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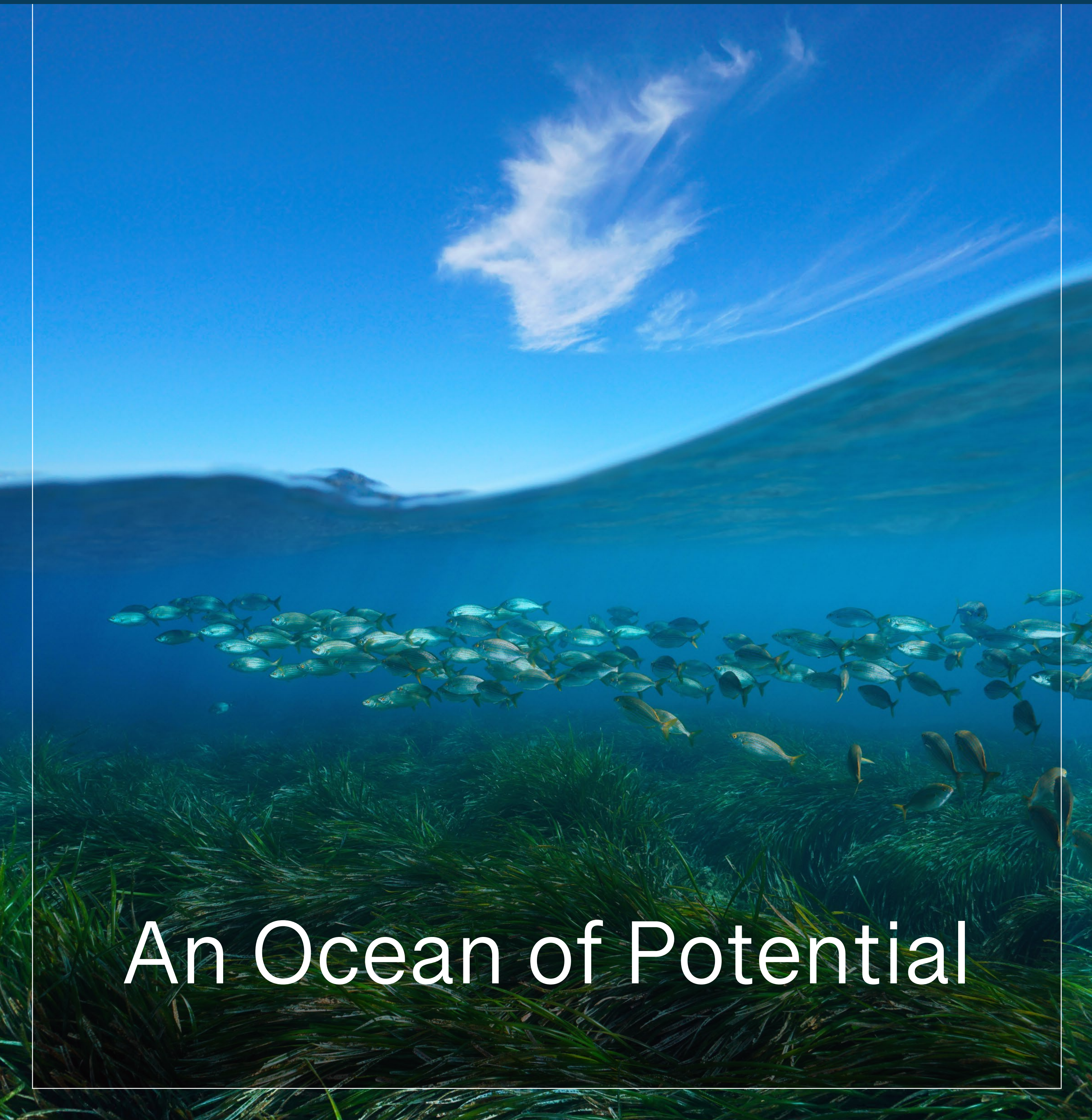
State of the Blue Carbon Market 2024



An Ocean of Potential

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About Ecosystem Marketplace

Ecosystem Marketplace (EM), a non-profit initiative of Forest Trends, is a leading global source of credible information on environmental finance, markets, and payments for ecosystem services. For nearly two decades, EM has run the world's first and only globally recognized and standardized reporting and transparency platform for voluntary carbon market (VCM) credit pricing data, news, and insights.

EM's flagship *State of the Voluntary Carbon Market* reports and other analyses on carbon credit market dynamics (e.g., prices, volumes, projects, corporate buyers, sellers, etc.) and carbon standard issuance and retirement data have become anticipated industry staples. EM also provides a publicly accessible data intelligence dashboard and a news platform for market coverage.

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Forest Trends Association is a 501(c)(3) organization founded in 1999. Forest Trends works to conserve forests and other ecosystems through the creation and wide adoption of a broad range of environmental finance, markets, and other payment and incentive mechanisms. Forest Trends does so by 1) providing transparent information on ecosystem values, finance, and markets through knowledge acquisition, analysis, and dissemination; 2) convening diverse coalitions, partners, and communities of practice to promote environmental values and advance development of new markets and payment mechanisms; and 3) demonstrating successful tools, standards, and models of innovative finance for conservation.

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Executive Summary

Coastal and marine biomes across the globe include vegetated habitats that sequester carbon at high rates, making these Blue Carbon (BC) ecosystems critical components of strategies to mitigate climate change. By some estimates, BC ecosystems sequester carbon at rates many times that of terrestrial forests, yet these important habitats are subject to high rates of conversion and ecosystem services loss worldwide. Significant investment in conservation and restoration is needed to stem degradation and maximize the potential of these ecosystems to mitigate climate change and help countries adapt suitably.

Despite increasing interest in and attention to BC, a recognition exists that the full potential of coastal and marine habitats in mitigating climate change is far from being realized, and that more could be done to catalyze marine initiatives, both in terms of scaling up existing projects and expansion to new geographies.

This report offers a status check on this still-emerging space. It provides a brief introduction to blue carbon, including leading BC project types, their potential in terms of climate mitigation and other environmental and social benefits, and challenges for blue carbon project development. We discuss outlook for demand and supply of BC credits and potential sources of public and private finance. Finally, recommendations are provided for rapidly scaling BC finance and project delivery.

Key findings

The Potential of Blue Carbon

- The presence of blue carbon in many countries' Nationally Determined Contributions mitigation strategies, as well as the pipeline of blue carbon projects, suggests that blue carbon is in a dynamic state of play at present. BC projects, however, remain relatively small scale and cannot meet the demand of public and private sector investors looking to offset carbon emissions.

Challenges for Blue Carbon Project Development

- There are a number of features that set BC apart from terrestrial or forest ecosystems when it comes to sequestering carbon. These include ecological considerations (the open nature of marine and coastal ecosystems); difficulties in delineating and monitoring BC habitats; and inherent vulnerability of coastal BC habitats to climate change. BC also differs from forest carbon across a number of legal and policy dimensions. These challenges can be overcome by innovative adaptation of terrestrial approaches to the special circumstances of coastal systems.

State of Markets for Blue Carbon

- BC remains a small and “boutique” slice of the overall voluntary carbon market, comprising less than one percent of overall credit transactions per year, although fetching higher prices per credit (Table 5). Overall, 10.9MtCO_2e (million tons carbon dioxide equivalent) in credit volumes have been traded in the 2020-2023 period.
- Almost all BC transactions reported are for credits from tropical countries.
- BC credits are sold at a significant premium over current carbon market rates, a reflection of high upfront capital costs and the space’s “boutique” appeal to buyers attracted to the multiple environmental and social benefits of BC habitat conservation and restoration. That said, price and volume of BC credit transactions have been quite volatile between 2020 and 2024.
- Demand for BC comes from two sources: corporate and investor demand for BC credits, and governments interested in BC for national climate accounting and/or sustainably financing marine protected areas.
- Several factors currently constrain supply, including high upfront capital costs, and a lack of available verifiers for BC methodologies.

Recent commitments signal the potential for large scale investments in BC, catalyzing the upscaling of projects in the pipeline.

Outlook for Blue Carbon Finance

- A large variety of revenue streams and technical support for marine conservation and restoration already exist. One particularly exciting new development is the issuing of "blue bonds" to support marine conservation and restoration.
- Carbon markets can channel additional private sector finance to help realize BC's potential, so long as carbon finance is carefully planned and executed with social, environmental, and economic sustainability in mind.
- One key issue in the field at the moment concerns the pros and cons of shifting from a focus on small scale demonstration projects to national or subnational jurisdictional approaches to blue carbon. Terrestrial REDD+ provides a framework for doing this, and a multilateral BC Facility could provide the capital and technical assistance to fully incorporate BC into Nationally Determined Contributions, REDD+ crediting, and cooperative approaches to carbon mitigation in shared ocean basins.

Recommendations for Scaling Blue Carbon Solutions

- This report suggests three main areas of focus necessary to elevate the importance of BC in the carbon portfolio and take advantage of BC's enormous potential to mitigate and allow adaptation to climate change.
    - Improving data and analytics, including verification of carbon sequestration in soils and sediments over the long term and as sea level rises, oceans acidify, and cumulative pressures increase.
    - Using state-of-the-art science, combined with user or traditional knowledge, to restore BC ecosystems effectively, increasing their resilience and their potential to mitigate climate change over the long term.
    - Securing financing streams to do what it takes to restore degraded BC ecosystems and safeguard those currently in good condition. This may mean coupling BC credit schemes with biodiversity certification or performance-based coastal and marine planning across wider geographies. In addition to considering the merits of a jurisdictional approach versus project-based approach, and envisioning how a nested approach might bring BC to scale, there are specific interventions needed to address the drivers of degradation in BC areas.
- Marine Spatial Planning is a powerful planning approach for ecosystem-based management and for restoration at scale and has been proven to catalyze BC initiatives.
- Finally, the World Bank and other development banks and multilateral agencies should catalyze public and private investments to maximize climate finance driving BC ecosystem conservation, through policies supporting not only marine spatial planning, but also coastal zone management, fisheries, sustainable tourism development, and trade.

BC projects could be used to deliver lasting revenue streams for conservation and restoration, as an incentive for reducing pressures on ecosystems, and as a means for putting more power in the hands of local communities to steward and respect nature. Overall, projects generating BC credits constitute a powerful force for nature-positive change.

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List of Abbreviations

BC	Blue Carbon
BCAF	Blue Carbon Accelerator Fund
BNCFF	Blue Natural Capital Financing Facility
CBD	Convention on Biological Diversity
CI	Conservation International
COP	Conference of Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPF	Carbon Partnership Facility
CTF	Clean Technology Fund
DLI	Disbursement-linked Indicator
ER	Emissions Reduction
FAO	UN Food and Agricultural Organization
FCPF	Forest Carbon Partnership Facility
FIP	Forest Investment Program
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas(es)
ICDP	Integrated Conservation and Development Project
IPCC	Intergovernmental Panel on Climate Change
ISFL	Initiative for Sustainable Forest Landscapes (Bio Carbon Fund) Joint Concept Note
IUCN	International Union for the Conservation of Nature
JNR	Joint Nested REDD+
LCDS	Low-Carbon Development Strategy
LULUCF	Land use, Land-use Change, and Forestry
MES	Marine Ecosystem Services
MPA	Marine Protected Area
MRV	Monitoring, Reporting, and Verification
MSP	Marine Spatial Planning
NAMA	Nationally Appropriate Mitigation Action
NBS	Nature-based Solution
NCS	Natural Climate Solution
NDC	Nationally Determined Contribution
NGO	Nongovernmental Organization
OBA	Output-based Aid
OECD	Organization for Economic Co-operation and Development
PA	Paris Agreement (UNFCCC)
PMES	Payments for Marine Ecosystem Services
RBCF	Results-based Climate Financing/Finance
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	REDD *plus* Conservation, Sustainable Management, Enhancement of Carbon Stocks
SDG	Sustainable Development Goal
UNCTAD	UN Conference on Trade and Development
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
VER	Verified Emission Reduction

Glossary

Additionality: Additionality describes the basis for issuing carbon credits for project activities that would not occur without finance from the sale of credits. Carbon credits can only be issued if the reduction or removal of carbon emissions would not otherwise have taken place. This necessitates a demonstration of financial additionality. For example, a solar energy installation that would be profitable to build without the sale of carbon credits is not considered additional, but a cookstove distribution project that reduces the burden of deforestation is additional, because deforestation would continue at a high rate if the cookstoves were not supplied to local communities. It also requires a demonstration that project interventions go beyond existing and enforced legal protection (as exists for most mangroves and coastal wetlands). Different project methodologies have specific modules for calculating project additionality.

Blue Carbon: Carbon stored in coastal and marine ecosystems, including saltmarsh, mangrove forest, seagrass meadows, macroalgae forests, and benthos. In the context of the carbon markets, blue carbon refers to a specific group of Forestry and Land Use project types that reduce/remove carbon dioxide from marine and coastal environments by restoring, conserving, or managing ecosystems, including wetland, mangrove, and seagrass habitats.

Blue Carbon Stocks: Carbon stored in above-ground plant biomass, in below-ground root biomass, and/or in soils. Of these, carbon locked in soils or marine substrate is the most durably sequestered.

Ecosystem Services: Nature's benefits, including provisioning of food and material, flood control, waste management, carbon storage, climate regulation, etc. When ecosystem services benefit humans, these can be called Nature's Contribution to People (NCP).

Exclusive Economic Zone (EEZ): An extension of jurisdiction beyond a coastal country's territorial sea, extending to 200 nautical miles beyond the coast.

Nature-based Solution: Actions to protect, conserve, restore, sustainably use, and manage natural or modified terrestrial, freshwater, coastal, and marine ecosystems to tackle socio-environmental challenges, like climate change. These solutions address social, economic, and environmental challenges effectively and adaptively, while simultaneously providing human wellbeing, ecosystem services, resiliency, and biodiversity benefits.

