



CO₂ Dissolution as Bicarbonate in Seawater: Potential Co-benefits for Net Primary Production

Arianna Azzellino¹, Daniela Basso², Eleonora Barbaccia¹, Mario Gabualdi¹, Francesco Pietro Campo³, Giovanni Cappello³, Stefano Cappello³, Stefano Caserini⁴, Federico Comazzi³, Selene Varliero¹, Pietro Macchi¹, Samira Alamooti¹, and Guido Raos¹

¹Politecnico di Milano DICA Civil and Environmental Engineering Department, Piazza Leonardo da Vinci, 32, 20133 Milano, MI, Italy

²Department of Earth and Environmental Sciences, University of Milano-Bicocca, CoNISMa Research Unit of Milano-Bicocca, Milan, Italy

³Limenet s.r.l., Galbiate (LC), Italy

⁴Department of Engineering and Architecture, Università di Parma

The dissolution of CO₂ in seawater as bicarbonate ions (HCO₃⁻) offers a promising alternative to geological storage, provided the process ensures long-term stability and avoids harming marine ecosystems. Storing CO₂ in the form of bicarbonate ions could remain effective for geologic timescales, potentially up to 10,000 years [1–3]. This approach involves treating natural seawater by mixing it with pre-equilibrated seawater solutions produced from the reaction of CO₂ with Ca(OH)₂, adjusted to maintain the same pH as seawater. Recent research [4] has shown that the resulting bicarbonate-rich solution is stable, but concerns persist regarding its potential environmental impacts. While alkalinity itself does not directly affect marine biology, its increase significantly alters pH and the concentrations of key ions and molecules, such as those in the carbonate system, which can directly influence biological processes. The extent of modifications to seawater carbonate chemistry depends on the amount of alkalinity added per unit volume and the rate at which this volume mixes with surrounding waters. The rate at which perturbed seawater equilibrates with the atmosphere is also a critical factor. Seagrasses, marine angiosperms that evolved from terrestrial plants and returned to the sea during the Cretaceous period (approximately 140 to 100 million years ago), play a vital role in marine ecosystems. Seagrass meadows are among the most productive ecosystems on Earth, with an average primary productivity ranging from 394 to 1200 g C m⁻² y⁻¹. These meadows provide numerous essential ecosystem services. Seagrasses are thought to benefit from ocean acidification, as they can utilize both CO₂ and HCO₃⁻ for photosynthesis, although they have a higher affinity for CO₂ and are often carbon-limited [6–7]. Additionally, evidence from natural volcanic CO₂ vents at Ischia, Panarea Islands, and Basiluzzo Islet—where conditions of natural acidification occur—indicates a correlation between increased dissolved inorganic carbon (DIC) and enhanced net primary production [8]. Building on existing literature, this analysis will explore the potential co-benefits of increased bicarbonate concentrations for seagrasses, aiming to assess how these benefits could enhance seagrass health and growth. It will also evaluate the opportunity to integrate this

technology with Nature-Based Solutions, such as seagrass restoration, to maximize ecosystem resilience and climate mitigation efforts.

References

- [1] Renforth & Henderson. (2017). Assessing Ocean Alkalinity for Carbon Sequestration. *Rev. Geophys.*
- [2] Middelburg et al. (2020). Ocean Alkalinity, Buffering and Biogeochemical Processes. *Rev. Geophys.*
- [3] Eisaman et al. (2023). Assessing the Technical Aspects of Ocean-Alkalinity-Enhancement Approaches. *State Planet*, 2-0ae2023, 1–29.
- [4] Varliero et al. (2024). Assessing the Limit of CO₂ Storage in Seawater as Bicarbonate-Enriched Solutions. *Molecules*. 29, 4069.
- [5] Duarte et al. (2005). Major role of marine vegetation on the oceanic carbon cycle. *Biogeosciences* 2, 1–8.
- [6] Invers et al. (2001). Inorganic carbon sources for seagrass photosynthesis: an experimental evaluation of bicarbonate use in species inhabiting temperate waters, *J. Exp. Mar. Biol. Ecol.*, 265, 203–217, 2001.
- [7] Koch et al. (2013). Climate change and ocean acidification effects on seagrasses and marine macroalgae, *Glob. Change Biol.*, 19, 103–132.
- [8] Guilini et al. (2017). Response of *Posidonia oceanica* seagrass and its epibiont communities to ocean acidification. *PLoS ONE* 12 (8): e0181531