

Assessing the Effectiveness of Blue Carbon Markets and Market Alternatives to Conserve Ecosystems, Mitigate Greenhouse Gas Emissions, and Benefit Local Communities – the case study of *Posidonia oceanica*

Context

Blue Carbon (BC) is the carbon captured and stored by oceanic and coastal ecosystems. Many recent studies have identified coastal BC ecosystems (mangroves, seagrass meadows, and tidal salt marshes) as a promising natural climate solution to limit global warming. In response, initiatives have been developed to quantify the economic value of BC and to finance its conservation and restoration through carbon credit markets. This project focuses on conservation of BC ecosystems which reduces the emissions arising from ecosystem degradation. Globally, the carbon emissions associated with the loss of BC coastal ecosystems is estimated to be 0.04 to 1.46 GtC y⁻¹ (~0.40 to 14.6% of global fossil fuel emissions).^{1,2}

BC is slowly being integrated into climate plans and carbon credit markets. More than half of the updated Nationally Determined Contributions (NDCs) included BC ecosystems as a nature-based solution.³ The Verra VCS methodology VM0007 included BC ecosystem conservation for the first time. The increased acceptance of BC credits has been met with both support and criticism. Supporters' efforts focus on "operationalizing marketable blue carbon" and building the business case for BC projects to attract private sector investment.⁴ Critics claim BC will be similar to forestry projects which systematically overestimate carbon benefits,⁵ and exploit local communities.

This study will focus on the emerging BC credit mechanisms for the conservation of *Posidonia oceanica*, an endemic Mediterranean seagrass species. This seagrass presents an ideal case study because: (1) it is a habitat-forming species with large carbon stocks; (2) it represents the challenges of studying BC ecosystems; (3) it has high political interest but limited concrete actions; and (4) its distribution in the Mediterranean Sea means it can be studied in the context of lower-middle to high-income countries.

Objective

Before further BC credits are issued, there is a need to determine the robustness of BC methodologies, and the effectiveness of BC markets to conserve ecosystems, mitigate greenhouse gas (GHG) emissions, and benefit local communities. Furthermore, it is of paramount importance to explore and assess possible alternatives to the BC market. This project will answer the following research questions:

- Do avoided emissions BC credits represent additional reductions in emissions and ecosystem degradation?
- How effective are BC credit projects at conserving ecosystem biodiversity and functioning, reducing GHG emissions, and benefiting local communities?
- Could alternatives to BC markets be more effective at reducing GHG emissions, conserving ecosystem biodiversity and functioning, and benefiting local communities?

Justification of the scientific approach

Following the existing carbon credit methodologies, emissions resulting from *Posidonia oceanica* degradation will be modeled using historical data in selected sites in France and Spain. The models will be compared to the "real emissions" from actual *Posidonia oceanica* regression data. Furthermore, the "real emissions" will be qualified with an uncertainty analysis of the techniques used to estimate carbon stocks, carbon burial, as well as other BC science uncertainties. A comparison of the model and the "real emissions" will determine if carbon credits represent additional reductions in emissions and ecosystem degradation.

To assess the effectiveness of BC credits to conserve coastal ecosystems, the drivers of coastal ecosystem degradation will be compared to the degradation drivers mitigated through the sale of carbon credits. A scientific literature review will determine the list of degradation drivers as well as the regression rates attributed to each. To determine the degradation drivers mitigated through carbon credit sales, selected conservation projects from the Verra VCS registry will be assessed. Mangrove projects will be used as proxies as there are currently no *Posidonia oceanica* projects in the VCS registry. The degradation drivers of mangroves will be compared to the degradation drivers targeted by carbon credit finance to assess whether carbon credit projects mitigate the main degradation drivers of coastal ecosystems.

To assess the effectiveness of BC markets to reduce GHG emissions, the total GHG emissions of a selected number of VCS registered BC projects will be analyzed from a system perspective. Taking inspiration from

life cycle and commodity chain analyses, as well as biodiversity impact chains, stakeholder benefits and GHG emissions will be quantified. The total GHG emissions will be compared to the net emission reductions associated with the projects. Using a similar systems approach, the economic benefit of the BC market stakeholders will be quantified. BC market stakeholders include investors, communities, scientists, etc. By taking a systems view of the beneficiaries, this section will analyze who benefits (and how much).

Alternatives to *Posidonia oceanica* BC credit markets will be explored. BC markets align with efforts to reinvent nature conservation to align with neoliberal capitalism. On the other hand, alternatives respond to the calls for transformative change which halt the pursuit of economic growth at the expense of the environment. Using the aforementioned methods developed, the effectiveness of *Posidonia oceanica* BC credit projects and alternatives will be compared. The alternatives will be a novel application of the principles of “convivial conservation” to coastal ecosystem conservation.⁶

Relevance to the Institut de la Transition Environnementale

This project addresses the key missions of the *Institut de la transition environnementale*. It addresses the urgent need of mitigating CO₂ emissions by investigating an ocean- and nature-based solution to store and conserve carbon while preserving biodiversity and livelihoods. It is fundamentally interdisciplinary, associating natural as well as human and social sciences, and involves supervisors with expertise on biogeochemistry, ecology, and economics. The ultimate ambition of the project is to pass critical knowledge to decision-makers and society on the hot and controversial topic of nature-based carbon markets.

Relevant publications from the supervisors (more references in CV of main supervisor)

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- Comte, A., Barreyre, J., de Rafael, R., Boudouresque, C-F., Pergent, G., Monnier, B., Ruitton, B., (2023) Operationalizing blue carbon principles in France: methodological developments and institutionalization. 5th Conference on the Effects of Climate Change on the World Oceans. Bergen, Norway.
- Gattuso J.-P., Magnan A. K., Bopp L., Cheung W. W. L., Duarte C. M., Hinkel J., Mcleod E., Micheli F., Oschlies A., Williamson P., Billé R., Chalastani V. I., Gates R. D., Irsson J.-O., Middelburg J. J., Pörtner H.-O. & Rau G. H., 2018. Ocean solutions to address climate change and its effects on marine ecosystems. *Frontiers in Marine Science* 5:337. <https://doi.org/10.3389/fmars.2018.00337>
- Gattuso J.-P., Williamson P., Duarte C. & Magnan A. K., 2021. The potential for ocean-based climate action: negative emissions technologies and beyond. *Frontiers in Climate* 2:575716. <https://doi.org/10.3389/fclim.2020.575716>
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2. IPCC. The Ocean and Cryosphere in a Changing Climate: Special Report of the Intergovernmental Panel on Climate Change. (Cambridge University Press, 2022). doi:10.1017/9781009157964.
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5. West, T. A. P., Börner, J., Sills, E. O. & Kontoleon, A. Overstated carbon emission reductions from voluntary REDD+ projects in the Brazilian Amazon. *Proc. Natl. Acad. Sci.* 117, 24188–24194 (2020).
6. Büscher, B. & Fletcher, R. Towards Convivial Conservation. *Conserv. Soc.* 17, 283–296 (2019).