REDD+: Reduced Emissions from Deforestation and Degradation in Developing Countries. These Forestry and Land Use projects are developed based on the voluntary REDD+ framework, developed by the UNFCCC to encourage financing of forest conservation and management in lower income countries where forests are at risk of land-use change or reduced carbon storage.

Introduction

Many countries have already catalyzed major action toward carbon emissions reductions through reducing deforestation, forest degradation, conservation, sustainable management of forests, and enhancement of forest carbon stocks (REDD+). The opportunities for ocean and coastal ecosystems to complement these mitigation efforts are many and are aided by the extensive experience gained through forest carbon initiatives. However, uptake of conservation and restoration projects in coastal and marine habitats that sequester carbon (collectively called blue carbon, or BC) has been slow and unsteady. Part of this has to do with inherent challenges of doing conservation and restoration in the ocean space. Another factor is the comparatively limited financing available to support BC project development, management, reporting, and verification.

Despite increasing interest in and attention to BC, a recognition exists that the full potential of coastal and marine habitats in mitigating climate change is far from being realized, and that more could be done to catalyze marine initiatives, both in terms of scaling up existing projects and expansion to new geographies. There are identifiable leverage points to bring BC to scale by assisting countries to incorporate BC habitats into their climate change mitigation strategies, as well as their planning for climate change adaptation and resilience. Likewise, there are untapped opportunities to share lessons learned from project development for the carbon market. Blue carbon remains in a dynamic state of play. Demand for carbon credits is growing in both compliance and voluntary markets, but in fits and starts. Many countries want to feature coastal management as part of integrated planning for sustainable development—both at the global level as guided by the Sustainable Development Goals (SDGs), and at the national level as coastal countries develop and expand their Blue Economies. The Kunming Montreal Global Biodiversity Framework and its 23 targets add new emphasis on the need to conserve and restore BC ecosystems, not only for their mitigation potential, but also because they support much of the world's biodiversity, either directly or indirectly. The management of coastal ecosystems for climate mitigation appears in several countries' climate change mitigation plans (known as Nationally-Determined Contributions, or NDCs), and may come to feature prominently in credit schemes under Article 6 of the Paris Agreement (Kizzier 2019; Herr et al. 2018). These and other drivers increase the demand for BC projects. Meanwhile, the supply of those projects is aided by increasing availability of guidance for designing and executing projects that offer additionality and can therefore generate revenues through carbon credits.[1]

[1] This guidance comes from academia (e.g., Howard et al. 2017); from coalitions such as the those that created the High Quality Blue Carbon Principles and Guidance, Integrity Council for Voluntary Carbon Markets' (ICVCM) Core Carbon Principles, the Voluntary Carbon Market Integrity (VCMI) Initiative's Code of Practice, and the Tropical Forest Credit Integrity (TFCI) guide (see CI 2022); from consulting firms such as McKinsey & Co. (Claes et al. 2022); and from development agencies, including GIZ (von Unger et al. 2020) and the World Bank's Pro Blue team (see World Bank 2024).

Box 1: Blue Carbon and the UNFCCC

Carbon sequestered and/or released from the management of coastal ecosystems is included, like any other human activities on land, in the Land Use, Land-Use Change and Forestry (LULUCF) category of the UNFCCC. The Intergovernmental Panel on Climate Change (IPCC) has a specific set of guidance (IPCC 2014) on how to include sinks and sources from coastal wetlands management into national GHG accounts. Like other LULUCF activities, countries, companies and individuals turn to specific projects that can offer them carbon offsets, guided by standards – many of which are still in development for some BC ecosystems.

Objectives of this Report

This study presents a brief synthesis of information on the current state of play with respect to BC markets, and presents thoughts on current BC supply and demand – which are significantly mismatched. It updates a 2020 study undertaken by Forest Trends for the World Bank, and builds on ongoing analyses undertaken by the World Bank, as well as the significant work of the International Blue Carbon Policy Working Group, the Scientific Working Group of the Blue Carbon Initiative and the Coastal Carbon Research Coordination Network, the Verra Blue Carbon Working Group, UNEP's former Blue Carbon Initiative, and others. These groups offer technical guidance on BC assessment; direction for international standards on above ground and soil biomass quantification of carbon; methods for monitoring, reporting, and verification (MRV); a set of international criteria for data collection, quality control, and archiving (Herr and Landis 2016); and resources for best practices in BC ecosystem conservation, restoration, and sustainable use (Howard et al. 2014).[2] The sheer number of technical support groups, scientific publications, and recent BC initiatives are testimony to the fact that BC is still considered a viable, investable, and important complement to other nature-based solutions (NBS).[3]

Multilateral development banks, such as the World Bank, have financed much of the public sector's investment in nature-based climate change mitigation. This occurs through capital provision for planning and launching projects through which the private sector underwrites conservation and restoration via the purchase of carbon credits in the carbon markets. Support is also delivered via bilateral aid for emissions reduction programs in many of the major biomes and geographies of the world, including coastal ecosystems. To better understand the BC space, in 2020 the World Bank commissioned Forest Trends to prepare a preliminary report on the state of the blue carbon market. The report that you are currently reading represents an updated version of that report, assessing the state of play in BC markets and speculating on the reasons the growth of BC across the world is often sporadic and has generally not met expectations. The report also offers recommendations on how to increase the use of carbon markets to secure the health and resilience of BC ecosystems. The overarching objective of this work is to assess demand drivers and the supply pipeline of Blue Carbon projects, with initial policy recommendations for optimally utilizing markets[4] to get BC to scale, as well as for finding ways to fully incorporate BC into climate strategies. This is thus a preliminary study to take stock of recent supply and demand dynamics in BC markets and identify opportunities to bring BC to scale. The report begins with an overview of BC, with the main focus on coastal BC in mangrove, seagrass, and saltmarsh ecosystems. Based on targeted interviews with investors and NGOs working in the BC space, and data collected by Ecosystem Marketplace, the report provides a snapshot of current demand for BC and characterizes BC project supply. Given the current situation and recent trends, the report teases out issues with BC financing, and explores policy instruments that can catalyze BC accounting, market expansion, and adoption of best practices to protect and restore BC ecosystems.

2 UNEP has also prepared several recent reports catalyzing expansion of BC projects beyond mangroves, including "Out of the Blue: The Value of Seagrasses to the Environment and to People" (2020) and "Protecting Seagrasses through Payments for Ecosystem Services: A Community Guide."

3 Nature-based Solutions (NBS) are defined by IUCN as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."

4 It should be noted that carbon offsets are a transitional measure intended to support societal movement toward true sustainability.

The Potential of Blue Carbon

Given the widespread recognition of the importance of coastal and marine habitats for human well-being, their role in climate change mitigation and adaptation, and the dangers of unsustainable use and indirect degradation of these ecosystems, one might expect a wholesale embrace of carbon markets as one source of finance to support effective conservation and management of these areas. That is not the case, however. While demand for BC offsets is growing, supply is still limited. Access to information about BC ecosystems and BC markets —once a serious constraint — no longer appears to be an issue (see Box 2 on page 20 for information resources and platforms supporting development of BC initiatives and policies).

Therefore, we may be at a critical juncture in which the ratcheting up of supply to meet global demand is made possible by getting governments and the private sector on the same page regarding BC potential.

Enthusiasm about the potential for marine and coastal ecosystems to fix and store carbon, and thus mitigate climate change, has been growing in recent decades. Explorations of how BC can be mainstreamed into carbon mitigation and emission reduction strategies, climate finance, and adaptation for climate resilience have resulted in a number of guidelines, including the 2022 High Quality Blue Carbon Principles and Guidance (Conservation International et al. 2022). There has been a dual focus on inventories (e.g., the IPCC guidance on inclusion of wetlands in national greenhouse gas inventories (IPCC 2014)) and on implementing mitigation and adaptation projects.

Over 170 nations host BC ecosystems, including mangrove forests, seagrass meadows, saltmarshes, coastal peatlands, and macroalgae beds, and many are turning to these habitats for both climate change mitigation and adaption. Most attention has been given to the big three coastal ecosystems: mangrove forests, seagrass meadows, and saltmarshes (Pendleton et al. 2012). Table 1 summarizes the major BC ecosystems and their contribution to emissions if converted or degraded.

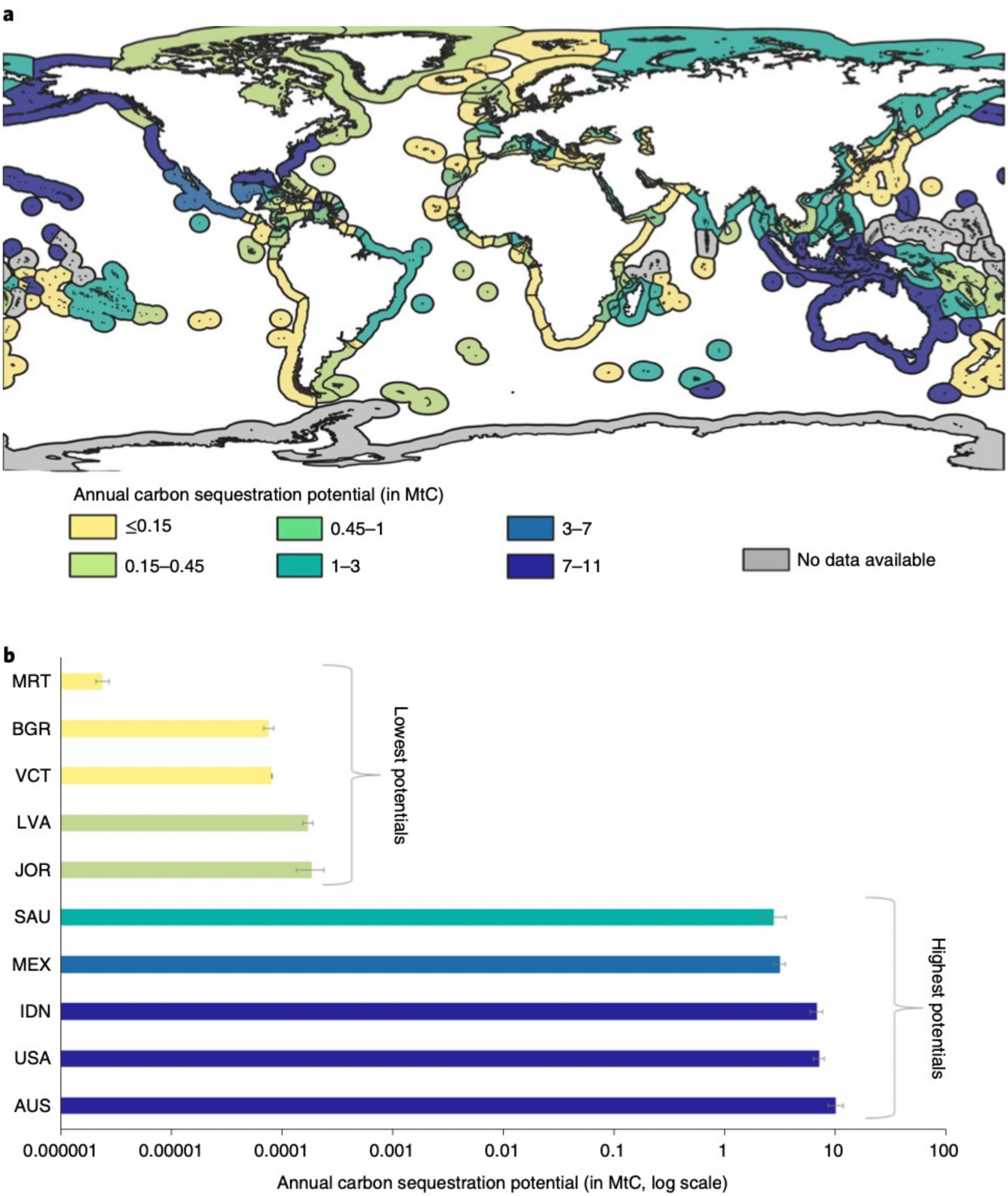
Vegetated coastal habitats are extensively distributed globally and under threat from multiple pressures. Mangrove ecosystems can be found in 118 countries, and the current extent of mangroves is estimated to be approximately 140,000 sq km (Bunting et al. 2018; Figure 1). Seagrasses are even more widespread, as they occur in tropical and higher latitudes, and estimates of worldwide coverage range from 160,000 to 600,000 sq km (McKenzie et al. 2020). Saltmarshes are more restricted, but nonetheless cover over 50,000 sq km of coastal lands.

Table 1. Blue Carbon Ecosystems: Global Extent, Rates of Conversion, Estimated CO_2 Emissions Due to Human Activities, and their Estimated Costs

Ecosystem	Global Extent (Mha)	Conversion Rate (% $year^{-1}$)	Organic Carbon in Biomass and the Top Meter of Sediment (Mg CO_2 ha^{-1})	Carbon Emissions (Pg CO_2 $year^{-1}$)	Estimated Cost (Billion US$ $year^{-1}$)
Tidal Marsh	2.2-40 (5.1)	1.0-2.0 (1.5)	237-949 (593)	0.02-0.24 (0.06)	0.64-9.7 (2.6)
Mangrove	13.8-15.2 (14.5)	0.7-3.0 (1.9)	373-1,492 (933)	0.09-0.45 (0.24)	3.6-18.5 (9.8)
Seagrass	17.7-60 (30.0)	0.4-2.6 (2.5)	131-552 (326)	0.05-0.33 (0.15)	1.9-13.7 (6.1)
TOTAL	33.7-115.2 (48.9)			0.15-1.02 (0.45)	6.1-41.9 (18.5)

Source: Reproduced from Crooks et al. 2020.

Figure 1. Mean Annual Carbon Sequestration Potentials



Source: Reproduced from Bertrand et al. 2022.

