The role of Blue Carbon in climate change mitigation and carbon stock conservation

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Abstract

The potential for Blue Carbon ecosystems to mitigate climate change and provide co-benefits was discussed in the recent and influential Intergovernmental Panel on Climate Change Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC).

The report's Blue Carbon emphasis being on coastal wetlands, it did not address the socio-economic considerations of using natural ocean systems to reduce the risks of climate disruption. **Here, we discuss Blue Carbon resources in coastal, open-ocean and deep-sea ecosystems and highlight benefits of measures (such as restoration, creation, conservation and protection), as well as challenges in valuation and governance of these strategies, along with the need for policy action for market development and global coordination.**

Efforts to identify and resolve these challenges could harness the potential for these natural ocean systems to store carbon. Conserving, protecting, and restoring Blue Carbon ecosystems should become an integral part of mitigation and carbon stock conservation plans on local, national and global scales.

Introduction

- Marine ecosystems that contribute to climate change mitigation by sequestering and burying carbon from the atmosphere are known as Blue Carbon ecosystems.
- Their disruption can cause additional carbon release into the ocean or atmosphere.
- These blue carbon cycles are not yet uniformly incorporated into climate strategies on local, national and global scales.

Blue carbon-driven ecological and economic climate change mitigation measures were introduced in the SROCC Special Report. The SROCC identified two management approaches in Chapter 5 (Bindoff et al. 2019):

- Actions to maintain the integrity of natural carbon stores,
- Actions that enhance the long-term removal of greenhouse gasses from the atmosphere through marine systems.

Our paper expands the discussion of the role of Blue Carbon in climate change mitigation strategies by focusing on:

- **the importance of conserving existing marine pathways** of carbon fixation, transport, burial and sequestration, and
- **the challenges associated** with the measurement, valuation, management, and governance of carbon in coastal open ocean, and deep-sea ecosystems

