex 6 specifically includes Ocean Fertilization (OF) which we assume includes microalgae (paragraph 24 (b) (iv) on page 8). Ocean Microalgae uses the ocean itself (and the seabed below the ocean) as the reservoir for storing excess carbon dioxide. Ocean Microalgae convert carbon dioxide into particulate organic carbon (POC) which sinks to various depths, including the seabed. Depending on depth, the POC may remain for decades to millenia (Boyd et.al.). This approach clearly achieves the durability, additionality, and leakage characteristics desired for carbon dioxide removals. Also, due to the vast seascape, a small increase in the percentage of carbon dioxide converted and stored in the ocean by Ocean Microalgae can have a large impact on atmospheric carbon dioxide.

Referring to: https://unfccc.int/process-and-meetings/the-paris-agreement/article-64-mechanism/calls-for-input/sb002-removals-activities : On page 5 of Annex 5, the first requirement for a removal is that Mechanism methodologies shall require that all removal activities monitor the achieved carbon stocks through their quantification using field measurements, or field measurements in combination with remote-sensing data where applicable. In the case of Ocean Microalgae, this may not be possible because of the variability of the baseline and the lack of precision of measurements now available.

Removing a gigatonne of carbon dioxide from the atmosphere would result in only a very small percentage change in ocean biogeochemistry, one that might not be measurable now. Just because it can not be measured at this time does not mean that the carbon dioxide has not been removed and safely sequestered for decades to thousands of years. In most cases the microalgae-induced CO_2 deficit spreads over a very large area within a brief period and the changes in pCO_2 are in the sub µatm range. This makes direct monitoring and verification of microalgae-removal extremely challenging and will likely need to rely on modeling and indirect experimental verification. The technique of Ocean Microalgae has huge potential. The process of measurement, reporting, and verification (MRV) for Ocean Microalgae is in its formative stages, and significant resources are being expended to address current issues.

Please update Annex 5 to include the possibility that Ocean Microalgae, and perhaps other approaches in the future, will be best verified through modeling, indirect measurement, or other approaches as determined by the best scientific consensus at the time. "

In addition, the definition of CDR MRV "cutoff dates" should recognize the natural carbon cycle has existed for several billion years and likely will continue "forever", whereas MRV adopts a human-scale end point measured in months or years. The effects obtained with Ocean CDR do not obey cut-off dates, rather the tail is long and convoluted.

We are pleased to provide the following citations relating to artificial upwelling/Ocean CDR:

Kemper J, Riebesell U and Graf K (2022) Numerical Flow Modeling of Artificial Ocean Upwelling. Front. Mar. Sci. 8:804875. doi: 10.3389/fmars.2021.804875

Dymond, Jack R; Lyle, Mitchell W (1985). Flux comparisons between sediments and sediment traps in the eastern tropical Pacific: Implications for atmospheric CO2 variations during the Pleistocene. Limnology and Oceanography, 30(4), 699-712, https://doi.org/10.4319/lo.1985.30.4.0699

Karl, D. M., & Letelier, R. M. (2008). Nitrogen fixation-enhanced carbon sequestration in low nitrate, low chlorophyll seascapes. Marine Ecology Progress Series, 364, 257–268.

Ian Walsh, Jack Dymond, Robert Collier (1988). Rates of recycling of biogenic components of settling particles in the ocean derived from sediment trap experiments, Deep Sea Research Part A. Oceanographic Research Papers, Volume 35, Issue 1, Pages 43-58, ISSN 0198-0149, https://doi.org/10.1016/0198-0149(88)90056-8

I.D. Walsh, W.D. Gardner, M.J. Richardson, S.P. Chung, C.A. Plattner, V.L. Asper (1997) Particle dynamics as controlled by the flow field of the eastern equatorial Pacific, Deep Sea Research Part II: Topical Studies in Oceanography, Volume 44, Issues 9–10, Pages 2025-2047, ISSN 0967-0645, https://doi.org/10.1016/S0967-0645(97)00079-9

Boyd, P.W., Claustre, H., Levy, M. Siegel, D.A., Weber, T (2019). Multi-faceted particle pumps drive carbon sequestration in the ocean. *Nature* **568**, 327–335. https://doi.org/10.1038/s41586-019-1098-2

Koweek DA (2022) Expected Limits on the Potential for Carbon Dioxide Removal From Artificial Upwelling. Front. Mar. Sci. 9:841894. doi: 10.3389/fmars.2022.841894

Siegel, D. A., DeVries, T., Doney, S. C., and Bell, T. (2021) Assessing the sequestration time scales of some ocean-based carbon dioxide reduction strategies, Environmental Research Letters, vol. 16, no. 10, 2021. doi:10.1088/1748-9326/ac0be0.

R.S. Lampitt, (1985) Evidence for the seasonal deposition of detritus to the deep-sea floor and its subsequent resuspension, Deep Sea Research Part A. Oceanographic Research Papers, Volume 32, Issue 8, Pages 885-897, ISSN 0198-0149, https://doi.org/10.1016/0198-0149(85)90034-2

National Academies of Sciences, Engineering, and Medicine. 2022. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

Romany M. Webb, Korey Silverman-Roati, and Michael B. Gerrard, “Removing Carbon Dioxide Through Artificial Upwelling and Downwelling: Legal Challenges and Opportunities”, Sabin Center for Climate Change Law, May 2022.

White, A., Björkman, K., Grabowski, E., Letelier, R., Poulos, S., Watkins, B., & Karl, D. (2010). An Open Ocean Trial of Controlled Upwelling Using Wave Pump Technology, Journal of Atmospheric and Oceanic Technology, 27(2), 385-396.

Thank you very much for your consideration.

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