In their 2021 paper "The Blue Carbon Wealth of Nations," Christine Bertram and colleagues calculated the blue carbon potential of coastal countries, assessing coverage of mangrove, saltmarsh, and seagrass within coastal waters, territorial seas, and Exclusive Economic Zones (EEZs) globally. Using conservative averages of carbon sequestration rates for each of these three major BC habitats: 24.0 ± 3.2 Million tons of carbon per year ($MtC\,yr^{-1}$) for mangroves, 13.4 ± 1.4 $MtC\,yr^{-1}$ for salt marshes, and 43.9 ± 12.1 $MtC\,yr^{-1}$ for seagrass meadows. The researchers determine that Australia, the United States, and Indonesia are the three countries with the largest annual carbon sequestration potentials aggregated over all three BCE types (10.6 ± 1.6, 7.5 ± 0.8, and 7.2 ± 0.9 $MtC\,yr^{-1}$, respectively) (Figure 1).

There are, of course, other BC ecosystems beyond the "big three"; for instance, the Abu Dhabi BC project identified five BC habitats in the Arabian Gulf: mangrove, seagrass, saltmarsh, sabkha, and cyanobacterial mats.[5] Peatlands, especially tropical coastal peatlands, are the subject of growing attention for their emissions reduction and offset opportunities (Crooks et al. 2020). Interest in macroalgal beds as a BC habitat has also recently grown. Despite claims to high levels of carbon fixing to the deep sea (Macreadie et al. 2019), macroalgae do not seem to sequester carbon into the soils beneath them at long-term rates comparable to seagrasses. Still, macroalgae such as kelp do have a potentially important role to play in emission reductions, since using seaweed as an animal feed significantly reduces the amount of methane gas produced by cows. Rather than thinking of this as a co-benefit, this is actually a multifaceted carbon benefit. Macroalgae delivers other important co-benefits as well, including improving water quality, reducing the spread of marine diseases, and working in concert with other marine biota to attenuate storm impacts - all extremely important components of climate change adaptation.

Other projects and programs have probed additional marine ecosystems for their contribution in sequestering carbon, including pelagic ecosystems (open ocean), where "fish carbon" and "whale carbon" have been quantified as significant (Pearson et al. 2023). The inclusion of such carbon-sequestering biota, as opposed to vegetated habitats, in BC considerations has proven to have limited applicability, however (Davis 2020).

Nonetheless, there is vast potential to value, preserve, and capitalize blue carbon—not only in mangrove ecosystems, but in many other coastal and marine ecosystems. But the question remains: if blue carbon has potential to figure into NDCs and if credits can be sold in the carbon markets, why hasn't there been a steadily increasing growth in BC projects?

In the next section of this report, we lay out biophysical factors that may explain the uneven growth in BC markets. This is followed by a discussion of carbon market dynamics, particularly recent volatility in BC credit pricing. Both need to be fully reckoned with before BC can come to scale.

[5] Cyanobacterial mats are widespread in the UAE, and carbon studies reveal these understudied habitats fix carbon at surprisingly high rates.

Blue Carbon Credits: A Taxonomy

Several features set BC apart from terrestrial or forest ecosystems when it comes to sequestering carbon. These must be considered by decision makers in formulating climate change mitigation and adaption strategies, as well as by private finance when evaluating BC investments. These features include ecological considerations, primarily: 1) the open nature of marine and coastal systems that requires consideration of linked habitats through an ecosystem-based management (EBM) approach; 2) the difficulty in determining boundaries of some BC habitats, and the difficulty in monitoring landscape/seascape level changes to BC habitat extent and conditions; and 3) the inherent vulnerability of coastal BC habitats in light of climate change effects, such as sea level rise, increased storm events, ocean acidification and deoxygenation, and other human stressors.

Mangrove Carbon

Mangrove refers to a group of salt-adapted trees that form mangrove fringes and forests across the tropical regions of the world. Mangroves fix carbon and sequester it in soils at rates many times that of terrestrial forests, making this ecosystem extremely important in climate change mitigation. According to UNEP (2014), emissions resulting from mangrove losses from cutting, coastal development, and other human-driven impacts make up nearly one-fifth of global emissions from deforestation. These losses result in economic damages of some US$6 - 42 billion annually (UNEP 2014). Mangroves are also threatened by climate change, which could result in the loss of a further 10 - 15 percent of mangroves by 2100 (UNEP 2014).

The ecological processes that take place in mangroves result in other ecosystem services (ES) beyond BC. These services have value in their own right.[6] However, many of mangrove ES act to reduce future risks to carbon sequestration, and are therefore inextricably tied to climate change mitigation. Mangroves can act together with mud flats to stabilize navigation channels and shorelines, prevent inundation from sea level rise and wind-induced flooding, and protect coastal communities and infrastructure (Ellison 2010). Mangroves are also one of the most important buffers against catastrophic flooding brought about by cyclones or tidal waves (Arkema et al. 2013; Livelihoods Funds 2020). Mangroves therefore not only sequester carbon, locking it away in soils, but also protect those soils from being washed away to release carbon back into the atmosphere. Mangrove distribution and condition can be discerned using remote sensing, so global mangrove coverage is well understood (Figure 2).

BC science is comparatively more advanced for mangroves compared to other ecosystems. Mangrove mapping, the quantification of carbon in mangrove leaf biomass and soils, and afforestation methods are well developed and tested. A 2018 study by Sanderman et al. mapped soil carbon sequestered by mangroves around the world, and this information is constantly being updated and refined. However, mangroves are at risk, not only from cutting for fuelwood or the conversion for agriculture and aquaculture, but also from coastal development for tourism and broader land-use and watershed changes, especially dam construction and water diversion in rivers that feed coastal mangrove areas. This makes both conservation of intact mangrove areas and restoration of degraded areas difficult, requiring an ecosystem approach that spans jurisdictions and involves more than coastal stakeholder groups. Although mangroves can rapidly accrete land to keep pace with changes in sea level (McIvor et al. 2013), mangrove habitats in many parts of the world **are extremely vulnerable to sea level rise when cumulative impacts undermine ecosystem function**. This potentially risks mangrove conservation investments, including BC projects that offer carbon offsets. This emphasizes the need for science-based approaches and solutions for developing mitigation projects and programs in these complex transitional habitats.

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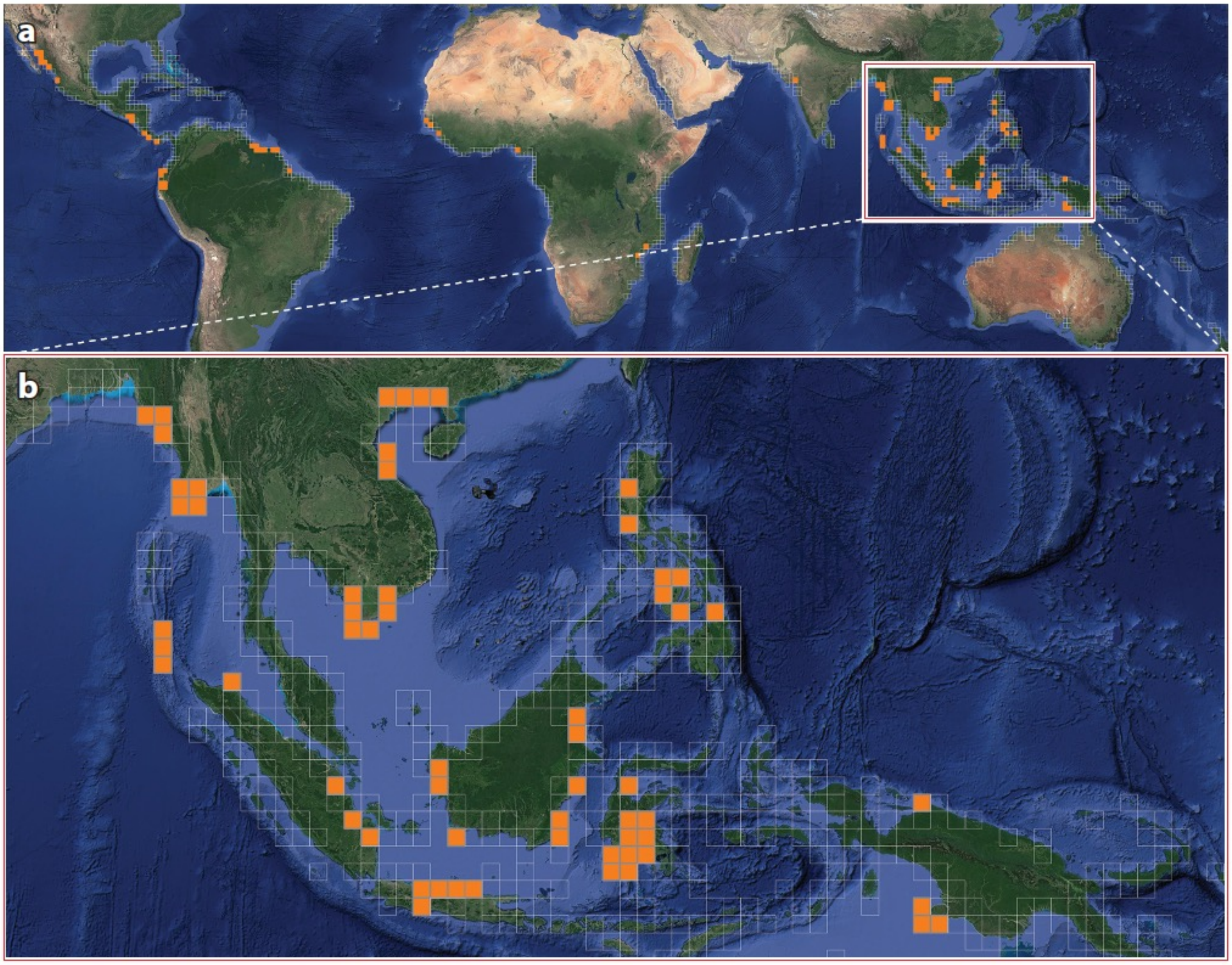
6 They also act to trap heavy metals and other toxins, and to some extent they can maintain salt balances. Thus mangrove plays a critical role in maintaining water quality, even as groundwater, freshwater, and seawater become increasingly degraded. Mangrove channels and tide-inundated mangrove support a variety of fisheries species through provision of nursery habitat. See Agardy 2013; Barbier et al. 2011 and others.

Figure 2. Global Distribution of Major Mangrove Areas (Shown in Orange), with an Expanded View of Southeast Asia



Source: Reproduced from Friess et al. 2019.

Legend: Particularly high rates of mangrove loss in Southeast Asia and worldwide are denoted in orange (1° × 1° tiles where mangroves (gray) and hotspots of substantial change (losses and/or gains) in mangrove extent were observed between 1996 and 2010).

Panel a is a global overview; ***panel b*** (enlargement of inset) highlights areas of substantial change in Southeast Asia, a key deforestation hotspot. Figure adapted from Thomas et al. 2017.

Seagrass Carbon

Seagrasses are flowering plants that live in shallow water photic environments in temperate, subtropical, and tropical regions of the globe. When seagrasses occur in extensive and well-developed meadows or seagrass beds, they sequester carbon at per hectare rates several times that of tropical forests. Although there has been no worldwide assessment of seagrass distribution and condition, beds are thought to cover more than 60 million hectares worldwide - an area approximately the size of France (UNEP 2020).

Seagrass meadows also provide important co-benefits, including providing feeding and breeding grounds for most neritic (coastal shallows) species that live in tropical and subtropical environments. It has been estimated that some 80 percent of coastal fisheries species rely on seagrass during some part of their life histories. The nitrogen-fixing ability of seagrass rhizomes allows these aquatic flowering plants to thrive even in the low-nutrient conditions typical of tropical seas. Therefore, while the biodiversity of a seagrass meadow at any point in time may be relatively low (especially when compared with coral reefs, or with transitional ecosystems, like estuaries and mangroves), the cumulative biodiversity can be high, with support to extensive food chains (van Lavieren et al. 2012). Component species of seagrass meadows, such as tunicates, exert controlling effects on phytoplankton production and thus support wider food webs, which in turn drive carbon fixing rates.

Seagrasses are destroyed deliberately during coastal and port development and land reclamation. Seagrasses are also degraded by sediment pollution and lowered coastal water quality. Warming sea temperatures driven by climate change exacerbate these impacts. Seagrass protection and restoration initiatives lag far behind mangroves, coral reefs, and other marine ecosystems, making seagrass meadows one of the most threatened marine habitats globally. A 2020 study by Salinas and colleagues suggests that seagrass losses in Australia alone translate to increased emissions equivalent to 5 million cars a year (Salinas et al. 2020). Australia now includes seagrasses in their Australian Emissions Reduction Fund to combat the accelerating rates of loss..

Nearshore seagrass is particularly important as its soil carbon is much higher than deeper-water seagrass. Once environmental quality declines cause seagrass declines, rapid release of soil carbon can occur because the buffer that living blades of grass give to wave- and current-related disturbance is removed. The result is equivalent to the release of carbon from seafloor substrates from acute disturbance like dredging. But unlike dredging, degradation can impact entire meadows, and not just restricted channels or areas where dredging takes place.

Saltmarsh and Tropical Peatland Carbon

Saltmarshes are tidal wetlands that fix and store carbon at extremely high rates. Because of the ability of these extensive wetlands to amass carbon in peaty soils, carbon sequestration rates are high. Coastal peat is a significant source of carbon sequestration (Crooks et al. 2020). Peatlands occur in the transition zone between marine and terrestrial habitats, and can extend landward into upland areas not considered part of the coastal zone. Tropical and subtropical peatlands cover some 47 million square kilometers (sq km), with significant expanses of peatlands in Southeast Asia, South America, and Africa (Gumbricht et al. 2017). The total tropical peatland stock (528-600 Petagrams) represents a major global reservoir for carbon (Hodgkins et al. 2018). In high rainfall areas, tidal peat swamps may form dome structures, building organic soils above elevations of tidal influence. If these domes are drained, they can collapse and rapidly emit CO_2. Crooks et al (2020) suggest that converted peat swamps (including but not exclusively tidal) in Southeast Asia emit carbon at a rate of 70-117 t CO_2 eq ha-1 yr^{-1}, representing 0.44 - 0.74 percent of annual global carbon emissions (Cooper et al. 2020).