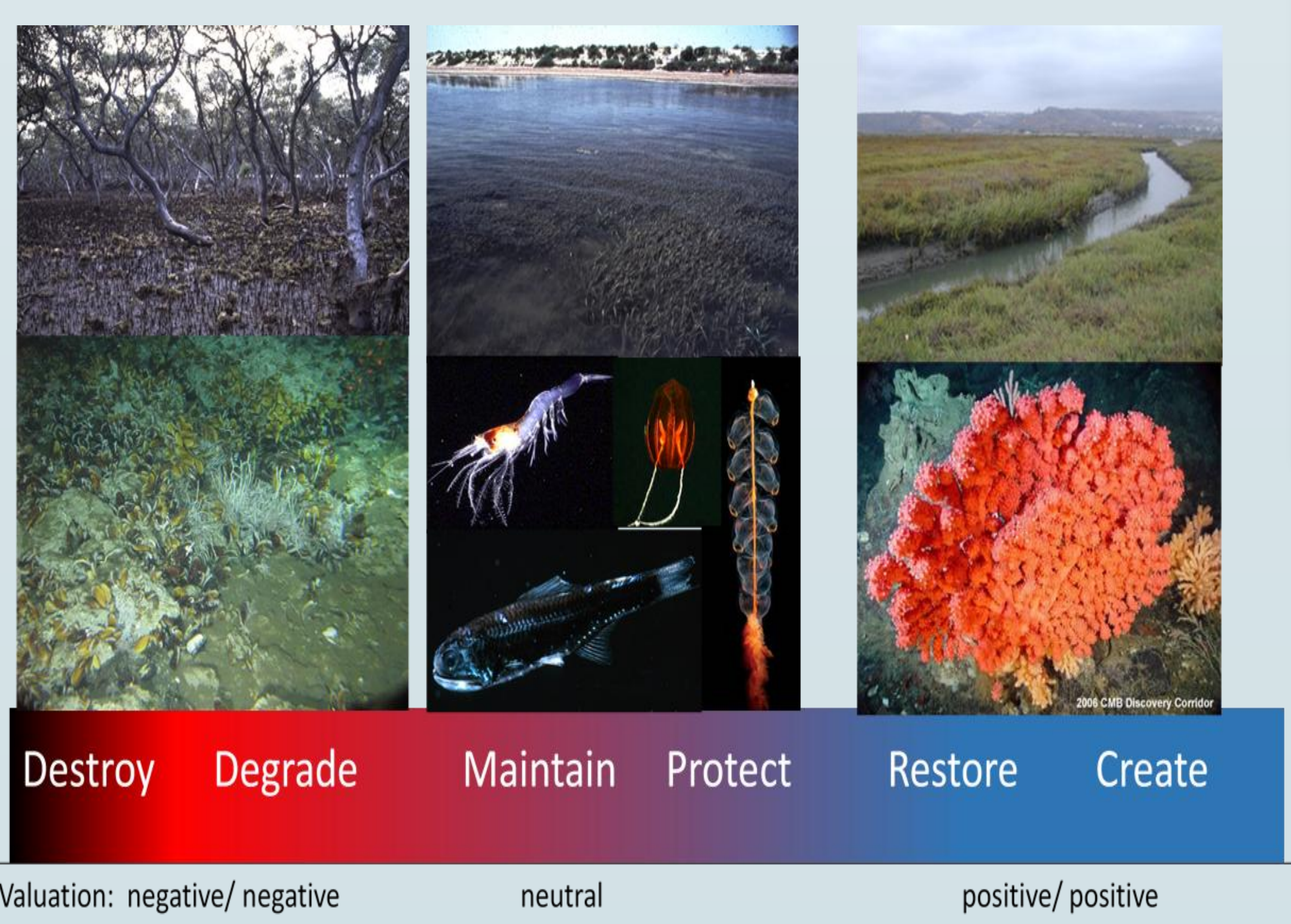


Figure 1. Blue carbon ecosystems and the spectrum of actions that affect their carbon value

Coastal Ecosystems

FUNCTIONING

- **Mangrove forests, saltmarshes, seagrasses** build up large stocks of organic carbon in the coastal zone (IPCC, 2019).
- **Anthropogenic activities have damaged vegetated coastal habitats worldwide** (Gullström et al., 2021).
- **Ocean warming affects the ability of marine systems to remove CO2 from the atmosphere ➔** damaged blue carbon stocks could switch from sinks to sources of methane and CO2 (Hiraishi et al., 2014; Macreadie et al. 2019).
- **Blue carbon coastal ecosystem have multiple co-benefits➔** flooding protection, ecosystem services etc, (Vegh et al. 2018).

VALUING

- **Using ecosystem-based adaptation (EbA) and nature-based solutions (NbS)** can mitigate climate change conflicts and help vulnerable communities.
- **Developing effective policies for climate change mitigation** involving the different fields of expertise (Cziesielski et al. ,2021).
- **Valuable aspects of these ecosystems** must be taken into account, including for instance the aesthetics and value for local culture.
- **Carbon markets and buyers of Blue Carbon credits** could choose to finance projects in areas that support their supply chain.
- **The no-regret approach** can be used from local to international level in order to increase social, economic and environmental policy benefits and resilience.