Macroalgae: Kelp Beds and Seaweed

The “big three” BC ecosystems (mangrove, saltmarsh, and seagrass) occupy 0.2% of oceanic surface area but contribute 50% of carbon burial in marine sediments (Serrano et al. 2019). There are, however, other pathways to marine carbon sequestration. Macroalgae, large multicellular algae (not plants) belonging to the red algae, green algae, or brown algae families, are the dominant carbon fixers in some temperate areas. These algae grow quickly, resulting in high turnover rates to fix carbon, but have few mechanisms for long-term storage of carbon. Their value as BC habitats is thus debatable, as the rates of sequestration in marine sediments appear low. That said, macroalgae cultivation — an enterprise which is showing dramatic growth rates throughout Southeast Asia and in parts of Africa and South America —can contribute to emissions reductions if seaweed products are used as cattle feed. Macroalgae in general, particularly kelp beds, provide numerous co-benefits alongside carbon storage.

Some countries are committed to using macroalgae as a climate change mitigation measure. Korea, for instance, as a Coastal CO_2

Removal Belt (CCRB), encompasses natural and farmed macroalgae stands (Chung et al. 2013). In farms that grow the perennial brown alga *Ecklonia*, a pilot CCRB farm can draw down ~10 tCO_2 per ha per year. Adjustments to the BC model to make macroalgae crediting possible is being pursued by carbon mitigation experts in Korea and elsewhere.

Oceanic Carbon

The open ocean presents several pathways for carbon sequestration. As stated in a 2020 World Bank report on Blue Carbon (Crooks et al. 2020), "there is current debate [within the IPCC] regarding the application of the blue carbon concept to other coastal and non-coastal processes and ecosystems, including the open ocean."

The biota of the open ocean drive marine carbon, which then influence planetary carbon cycles and climate. Much recent attention has focused on the ocean's biological carbon pump, through which a portion of the carbon being cycled through marine food webs falls to the sea floor and is sequestered (Martin et al. 2020). Whale and fish carbon have also received attention as a potentially important drivers of carbon sequestration in the seafloor (Pendelton et al. 2012; Fullenkamp et al. 2020).[7] However, incorporating such pelagic sources of carbon into credit markets is currently not possible, not only because of incomplete knowledge on carbon sequestration rates and trends, but also because much of this carbon cycling takes place beyond the jurisdictions of coastal countries.

[7] A blog by the IFC (https://www.imf.org/en/Publications/fandd/issues/2019/12/natures-solution-to-climate-change-chami) concluded that the value of a single whale in locking up carbon is approximately $1 million over its lifetime, and when carbon sequestration values are added to other values, this amounts to an estimated $1 trillion across the global great whale populations. Whales residing in circumscribed areas, such as off the coast of Brazil, contribute billions of dollars-worth of carbon fixing. Bringing these considerations of oceanic carbon into offsetting or carbon crediting discussions has been difficult, however, since the contribution of whale and fish carbon to actual sequestration has not been determined. Add to that the complexity posed by organisms that are highly migratory like whales, and it becomes difficult to see how jurisdictions could include oceanic carbon in their accounting (see Herr interview in Davis 2020).

Challenges for Blue Carbon Project Development

BC habitats and ecosystems can contribute to carbon mitigation measures, providing offset opportunities as well as climate change adaptation measures. Yet, despite its promise, BC has been slow to materialize in carbon accounting, carbon markets, and climate policy. In the past, a main constraint for governments (at all levels), BC providers, and BC project developers has been accessing reliable and comprehensive information on BC —especially on how to conduct assessments, design BC projects, and find ways to market BC credits. For this reason, many of the BC working groups (International Blue Carbon Policy Working Group, the Scientific Working Group of the Blue Carbon Initiative and the Coastal Carbon Research Coordination Network, the Verra Blue Carbon Working Group, Blue Carbon Program of UNEP) have invested in new platforms to make BC information and guidelines broadly available (Box 2). AGEDI, the information branch of the Environment Ministry of Abu Dhabi, also maintains a comprehensive portal on BC information resources.[8]

Beyond these biophysical considerations, BC also differs from forest carbon in the legal and policy dimensions: 1) the absence of private property rights for some BC lands/submerged lands (though this can be true for some terrestrial forested landscapes as well); 2) the policy implications of the open nature of marine systems in which it is necessary to have any REDD+ or other potential BC initiatives consider linked habitats in an Ecosystem-based Management framework; 3) the challenges in completing BC and other Ecosystem Services (or co-benefit) assessments, as well as carbon verification, and the limited number of certifiers that are up to the task; 4) the inherent difficulty and relatively high cost of doing meaningful and effective surveillance and monitoring in most BC habitats; 5) the general lack of understanding among decision-makers about the potential for BC in mitigation and adaptation strategies; and finally, 6) the relatively low value of carbon as compared to the potentially high value of coastal development, especially in the short term. These features have presented some challenges, mostly overcome by innovative adaptation of terrestrial approaches to the special circumstances of transitional and marine environments.

Despite these hurdles, BC's profile is rising on the world stage. In the years since BC appeared on the radar screen, wetland scientists and marine ecologists have worked with carbon cycle scientists to create and test various methodologies to assess carbon fixing and sequestration potential of different habitats under different conditions. At the same time, environmental NGOs and verifying organizations have facilitated BC project development by providing technical assistance in carbon accounting, upfront capital costs for designing and launching projects, and by facilitating negotiations with stakeholders.

Governments, project developers, and investors are all grappling with the special circumstances of BC. Yet enthusiasm and ambition to incorporate BC in mitigation and adaptation has only increased. BC is beginning to appear in national carbon assessments and NDCs, and managing coastal and marine areas now includes instituting policies that consider conservation and restoration for securing BC, alongside other values. Often these policies are not carbon mitigation policies per se, but rather are adaptations of existing coastal zone management, fisheries management, species conservation, marine spatial planning, and maritime development policies (often with accompanying new legislation). In addition, climate policies at the national and subnational level are beginning to incorporate nature-based

8 https://bluecarbonportal.org/مشروع-أبوظبي-لدراسة-الكربون-الأزرق/abu-dhabi-blue-carbon-demonstration-project-document-library/).

solutions and carbon offsetting involving BC habitats and ecosystems. Setting the right incentives and avoiding double-counting can ensure that BC offsets can be a transition tool to steer countries toward effective climate mitigation and adaptation. Significant guidance exists to steer governments toward effective management and restoration of BC ecosystems, and guide the development of high quality BC projects for the carbon markets (Box 2).

Box 2. Sampling of Information Resources for Blue Carbon Initiatives and Policies

Blue Forests Solutions (https://www.blueforestsolutions.org/international-commitments)
Provides an explanation of how blue forests (mangrove BC) can figure in NDCs, NAMAs, REDD+, and also alludes to related Convention such as RAMSAR, CBD, and agreements to protect marine biota.

Columbia University Earth Institute Database on CO2 Removal Laws (cdrlaw.org)
On October 9, 2020, researchers at Columbia University launched the world's first database of carbon dioxide removal laws. The publicly available database provides an annotated bibliography of legal materials related to carbon dioxide removal and carbon sequestration and use. The site has 530 resources on legal issues related to carbon dioxide removal, including such techniques as: direct air capture, enhanced weathering, afforestation/reforestation, bioenergy with carbon capture and storage, biochar, ocean and coastal carbon dioxide removal, ocean iron fertilization, and soil carbon sequestration.

Impact Partners (http://impactpartners.iixglobal.com/about)
Impact Partners helps investors identify, evaluate, and invest in social and environmental investment opportunities. The Impact Partners private placement platform features impact investment opportunities in Impact Enterprises operating across sectors including clean technology, renewable energy, sustainable agriculture, education, healthcare, and water and sanitation. Impact Partners is dedicated to showcasing high impact investment opportunities that create triple bottom line returns consisting of people, planet, and profit.

Marine and Coastal Finance Working Group - The Conservation Finance Alliance (CFA) (https://www.conservationfinancealliance.org/marine-and-coastal-finance)
The Marine and Coastal Finance Working Group of the Conservation Finance Alliance develops guidance material for coastal and marine conservation practitioners to build capacity on conservation finance and developing entries to the revised Conservation Finance Guide. The CFA also compiles lessons learned and case studies from innovative pilot activities and disseminates information, coordinating and collaborating with existing initiatives focused on marine and coastal conservation finance to complement on-going efforts undertaken under the auspices of other organizations.

Natural Capital Project (InVEST) Blue Carbon Model (https://naturalcapitalproject.stanford.edu/software/invest-models/coastal-blue-carbon)
The InVEST Blue Carbon model quantifies the value of carbon storage and sequestration services provided by coastal ecosystems. This model is one of the first coastal blue carbon tools where users can provide spatially-explicit information on disturbances to vegetation caused by climate change (e.g., sea level rise) and human activities (e.g., draining of a wetland or shoreline hardening). The Blue Carbon model can also be used to value avoided emissions and identify where on the land or seascape there are net gains or losses in carbon over time.

Box 2. Sampling of Information Resources for Blue Carbon Initiatives and Policies (*continued*)

The International Blue Carbon Initiative (https://www.thebluecarboninitiative.org)
The International Blue Carbon Initiative provides technical information, policy advice, and public awareness resources. Their Blue Carbon Manual offers a clear, step-by-step guide for assessing BC potential and designing BC initiatives and policies. It covers project conceptualization and field measurement planning, field sampling of soil carbon pools, estimating CO2 emissions, remote sensing and mapping, and data management. The IBCI also maintains an extensive library of publications on all features of BC.

The Mangrove Breakthrough (https://www.mangrovealliance.org/news/the-mangrove-breakthrough/)
The Global Mangrove Alliance was launched in 2018 at the World Ocean Summit and is comprised of NGOs, governments, scientific institutions, and communities, Together with the UN High Level Climate CHampions, it spearheaded the Mangrove Breakthrough, launched at UNFCCC COP27 in Sharm el-Sheikh, Egypt. The Mangrove Breakthrough stipulates a common agenda for mangrove protection and restoration.

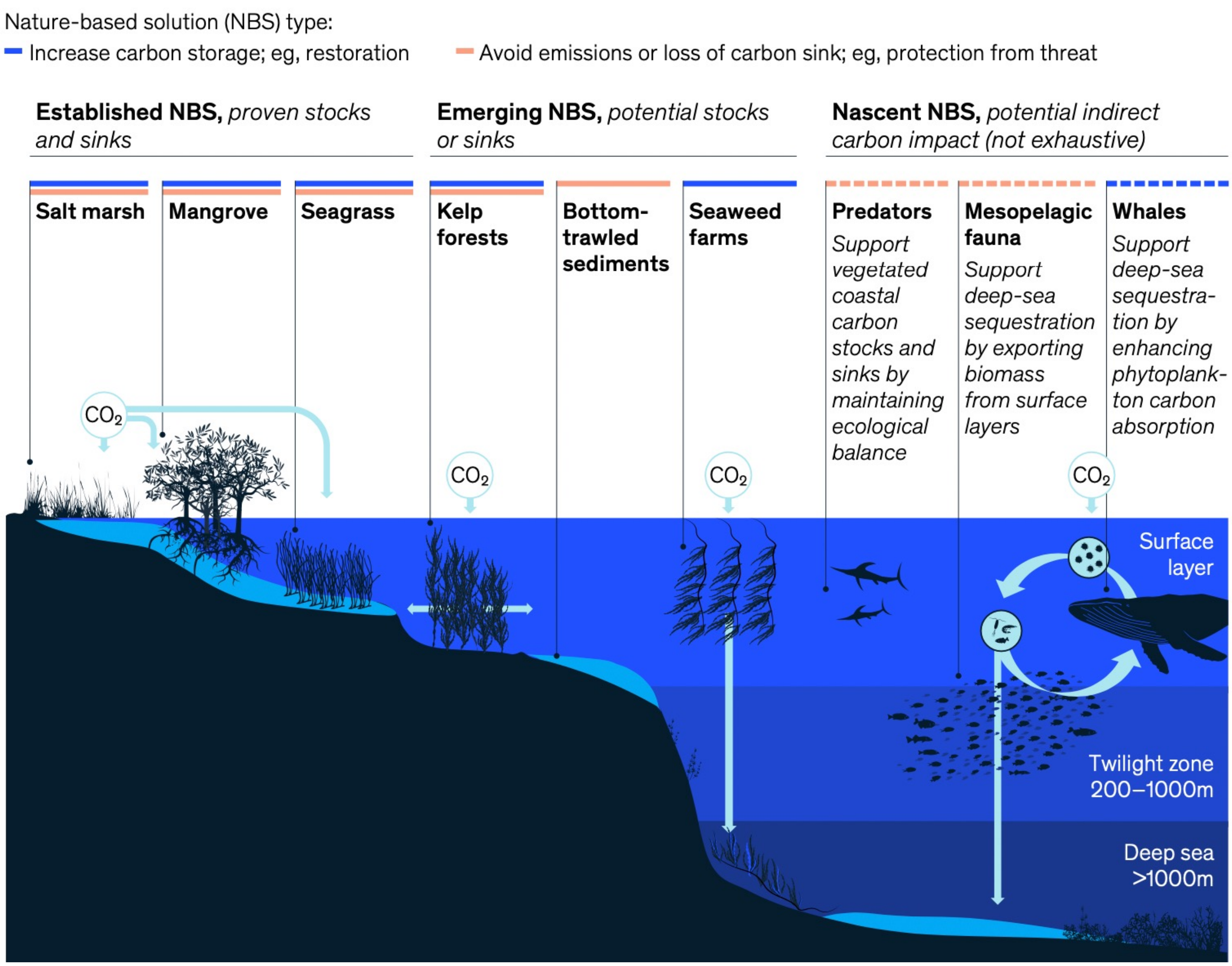
Verra (https://verra.org)
Offset standard manager and developer Verra released pioneering BC methodology in September of 2020 - the first BC methodology to be approved under any major GHG programme. The methodology is a revision to the VCS REDD+ Methodology Framework, adding BC conservation and restoration activities as eligible project types. The release and uptake of the methodology is expected to unlock new sources of finance for tidal wetland conservation and restoration activities. The Verra methodology covers avoided planned, and unplanned, deforestation; reduced forest degradation; afforestation; reforestation; revegetation; avoided, planned, and unplanned, peatland degradation, and restoration; avoided, planned, and unplanned tidal wetland degradation, and tidal wetland restoration.

World Bank Climate Explainer Series (https://www.worldbank.org/en/news/feature/2023/11/21/what-you-need-to-know-about-blue-carbon)
The World Bank has several resources on BC; one example is the Climate Explainer Series which presents information on BC ecosystem services, condition of BC habitats, barriers to conservation, and World Bank knowledge products on blue carbon, including “Unlocking Blue Carbon Development: Investment Readiness Framework for Governments” (World Bank 2023).

Climate, Social, and Environmental Benefits of Blue Carbon Development

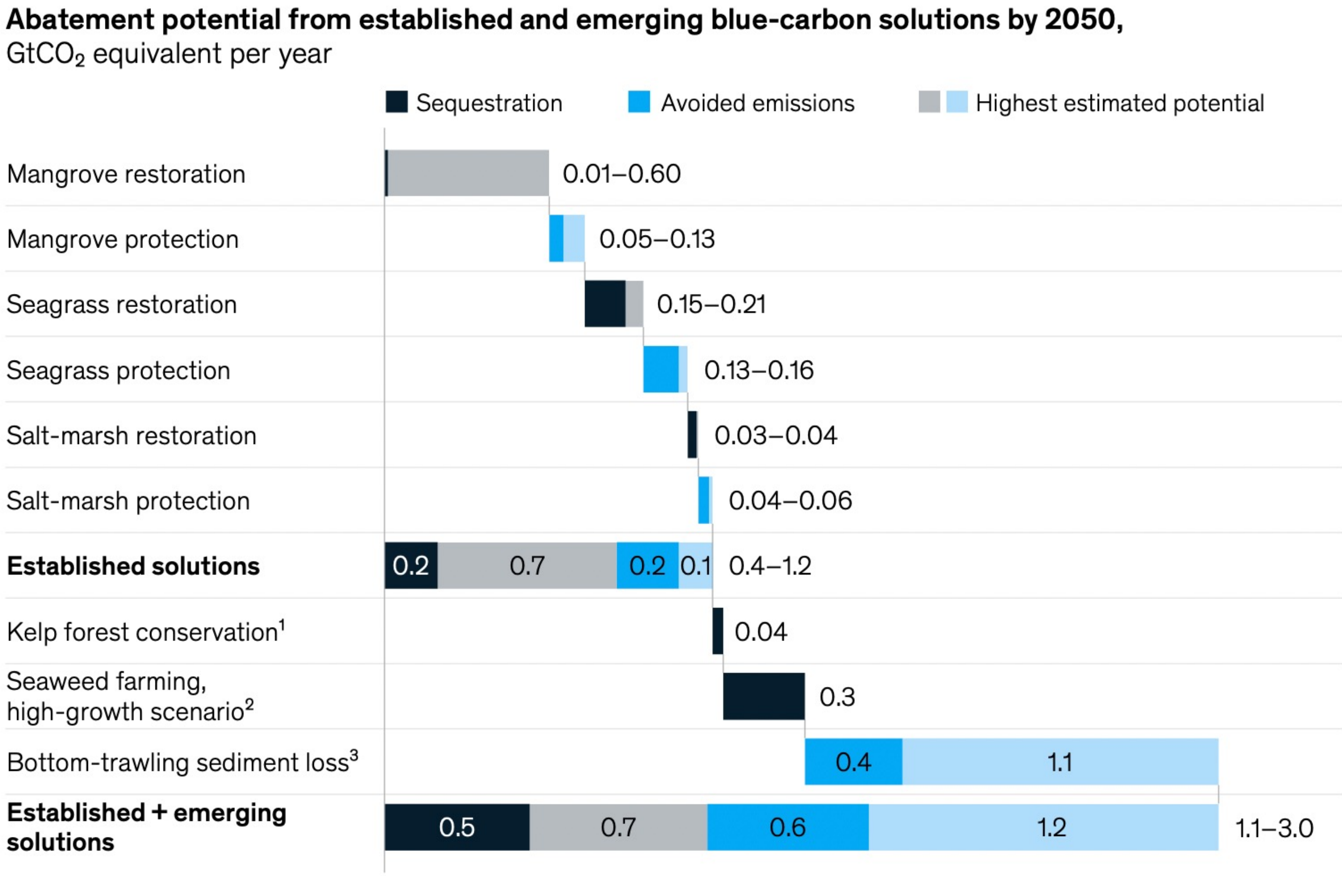
Blue carbon habitats provide a wide array of ecosystem services, and are some of the most "service-rich" habitats in the world. The 2005 Millennium Ecosystem Assessment provided the first comprehensive description of coastal ecosystem services, including those generated from BC habitats (Agardy and Alder 2005). The assessment was largely descriptive, but it did suggest the degree to which coastal populations rely on multiple ecosystem services from oceans and coasts, and also uncovered disturbing trends in marine ecosystem services delivery. Recent papers have updated this assessment and have summarized the state of the art on identification of marine ecosystem services (MES), the drivers behind loss or degradation of those MES, and the economic value of co-benefits provided by BC habitats (Claes et al., 2022; Himes-Cornell et al. 2018) (Figures 3 and 4).

Figure 3. Established, Emerging, and Potential Blue Carbon Stocks and Sinks



Source: Reproduced from Claes et al. 2022.

Figure 4. Estimated Abatement Potential of Established and Emerging Blue Carbon Solutions



[1] High-level, high-uncertainty estimate.
[2] Seaweed farming sequestration depends on area of implementation and is potentially much higher. Potential shown is the reported 14% per annum growth-based estimate in the ocean as a solution.
[3] Lower bound is estimated as the long-term abatement potential (40% of current emissions rates) of emissions from bottom trawling in areas shallower than 50 meters.
Source: Source: Peter Macreadie et al., "Blue carbon as a natural climate solution," *Nature Reviews Earth & Environment*, November 2021, Volume 2; Ove Hoegh-Guldberg et al., *The ocean as a solution to climate change: Five opportunities for action*, World Resources Institute, 2019; Enric Sala et al., "Protecting the global ocean for biodiversity, food and climate," *Nature*, March 2021, Volume 592; McKinsey analysis

Source: Reproduced from Claes et al. 2022.

In 2019, Hoegh-Guldberg and colleagues summarized the vast potential of ocean ecosystems in mitigating climate change (Hoegh-Guldberg 2019); in 2022 McKinsey & Company prepared a comprehensive report (Claes et al. 2022) assessing abatement potential of existing and emerging blue carbon.

More precise economic valuations have been done on individual BC habitats in various locales,[9] and these studies have been used to estimate the total ES values being delivered by BC ecosystems globally. It is estimated that the total value of mangroves, saltmarshes, and seagrass around the world is over $1.6 billion per annum (The Blue Carbon Initiative 2024).

These macroeconomic assessments are important for awareness-raising and can focus attention on BC habitats. Furthermore, context-specific studies are needed to craft protection and restoration regimes for BC habitats that consider costs of protection against the benefits provided. A good example is a recent study which assessed the concordance of economically and cultural valuable surf spots and BC habitats to make the case for protecting surf spots and associated habitats (Bukoski

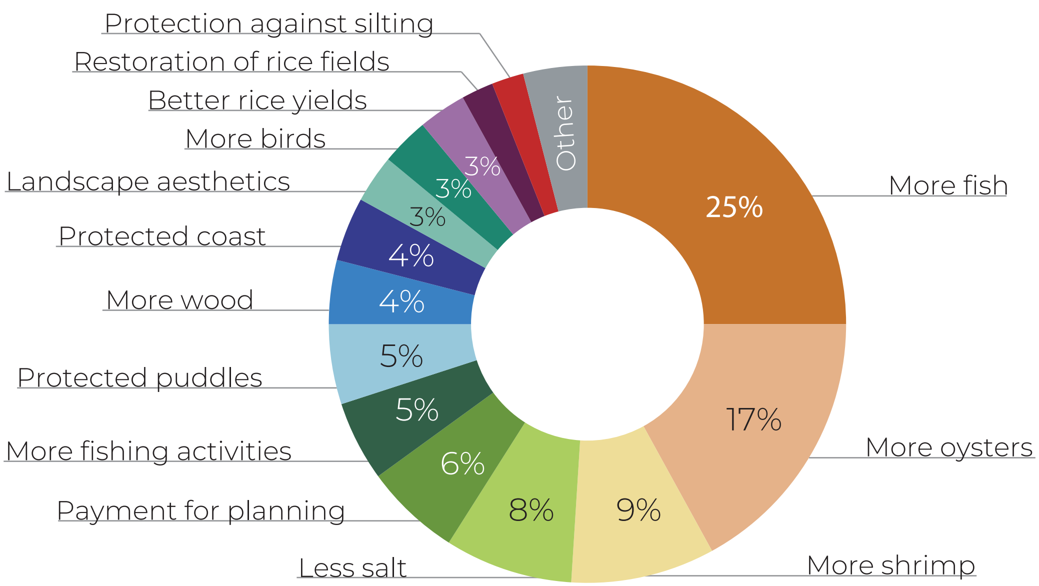
[9] Barbier et al. 2011 summarizes many of these studies and has been used as the basis for benefits transfer-based valuations of BC co-benefits.

et al. 2024). The authors used global spatial datasets of irrecoverable carbon (defined as carbon stocks that, if lost today, could not be recovered within 30 years' time), surf break locations, ecosystem types, protected areas, and data on Key Biodiversity Areas to identify areas of concordance. They concluded that a total of 88.3 million tonnes of irrecoverable carbon were held in surf ecosystems (of course in addition to the immense values of these sites for cultural ecosystem services, such as tourism, recreation, spiritual rejuvenation, etc.). A qualitative sense of the broad scope of benefits provided by BC ecosystems is best described by grouping of these benefits into categories that relate to major classes of use (Table 2).

Table 2. Major Co-benefits Provided by Blue Carbon Habitats, Classified According to Major Categories of Use

Key BC ES (co-benefits)	Ecosystem Processes	Beneficiaries	Threats and Pressures
Marine Biodiversity	Maintaining productivity / ecosystem health, disease suppression	Commercial and small-scale fishers, ecotourism operators, hotel and resort owner/operators, coastal communities	Habitat conversion, pollution, over-exploitation of resources and destructive fisheries in coastal areas; over-exploitation/ incidental catch; climate change
Commercial Fisheries Resources	Maintaining marine productivity that sustains the fishing industry and supports communities	Fishers, fisheries product processors, exporters, Treasury	Over-exploitation and illegal fisheries in ecologically important areas, destruction of critical habitat, climate change
Sports Fishery Resources	Providing high-value game fish	Sports fishing operators, marinas, hotels, associated service sectors	Overfishing and incidental catch of target species, reduction of prey (forage fish), pollution affecting reproductive potential
Small Scale Fisheries	Maintaining coastal productivity that sustains coastal communities and provides livelihoods / food security	Coastal communities, fishing associations, sellers	Pollution, habitat conversion (e.g., conversion of coastal habitat for industrial agriculture), indiscriminate fishing methods, restricted access (e.g., industry displacing small-scale users)
Space for Aquaculture	Providing clean water, nutrients, seed stock for farmed marine species	Aquaculture operators, product processors, sellers, coastal communities providing space for farms	Habitat loss, erosion, pollution, hydrological changes affecting water quality and flushing, disease/pathogen spread
Fisheries Nursery Habitat	Providing sustained recruitment to fished populations of fishery species	Commercial and small scale fishers, sports fishers and operators, aquaculture/ mariculture operators, sellers	Habitat destruction from dredging, trawling; deforestation of mangrove; seagrass habitat degradation; pollution; hydrological changes
Water Quality Maintenance	Removing excess nutrients and toxins from water column; disease suppression	Coastal communities, fishery sector, exporters, ecotourism operators, coastal tourism operators, hotels and resorts	Loss of wetlands and seagrasses/ macroalgae, pollution in watersheds, waste management along coasts and watersheds, over-exploitation of shellfish
Shoreline Stabilization	Providing stable shorelines and beaches for infrastructure and use	Coastal communities, coastal hotels and resorts, landowners, beach and ecotourism operators	Inappropriate coastal construction; loss of wetlands, seagrasses, and reefs; over-exploitation of grazers (e.g., parrotfish); climate change
Storm Impact Mitigation	Providing protection from cyclones, hurricanes, storm surge, tsunamis	Coastal communities, resorts, marinas, fishing ports and industry	Deforestation of mangroves; destruction of macroalgae beds, seagrass meadows; coral and shellfish reefs; inappropriate siting of infrastructure; climate change
Ecotourism	Providing wildlife and scenery for the profitable ecotourism sector	Ecotourism operators, hotels and resorts, nature centers and parks, service industry for tourism	Over-exploitation of high-value species, illegal fishing, loss of habitat, pollution, commercial exploitation/development of natural spaces/protected areas
Research & Education	Providing systems, habitats, and species to study to gain understanding of the sea and its uses	General populace, academic and research institutions, scientific community, marine managers (including fisheries managers)	Over-exploitation and degradation leading to biodiversity loss, ecosystem imbalances; industrial use of ocean space limiting access; illegal fishing

Figure 5. Perceptions of Benefits Provided by Blue Carbon Project Restoration of Mangroves in Senegal



Main benefits and advantages perceived by local communities following the Livelihoods-Senegal mangrove restoration project

Source: Livelihoods Funds 2019.

Many of the Livelihood Funds BC projects have provided data on BC co-benefits, and the community perception of co-benefits.. In Senegal, for instance, the afforestation of mangroves has improved ecosystem health and productivity, and people feel they are seeing (and catching) more fish and oysters, experiencing more shoreline stability, and enjoying greater aesthetics (Figure 5).