Open Ocean

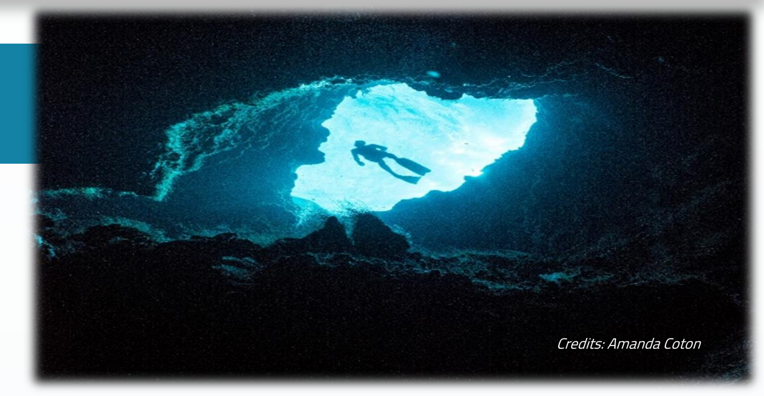
FUNCTIONING

- **Marine phytoplankton are responsible for ~50 % of global primary production (~50 Gt C/year).**
- **The amount of carbon fixed by phytoplankton and then sequestered varies regionally & temporally➔** depending on surface water productivity, grazing/ microbial degradation, turbulence (Barnes et al., 2020; Briggs et al., 2020).
- **Fecal pellets, exoskeletons, dead animals and the vertical migrations of open ocean animals** also transport the carbon from phytoplankton into the deep sea (Barnes and Tarling 2017; Boyd et al., 2019).
- **Ocean warming and acidification** are projected to slow sinking of particulate organic carbon to the deep seafloor➔ 10-15% by the end of this century (Bindoff et al., 2019).

VALUING

- **The inclusion of social welfare variables** in calculations of climate-change mitigating BCP impacts is now becoming key in policymaking of open-ocean measures.
- **Providing information on the associated benefits of Blue Carbon** can help increase financing (Siegel & Jorgensen, 2011; Ullman et al., 2013), comparing the present monetary value of benefits with the cost of investing in them.
- **Cost-benefit approaches in financial investments ➔** show how natural resources, including species, habitats, and biodiversity, provide tangible value to humans (Chami et al. 2020a, Dasgupta, 2021).

Deep sea



FUNCTIONING

- **DIC is ~70% of the total OC in the ocean.** Most of it is found at depths >1, 000 m where this carbon remains out of contact with the atmosphere for thousands of years (Hansell et al. 2009).
- Mesopelagic zooplankton and fish typically migrate large distances and play a major role in **transporting carbon down from surface waters** (Davison et al., 2013; Steinberg and Landry, 2017; Kiko and Hauss, 2019).
- **Rising bottom temperatures or shifting of warm currents** could increase the release of carbon stored in buried methane hydrates on continental margins (Ruppel & Kessler, 2016).
- **The ocean plays a critical role in global climate regulation** through uptake and storage of heat and carbon dioxide, possible changes can affect the productivity, distributions of deep-sea fauna, (Mora et al., 2013; Sweetman et al., 2017; Morato et al., 2020).

VALUING

- **Generation of international conservation agreements** on these ecosystems and the species that inhabit them can maintain ongoing carbon sequestration pathways.
- **International innovative coordination and joint strategies** can avoid habitat degradation and ensure the integrity of carbon cycling and sequestration.

Governance

- **Change the traditional model of business-as-usual** by identifying the environmental sector as "the essential of social and economic wealth", via its climate mitigation services and associated co-benefits.
- **Enforce international tax payment** for industrial fisheries or leisure boats in order to protect blue carbon ecosystems (open ocean & deep sea) through coordination between ports, cities and nations, in a competitive economy.
- **Support carbon pricing through Emissions Trading Schemes (ETS),** which facilitate the trade of permits for GHG emissions by capping the total level of emissions allowed; or carbon taxes, which set a price on carbon itself.
- **Promote reliable Blue Carbon projects in regulated carbon markets**, using robust financial & scientific analysis of the permanence of these ecosystems to estimate Blue Carbon offsets.
- Provide an optimal approach for Blue Carbon ecosystem management with **synergies between climate adaptation & mitigation strategies** within NDCs.
- **Include coastal ecosystems in NDC design & management** to foster external financial support and climate finance for their sustainable management.
- **Adapt marine spatial planning** to a community perspective in order to meet local needs, becoming an efficient source of long-term development.
- **Modernize joint coordination strategies** among different states and UN agencies regarding international waters in order to define achievable, realistic and progressive protocols agreements.
- **Use MPAs as important governance responses** to coordinate ecosystem management, resource utilization and biodiversity conservation.

Conclusion

- **The Paris Agreement** requires serious commitment among all its stakeholders involved to achieve carbon neutrality by 2050.
- **Nature-based solutions** play a key role in maintaining active blue carbon sequestration processes and preventing human assisted-nature-based emissions.
- **Financing from stakeholders requires a transparent and credible system** to manage such a market.
- **Applicable and fast-paced governance practices and integrated policies are needed,** starting with partnerships with the private sector as well as the active and long-term involvement of local communities.

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