These estimates of benefits are often cast as against a counterfactual in which BC habitats are lost or degraded. Yet it is worth considering the relative benefits of BC for projects which maximize carbon storage and sequestration, versus those projects that optimize benefits across multiple ecosystem services and values to humans. This has been recently studied in forest ecosystems and, in a paper by Gopalakrishna and colleagues (2024), it was shown that in forest restoration, inevitable trade-offs between environmental and societal outcomes can be reduced when spatial planning aims to optimize ecosystem services for climate change mitigation, biodiversity, and societal gains simultaneously. More quantitative studies need to be done in BC ecosystems to see if this is also the case in the marine and coastal domain. If so, then it may be that BC initiatives that aim to maximize carbon storage and sequestration for the purpose of generating carbon credits may in fact be less valuable than initiatives that protect biodiversity and increase resilience, with climate change mitigation and credit generation as a side or co-benefit (World Bank 2024).

There are many challenges in assessing benefits and performing valuations on ecosystem services being delivered by BC habitats. Valuation is context-specific, yet most studies—especially those conducted at large geographical scales—utilize a benefits-transfer approach or other potentially over-estimating methodologies, such as the travel cost method. Cost considerations for generating the high-resolution data needed for risk assessment models (e.g., for flood protection from mangroves) may limit the ability to derive such needed information (Menendez et al. 2019). We emphasize the need for rapid, case- or region-specific assessments.

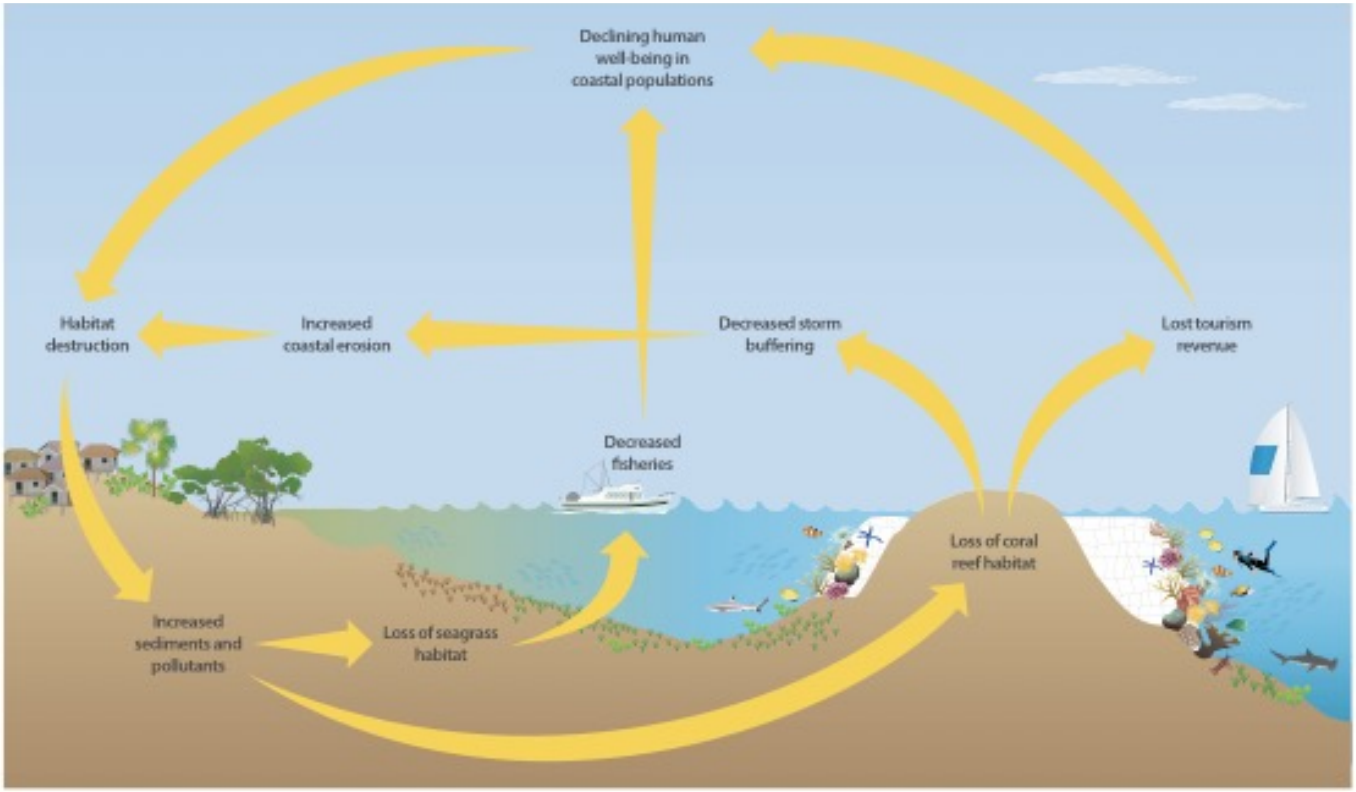
Figure 6. Variety of Ecosystem Services Provided by Coastal and Marine Systems the Livelihoods Funds

Source: Reproduced from Agardy et al 2011.

Although individual ecosystem services originating from natural habitats on land, along the coast, and in the sea can be identified, assessed, mapped, and analyzed for real and potential economic value, it is important to note that no ecosystem service exists in isolation from other ecological processes and delivery of other services. Natural systems are highly interlinked, and human well-being is coupled to the existence of multiple ecosystem services, all of which are being delivered simultaneously. These linkages and feedback loops mean that development decisions or carelessness that cause the loss of habitat or species will affect more than one ecosystem service of value, and a multitude of stakeholder groups (Figure 6).

Each of the major BC ecosystems/habitats provide carbon sequestration and co-benefits due to the ecological processes that are taking place there, no marine ecosystem exists in isolation. In addition, cumulative direct and indirect impacts on ecosystem functioning and health drive a cascade of negative impacts, ultimately affecting the human well-being of communities that live near and rely on BC ecosystems (Figure 7).

Figure 7. Connectivity and Cascading Effects of Degradation in Coastal and Marine Ecosystems



Source: Reproduced from Agardy et al. 2011.

State of the Market for Blue Carbon

In this section, we review data from Ecosystem Marketplace's annual Global Carbon Survey, extracting insights on the size, scope, and direction of carbon market finance flowing to BC, including leading project types and a discussion of price volatility in this market space.

Leading Blue Carbon Project Types Transacted

BC remains a small, "boutique" slice of the overall voluntary carbon market, comprising less than one percent of overall credit transactions per year, even though it fetches higher prices per credit (Table 5). Overall, 10.9 MtCO_2e in credit volumes were traded in the 2020-2023 period.

Among coastal ecosystems, BC credit initiatives are most common in mangrove ecosystems, which transacted millions of tons of carbon dioxide equivalent (MtCO_2e) between 2020 and 2023 (Table 3; Table 5). These "salty forests" are akin to terrestrial forests, although important distinctions can be made in terms of property rights, the legal and institutional frameworks for managing them (most mangroves already enjoy legal protection), and the extent to which both hydrology and sediment transport factor in to protection and restoration of the habitat. However, their similarities to terrestrial forests have provided an opening to bring coastal and marine carbon onto the world stage.

Verification is a critical part of offsetting, and various verification standards have been developed. The Verified Carbon Standard (VCS), in particular, has established a blue carbon practice with its Wetland Restoration and Conservation (WRC) standard and has developed a string of methodologies, including for restoration of mangroves, tidal marshes, and seagrass meadows (VM0033) and conservation (in review soil modules under VM0007; VCS 2015) (Crooks et al. 2020).

Geography of Blue Carbon Transactions

Almost all of the BC transaction data that Ecosystem Marketplace has received comes from tropical countries, with the exception of some transactions from projects in the US, Germany, and Pakistan and several transactions from unspecified countries. Only 274 kt CO_2e out of the full transaction volume of 10.9 Mt CO_2e for BC credits from 2020-2023 (Table 4) were for non-tropical BC credits.

Table 3. Blue Carbon by Credit Category

	Marine		Terrestrial	
Blue Carbon Credit Category	Mangroves Restoration / Conservation	Seagrasses	Afforestation, Reforestation, and Revegetation (ARR) and Wetland Restoration	Wetland Restoration / Management

Table 4. Blue Carbon by Credit Category

Type	Million tons of CO_2e
Tropical	10.63
Non-tropical	0.27
Total	10.9

BC initiatives are still centered on relatively small-scale, community-based projects, although there is significant potential to bring BC to scale through regional initiatives. However, some BC initiatives are large enough projects that they encompass significant proportions of BC ecosystems within a region. For instance, BC projects supported by the

Livelihoods Funds in Senegal, India, and Indonesia have restored almost 20,000 hectares of mangroves, and are projected to sequester several millions of tons of CO_2 across the 20-year project lifecycle.

Blue Carbon Credit Pricing and Volumes Transacted

Ecosystem Marketplace (EM) data show that BC credits are sold at a significant premium over current carbon market rates.[10] Project developers tell EM that high credit prices are a reflection of high capital costs for BC project development. To date, BC remains something of a "boutique" category, attracting investors interested in carbon sequestration alongside other environmental and social benefits of BC habitat conservation and restoration.

Price and volume of BC credit transactions have also been quite volatile between 2020 and 2024 (Table 4).[11] Strikingly, volumes have dropped precipitously since 2020, while prices rose just as dramatically. For instance, prices for mangrove restoration credits rose from $10.50 in 2021 to $26.03 in 2023, with the peak price in 2022 set at $28.15 per carbon credit (see Table 5). During the same period, the volume of mangrove restoration volumes dropped more than 95%. Blue carbon project developers reporting to EM are listed in Appendix A.

Contrast these trends to the broader carbon market, where volume has also been fairly volatile, but average prices have risen from $2.56 in 2020 to $6.63 in 2023 (Table 6). Comparisons to all forestry and land use are in Table 7.

Table 5. Annual Volumes and Prices for Blue Carbon Transactions Reported to Ecosystem Marketplace, Recent Years for Which Data is Available

Year	Project type	Volume	Price
2021	Afforestation, Reforestation and Revegetation (ARR) and Wetland Restoration	3,322,365	$7.25
2022	Afforestation, Reforestation and Revegetation (ARR) and Wetland Restoration	3,099,285	$10.02
2021	Mangroves restoration / Conservation	337,982	$10.50
2022	Mangroves restoration / Conservation	291,285	$28.15
2023	Mangroves restoration / Conservation	10,970	$26.03

Table 6. Total Volume and Average Price for all Voluntary Carbon Market Transactions, 2020-2023

Year	Volume	Price
2020	208,184,951	$2.56
2021	516,447,992	$4.07
2022	253,804,388	$7.37
2023	111,267,275	$6.63

Table 7. Total Volume and Average Price for all Forestry and Land Use Carbon Credit Transactions, 2020-2023

Year	Volume	Price
2020	59,645,769	$5.46
2021	245,450,921	$5.87
2022	113,009,263	$10.14
2023	36,408,131	$9.91

10 Although, see Jones 2020, in which the low prices on the voluntary market are highlighted in comparison to the European emission trading price.

11 The volumes and prices reported for the whole VCM and for Forestry and Land Use differ slightly from what was published in the 2024 State of the Voluntary Carbon Market report.

EM does not collect data on how project developers set prices, so we can only speculate why prices have fluctuated so significantly in the past few years, and similarly why volumes for forestry credits and BC credits increased through 2022 and then dropped dramatically in 2023, falling below 2021 volumes. One theory is that the “low hanging fruit” in the form of mangrove projects with clear additionality were “picked” early on, and finding projects has become increasingly more difficult.

Public sentiment and policy shifts may account for some slowing down as well, including fears that carbon projects, especially BC projects, could result in neocolonial “ocean grabbing” and inequitable sharing of benefits (Valdez et al. 2024; Vierros 2017; Conservation International 2022). Growing, valid concerns about equity and justice in planning, designing, and executing projects has meant additional time and financial costs for project developers. Finally, it is likely that the COVID-19 pandemic affected the development of new projects, such that projects bearing credits in 2021 and subsequent years were planned well before the pandemic, and new projects were inhibited by pandemic restrictions on travel, meetings, negotiations, and building of the trust that BC projects require.

Outlook

Demand Potential for Blue Carbon

This section presents a preliminary assessment of anticipated sources of demand for BC, based on what is available from public information (websites) and published literature, as well as interviews with key investors. The report summarizes what is known about demand to date, as well as current buyer interest in various types of blue carbon projects such as restoration, conservation, compliance with protected area or SDG targets, and their regional preferences.

In recent years, there has been a sudden resurgence of interest in BC, both as a mitigation investment and as a vehicle by which to catalyze protection of habitats that deliver a wide range of additional services beyond carbon sequestration. Countries that have committed to protected area targets under the CBD and the SDGs are looking at the potential for BC projects to be the entry points to planning and implementing marine and coastal protected areas that include mangrove, seagrass, and interlinked habitats like coral reefs. In small-scale protected area projects, the promise of revenue streams generated from carbon credits can be an adequate incentive for delineating such protected areas.

For larger-scale transactions, offset trading between countries as prescribed in Article 6 of the Paris Agreement may well set the stage. Additionally, BC is increasingly seen as a vehicle to initiate co-management, especially in marginalized coastal communities. Incentive mechanisms to get community participation in protecting BC habitats is a key driver of sustainable community-based initiatives, and is one reason for the proliferation of small BC projects in developing countries.[12]

Key demand drivers for BC opportunities can be broadly grouped into two categories: 1) Private sector investor demand for BC for carbon sequestration, including impact investors looking for carbon opportunities alongside other environmental/social benefits, and corporates searching for carbon credits, specifically BC credits, to meet net-zero commitments and for corporate responsibility reasons; and 2) governments interested in BC for national accounting (including incorporation of BC in NDCs) and sustainably financing marine protected areas.

Private Sector Demand

In terms of private sector demand for voluntary offsetting, it is clear that BC demand has benefitted from overall voluntary carbon market growth driven by corporate net-zero pledges.

Trade and industry associations are also making bold commitments. ICAO, representing airlines, has a developed a compliance mechanism, CORSIA, to limit the growth of emissions from international air travel from a baseline year of 2019 (ICAO 2020). The shipping industries and port authorities of the world are investigating offsetting potential, alongside efficiency measures to reduce emissions.[13] Other sectors, such as the superyacht industry[14] and even sports leagues, are looking to offset carbon in ways that relate to the oceans they rely upon.

To meet voluntary carbon market demand, countries in Southeast Asia (particularly Indonesia), the Indian Ocean region, West Africa (especially Senegal), and Latin America (especially Mexico) appear to have the most promise in terms of presenting the enabling conditions necessary to support BC initiatives. Furthermore, these geographies have a wide spectrum of BC opportunities at different scales, and with different combinations of restoration versus conservation initiatives.

[12] Herr et al. 2017 describes community-based management as perhaps the most important pathway to BC.

[13] Port of Rotterdam, Netherlands provides a leading example.

[14] The superyacht sector is organized into an association called SYBAss, and the majority of companies have supported the sector's Water Revolution Foundation, which is providing guidance to companies on BC offsetting.

Private sector and civil society groups can catalyze this first broad demand driver by lining up impact investing. The Livelihood Funds' carbon fund is one leading example, with initiatives focused on community-based restoration or afforestation of mangroves, in projects with restoration areas averaging about 5,000 hectares. The Fund provides capital for social and environmental research needed to underpin design, feasibility studies, growing mangroves in nurseries, transplanting mangroves in suitable restoration environments, and conducting detailed monitoring to measure impact (not just carbon sequestration but also delivery of co-benefits). Livelihood Fund investments span 20 years, unlike the shorter 3-5 year timeframes of most marine conservation/restoration projects. In contrast, the investments of the Althelia's Sustainable Ocean Fund are focused on sustainable fisheries initiatives, with prospective projects to include BC components to provide revenue generation for marine protected areas (MPAs) that boost fisheries productivity.

Recent demand signals suggest a ramping up of BC investment. For example, Salesforce recently made a million-ton high quality blue carbon commitment as part of its nature positive strategy. The Symbiosis Coalition, which has brought together Google, Meta, Microsoft, and Salesforce to make major Advance Market Commitments for nature-based carbon removals (guaranteeing offtake of up to 20M tons), intends in its next Request for Proposals to focus on mangrove restoration (Christopherson and Hansen 2024). Newly-minted guidance on how to develop high-quality BC projects, such as the Mangrove Breakthrough Financial Roadmap: Unlocking investment at scale in critical coastal ecosystems (Systemiq 2023) and The Nature Conservancy's nature-based credit science decoder report on Blue Carbon (Simson and Smart 2024) build on the High Quality Blue Carbon Principles and Guidance launched by the World Economic Forum in 2022 (Conservation International et al. 2022). This guidance should accelerate the development of BC projects at scale, taking advantage of legislative enabling conditions, such as the EU Restoration Law of 2024, and the global commitments on restoration made under the Kunming-Montreal Global Biodiversity Framework (Convention on Biological Diversity 2022).

Public Sector Demand

The second demand driver is government to include BC accounting in climate policy frameworks. Some of this is driven by compliance carbon mechanisms, including Article 6 of the Paris Agreement. Additional interest in BC comes from needing to make good on global commitments, such as the Sustainable Development Goals (in particular, SDG 14 Life Below Water) as well as the Convention on Biological Diversity targets. Blue Carbon is now being considered one of a number of revenue-generating schemes for countries implementing protections through MPAs, for instance.

Environmental NGOs have been instrumental in supporting governments as they consider BC and develop policies to protect BC ecosystems. This includes IUCN, CI, and UNESCO's Intergovernmental Oceanographic Commission work together through the International Blue Carbon Initiative to catalyze BC policies in Costa Rica, Ecuador, Indonesia, and the Philippines. These NGOs also promote BC conservation best practices by providing pilot project financing and by partnering with local institutions to execute demonstration projects. Through the broad scientific network built by the International Blue Carbon Initiative, technical advice coming from academia and the scientific community is made accessible to local and national governments. Other NGOs work at the regional or national level. For instance, in the US, Restore America's Estuaries and Earth Corps work with the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service to promote BC policies at the national level, while research institutions like Nicholas Institute at Duke University and consulting firms, like Silvestrum Climate Associates, catalyze BC initiatives at the state level, providing technical advice to give shape to demand while identifying supply.

Emission reductions will depend on public demand for BC being met by full accounting of BC in NDCs and by policies that effectively protect and restore BC ecosystems, while private sector offsetting provides needed revenues to support this transition. Therefore, to most effectively capitalize on BC's potential, support should be given to governments on identifying BC, incorporating BC in accounting systems, and—most importantly—on implementing cost-effective best practices to conserve and enhance BC ecosystems. Care should be taken, however, not to impede or constrain private sector investing that achieves effective (if smaller-scale) results, often despite changes in political administrations and corresponding shifts in priorities and policies.

Trends and Scale in Blue Carbon Supply

A glimpse into the nature and scope of early BC projects is provided in Appendix B, which summarizes responses to a Blue Natural Capital Financing Facility (BNCFF) call in 2020. Other institutions have issued similar calls in the intervening years, including Ocean Risk and Resilience Action Alliance (ORRAA), The Global Fund for Coral Reefs, and Blue Action Fund.

Factors Limiting the Scale and Scope of Blue Carbon Supply

Conservation, management, and restoration of coastal and marine ecosystems is costly and complex. Even more so than terrestrial ecosystem management, marine and coastal management requires dealing with multiple cumulative impacts, numerous overlapping and sometimes unclear jurisdictions, and a wide variety of stakeholders with different vested interests.

As a result, creating and implementing BC initiatives in these ecosystems requires high upfront capital costs to properly assess carbon sequestration rates, understanding of drivers impacting ecosystem services delivery, capacity to perform due diligence to detail property and use rights, and working with authorities to put into place community-based management and monitoring. Supply is further constrained by a paucity of available verifiers for BC methodologies.

Nonetheless, measures are being taken to improve the supply of BC projects in the pipeline available to investors, as outlined by the BC Working Group and reinforced by interviews with investors, project developers, BC practitioners, and policy specialists. Paramount among these is providing access to financing to support BC feasibility studies and accounting, project design, and support for the coastal and marine management activities, including monitoring, surveillance, enforcement, stakeholder engagement, public awareness, *inter alia*. For restoration projects that require significant capital, additional financing streams may be needed.

Blue Carbon Finance

This section of the report briefly summarizes the BC financing arena, and the tools available to project developers, communities, and governments to identify sustainable financing for creating marketable BC projects that can restore and sustain BC ecosystems.

There is a typology of tools available to project developers, communities, and governments to identify and craft sustainable financing for marketable BC projects. Some of these tools are information tools (see Box 2) that create the necessary information base for implementing a project, program, or policy, and for verifying that interventions taken are resulting in carbon sequestration and other ecosystem services. The following discussion differentiates between general marine conservation/restoration finance, which can create the necessary enabling conditions for BC, and carbon finance for developing BC credits.

Marine Conservation and Restoration Finance

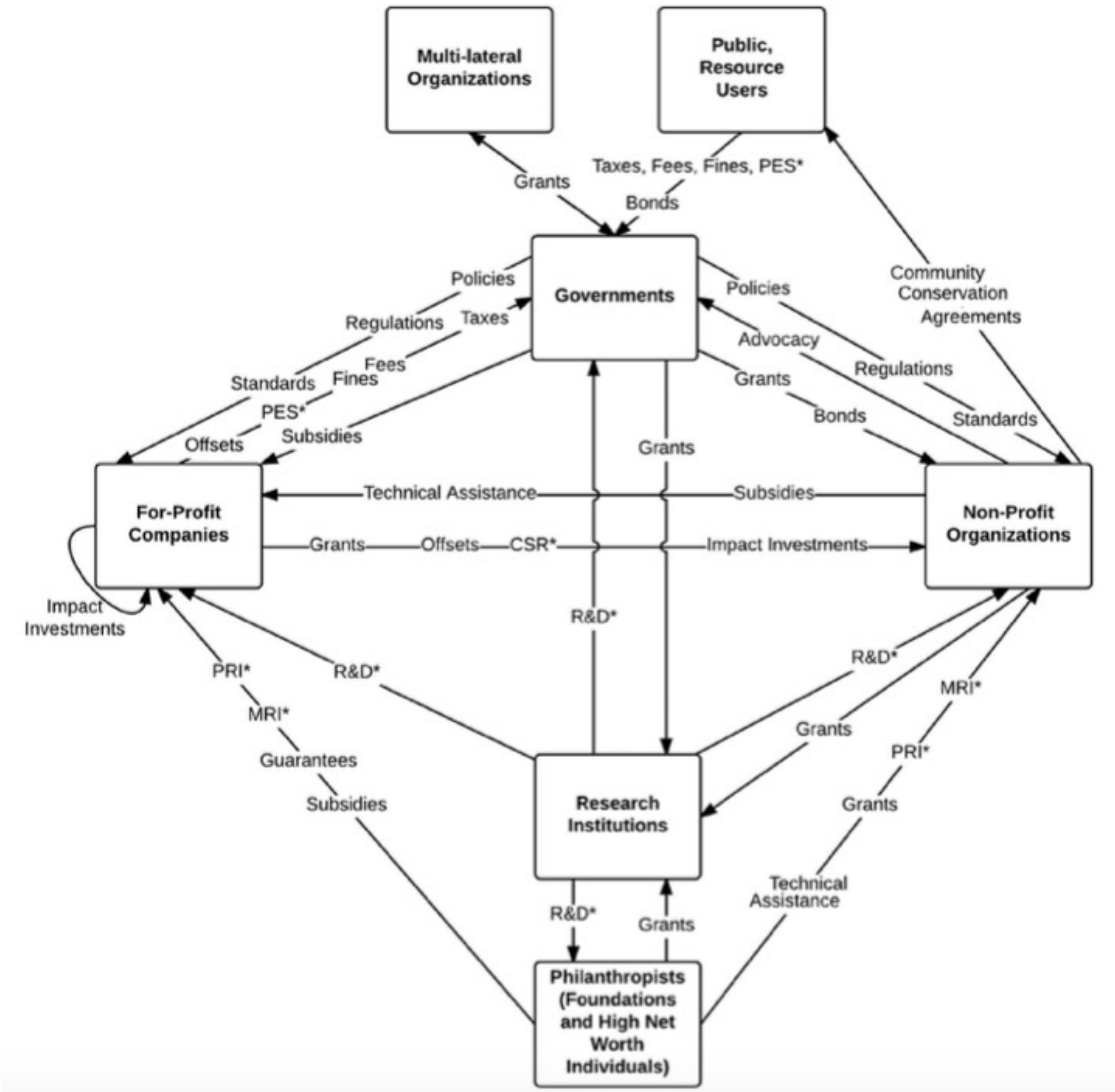
The marine conservation finance picture is not simple: revenue streams and technical support for marine conservation can come from many different sources. In what has now become a classic, Barry Spergel and Melissa Moye in *Financing Marine Conservation: A Menu of Options* reviewed broad categories of tools available, including government revenue allocations, grants and donations, tourism revenues, real estate and development rights, fishing industry revenues, energy and mining revenues, and for-profit investments linked to marine conservation (Spergel and Moye 2004). Over a decade later, Melissa Bos and colleagues reviewed marine conservation finance, and stressed the collaborative nature of conservation finance—a feature that is not deliberate so much as by default (Figure 8; Bos et al. 2015)). A few years later, Melissa Walsh took a deeper dive on marine conservation finance, outlining new areas for revenue generation with a focus on the private sector (Walsh 2017). Coupled with grey literature on marine conservation financing that is widely disseminated by NGOs, it would now appear that sufficient BC financing models exist, and that guidance for using those tools is also not in short supply.

One such tool to catalyze marine conservation/restoration finance is Payments for Marine Ecosystem Services (PMES) that are focused on BC and BC ecosystems. PMES are not well-established, despite their enormous potential for generating badly needed funds for conservation, and their ability to strengthen co-management arrangements. A notable exception is the Socio-Manglar program in Ecuador, a system that allows for payments to be made to coastal (and generally impoverished) communities in coastal Ecuador in exchange for interventions that improve the delivery of ecosystem services coming from mangroves, including carbon sequestration. With support from the World Bank, Costa Rica examined the feasibility of PMES in fisheries that focused on ecosystem protections, including BC ecosystems (Agardy 2020). In June of 2024, Costa Rica announced a national program for PMES, with a strong focus on BC habitats.

Other new models are emerging. One particularly exciting new development is the issuing of "blue bonds" to support marine conservation and restoration. Several years ago, the government of Seychelles made a splash by issuing a blue bond for marine planning and investment based on debt swaps. At the subnational level, California's proposed climate resilience bond has accommodations for NBS in coastal wetlands, potentially providing finance to create the enabling conditions for BC project development (Bianco et al. 2020).

While the deeper the stacking of carbon sequestration with other measurable (and valued) ecosystem services would open up a larger portfolio of financing tools, many in emerging environmental markets, such as biodiversity and voluntary carbon, are concerned about being able to maintain rigorous safeguards for integrity with stacking. In the case

Figure 8. The Collaborative Nature of Marine Conservation Finance



Source: Reproduced from Bos et al. 2015.

of PES, theoretically a single BC habitat could act as a revenue generator arising from BC and at the same time attract buyers of other ecosystem services (Forest Trends 2010). Similarly, the broader the bundling of carbon sequestration across a landscape with other ES, the larger the potential pool of finance (e.g., Verra 2020). But this is contingent on governance and guardrails set up in other ES markets, and whether stacking or bundling are permitted.

BC clearly needs private sector buyers, and needs to look to the lessons learned from initiatives like the Livelihoods Funds and Althelia. These initiatives not only provide pre-financing and long-term investments, but capacity building (in the case of Livelihoods Funds, the investment occurs over a 20-year time horizon, instead of the two to three years typical for most projects). Althelia has its Accelerator, for instance, which finances and supports capacity building in carbon offset projects.

It is important to distinguish in a discussion of marine finance between *conservation* and *restoration*. Marine restoration financing utilizes the same set of tools as marine conservation, but generally speaking, the needs for finance are greater for restoration than for conservation. (This explains why restoration projects tend on average to be smaller than conservation projects, such as those focused on creating and maintaining MPAs). Reported costs of marine restoration projects typically range from $80,000 to $1.6 million per annum (2010 rates), but the actual figures may be significantly higher (Bayraktarov et al. 2015). Among BC habitats, mangrove is generally the cheapest to restore and therefore mangrove restoration projects tend to be larger than seagrass or saltmarsh restoration projects (Bayraktarov et al. 2015). Interestingly, in reviewing 235 marine coastal restoration initiatives, Bayraktarov and co-authors found no economies of scale in their 2020 study:

> *There was no evidence for economies of scale in studies reporting on total restoration costs. This suggests that restoration techniques are not yet sufficiently robust such that larger investments lower cost per unit effort. Finding ways to build economies of scale will thus catalyze the transition to larger restoration projects.*

Finance is needed not only to launch BC conservation and restoration initiatives, but to monitor their success. However, the outcomes of restoration, and conservation, can only be ascertained with long term monitoring (Hein et al. 2017). Unfortunately, most BC projects have a shorter lifespan, and monitoring typically lasts five years at most.

Carbon Market Finance

Carbon finance has been criticized when projects get hijacked by profiteers and "carbon cowboys," whose sole interest is the profitability of carbon credits. One can imagine a worst-case scenario where carbon finance could drive "plantation blue carbon" in which mangroves are grown to sequester carbon but provide few other ecosystem services, and at the same time facilitate land-grabbing in areas where communities are politically marginalized.

However, carbon finance that is carefully planned and executed with social, environmental, and economic sustainability in mind can lead to broad positive outcomes. According to the Livelihoods Funds website, the companies that have invested in Livelihoods Funds are committed to reducing emissions by transforming their production models and offsetting what they cannot reduce through projects that benefit poor coastal communities.

To some extent, the viability of carbon finance projects is dependent on carbon price.[15] Ecosystem Marketplace data show a price range in the 2020-2023 period between $5.70 and $13/ton. The weighted average price was $5.75/ton; prices are generally higher for low-volume mangrove projects than for higher volume projects. As reported by the World Bank, early BC finance projects attempted to internalize the social benefits of carbon by recognizing values in a higher price per carbon credit ($12-20/ton) (Crooks et al. 2020). However, carbon at such premium prices may not be marketable at larger scales.

Walsh et al. (2017) propose some general rules for designing projects and programs to capitalize on carbon finance, including: 1) Use the mitigation hierarchy; 2) Check "offsetability"; 3) Deliver net benefits; 4) Allow third-party implementation; 5) Require direct and specific action; 6) Use strategic sites; 7) Adhere to a temporal strategy; 8) Stipulate financial liability; and 9) Practice monitoring and adaptation (Walsh 2017).

[15] Note the sample of available price data for BC is quite small. Only a handful of respondents in this year's Ecosystem Marketplace carbon markets survey (out of a total of more than 150 respondents) indicated that they were invested in BC (and all of these were mangrove projects) and provided price data.

The World Bank has gone even further in articulating what criteria must be met for results-based carbon finance. In a 2017 report on Results-based Carbon Finance, the World Bank argues that results-based carbon finance can facilitate carbon pricing and market building, support host country policy processes to achieve their NDCs, and leverage private sector activity and financing. Results-based finance can thus play a critical role in mobilizing the resources and supporting the policies and actions needed to achieve the objectives of the Paris Agreement.

Finance could be optimized by a BC-tailored facility. Existing facilities set up by the World Bank and other multilaterals provide essential support to countries striving to reduce emissions and meet climate goals. However, they may be insufficient for BC potential to be fully met. Examples of existing facilities include the World Bank's FCPF which guides implementation of emissions reduction activities under REDD+, including piloting the purchase of REDD+ credits and incentivizing the development and implementation of sustainable land-use activities. The World Bank's *Transformative Carbon Asset Facility (TCAF)* works with national policy makers to help shape environmental, energy, and climate change policy to reach meaningful scale and create a lasting, transformative social impact. And its Carbon Initiative for Development has a portfolio of programs that supporting similar emissions reduction projects, with a Standardized Crediting Framework—a new approach to crediting emission reductions in the post-Kyoto era. The Unit also includes climate change and environment programs administered through the World Bank with the Green Climate Fund and the Pilot Program for Climate Resilience.[16]

Another climate facility is the *NDC Support Facility (NDC-SF)*, a multi-donor trust fund created to facilitate the implementation of the NDCs pledged by countries under the Paris Agreement. Its activities are implemented in close coordination with and in support of the country engagement process of the NDC Partnership, a global coalition of developed and developing countries and international institutions, including the World Bank, working together to mobilize financial and technical support to achieve countries' climate goals and enhance sustainable development. Managed by the World Bank, the NDC-SF channels funds to Bank Group teams that are working to implement the climate change targets set out in the NDCs of client countries. It seeks to support rapid, material action on implementation at the country level, including on NDC-related policy, strategy and legislation, budgeting and investment, as well as monitoring and evaluation frameworks. NDC-SF grants contribute to a host of activities such as analytics and knowledge sharing, capacity building, and improving cross-sectoral coordination among government stakeholders, donors, and private sector entities. The NDC-SF works with all regions within the World Bank, and with other trust funds at the World Bank Group, and with the IFC to maximize financial leverage for in-country climate action.[17]

Can a REDD+ Framework Bring Blue Carbon to Scale?

Discussions on how to bring carbon credits to scale, and to bring BC fully into climate change mitigation and adaptation, have turned into a debate about the value of small-scale demonstration projects that collectively contribute to significant mitigation versus national or subnational jurisdictional approaches. This debate has been ongoing in forest carbon circles, and we might anticipate that similar arguments will be made in the BC front. That said, there is a convergence of opinion in forest carbon that measurement and accounting needs to be done at the jurisdictional or national scale, but investment can be effectively done at smaller scales, and the same may be true for BC.

In some respects, previous experience with carbon offsets in forests and assessments of REDD+ and its jurisdictional approaches to emissions reductions facilitate bringing BC to scale. Specifically, incorporation of BC into the

16 Read more at World Bank Group's Climate Finance and Initiatives webpage: https://www.worldbank.org/en/topic/climatechange/brief/world-bank-carbon-funds-facilities.

17 Read more at: https://www.worldbank.org/en/programs/ndc-support-facility.

REDD+ agenda, driven by interest in unlocking the potential of marine and coastal ecosystems as nature-based solutions, will be made easier by considering lessons learned from the REDD+ experiences on land (e.g., Sunderlin et al. 2014). Verra has guidance on jurisdictional nested REDD+, which it claims has been helpful for trade association industry-wide offsetting (e.g., CORSIA's) in line with the Paris Agreement (Verra 2022).

In a paper published by the World Resources Institute, Frances Seymour explores four key strengths of a jurisdictional approach: 1) Governments have authority to control land-use change at landscape scales; 2) Access to international carbon markets for jurisdictional-scale emission reductions is an essential source of incentives for change; 3) Incentives for jurisdictional performance can better protect the social and environmental integrity of emissions reduction credits; and 4) Official climate negotiations and public and private supply chain initiatives are converging on the jurisdictional scale. Detailed thoughts for bringing carbon crediting to scale using jurisdictional approaches that still ensure private sector project-level investment, as presented by Seymour 2020, are presented in Box 3.

Lessons learned from forests indicate that a jurisdictional approach requires careful consideration of conditionality in performance-based crediting and attention to the following principles:

1. Direct linkage of tenure reform with targeted environmental outcomes.
2. Enforcement of existing rights of exclusion for local stakeholders, including clarification of carbon tenure rights, and enabling REDD+ collaboration between proponent organizations and government institutions in resolving tenure issues.
3. Tapping into robust funding streams that are complemented by national policies and actions such as decoupling agricultural growth from agricultural area expansion, developing sustainable agricultural supply chains that correspond to REDD+ goals, reducing demand for unsustainable uses, and improving land-use decision-making through attention to governance, notably corruption and cronyism.
4. Enforcing laws against illegal and illicit activities (CIFOR 2018).

Box 3. Recommendations for Jurisdictional Approaches to Carbon Crediting (Seymour 2020)

Project-scale activities — be they small community forest enterprises or larger forest and peatland restoration efforts — will require a part of the estimated $100 billion additional annual investment needed for nature-based solutions to transition towards a more sustainable food and land-use economy by 2030. Ideally, private investments in such activities would be made profitable through domestic policy reforms such as ending illegal logging and repurposing agricultural subsidies toward climate-friendly land use incentivized in part by the prospect of jurisdictional-scale REDD+ payments. But to the extent that the business models for such investments depend on the sale of carbon credits, in the future those revenues will have to be mediated through jurisdictional-scale crediting based on equitable benefit-sharing arrangements. Otherwise, we run the risk of double-counting emission reductions.

While it would be difficult for governments to restrict legal voluntary transactions between willing buyers and sellers, governments can and should restrict crediting in compliance regimes to transactions more likely to serve the public interest. Crediting at the level of individual projects unnecessarily risks diverting new sources of private sector finance away from the demand signal needed to incentivize jurisdictional performance. In the absence of compliance markets, recognizing corporate claims to offsetting their fossil fuel emissions with the voluntary purchase of project-level credits, for example in meeting “net-zero” targets, would have the same effect.

Each of these principles could apply equally well to BC carbon crediting from BC ecosystems, including by considering agricultural practices and how they impact coastal ecosystems, incorporating aquacultural practices, and considering the many unsustainable, illegal, and unregulated uses of coastal and marine BC ecosystems. REDD+ provides the framework for doing this, and a multilateral BC Facility could provide the capital and technical assistance to fully incorporate BC into NDCs, REDD+ crediting (Kizzier 2019), and cooperative approaches to carbon mitigation in shared ocean basins.

Despite the importance of national jurisdictional approaches, subnational initiatives may be more feasible, certainly are more flexible, and may offer even more options for blended finance. California's climate resilience bond, first proposed in 2020, for instance, recognizes climate risks to the state, as well as insufficient responses to climate change on the national level, and presents a results-based framework that offers considerable flexibility around how targets are achieved.[18] The bond allocates $320 million to coastal wetlands restoration and another $130 million to NBS to build resilience. California considers climate policies as not only environmental policies, but also economic and workforce policies, leading to greater sustainability and equity for all Californians. As an example of subnational jurisdictional approaches to emissions reductions, it presents perhaps surprisingly relevant lessons for lower income countries.

The potential success of subnational jurisdictional approaches, however, is highly dependent on a functional relationship between national and state agencies, as per what is called the "new climate federalism" in the US (World Resources Institute 2024).

All in all, a mix of project-based and jurisdictional approaches is needed across multiple scales. Projects can innovate and are more responsive to the needs of communities, especially in places where there is a long history of mistrust or worse between communities and governments.

For BC, a nested strategy that allows for large-scale conservation and restoration of BC ecosystems through jurisdictional approaches, while creating openings for high-impact private sector investments that catalyze community-based conservation and restoration at smaller scales, would create order and efficiencies, allowing alignment between projects and national REDD+ reference levels and programs.[19]

[18] According to the Governor's Statement http://www.ebudget.ca.gov/2020-21/pdf/BudgetSummary/ClimateResilience.pdf, a $4.75 billion climate resilience bond was on the Nov 2020 ballot to support investments over the next five years to reduce specific climate risks across California through long-term investment in natural and built infrastructure, especially in the state's most climate-vulnerable communities. The bond was structured based on climate risks, with 80% allocated to address immediate, near-term risks (floods, drought, and wildfires), while the remaining funds for addressing long-term climate risk (sea level rise and extreme heat). A new $10 billion climate resilience bond was passed by the state on July 3 2024, and will be on the ballot on November 5 2024 as Proposition 4.

[19] A handful of countries actually use the term "blue carbon": Bahrain, Philippines, Saudi Arabia, Seychelles, and the United Arab Emirates, and some of these – as well as others – recognize the dual role of coastal wetlands for mitigation and adaptation purposes. Seagrass beds are referenced by the Bahamas, Bahrain, Belize, Kiribati, Honduras, Madagascar, Mauritius, Mexico, Saint Kitts and Nevis, Sri Lanka, Sudan (which seeks to "accommodate salt marsh, mangrove and seagrass"), and the United Arab Emirates (Herr and Landis 2016). If countries that make specific reference to "soil carbon" – Malawi, Mongolia, Namibia, Pakistan, and Zambia – and the countries that reference mitigation actions focusing peat or wetlands in general are added, the list of parties targeting the conservation and/or sequestration capacity of wet (organic) soils is truly extensive and globally distributed.

Recommendations

Several options exist for expanding emissions reduction through BC strategies, delivering carbon credits with co-benefits, and promoting private sector investment in BC protection and restoration. Although demand for BC is growing, the marketable supply of projects is not keeping pace, and this report identifies —in a preliminary manner —how that dynamic might be effectively changed. The report suggests steps be taken to elevate the importance of BC in the carbon portfolio and take advantage of BC's enormous potential to mitigate and allow adaptation to climate change.

To do this effectively, three main areas of focus all need to be addressed:

1. Improving data and analytics, including verification of carbon sequestration in soils and sediments over the long term and as sea level rises, oceans acidify, and cumulative pressures increase.
2. Using state-of-the-art science combined with user and/or traditional knowledge to restore BC ecosystems effectively, increasing their resilience and their potential to mitigate climate change across the long term.
3. Securing financing streams to do what it takes to restore degraded BC ecosystems and safeguard those currently in good condition.

In addition to considering the merits of a jurisdictional approach versus project-based approach, and envisioning how a nested approach might bring BC to scale, there are specific interventions needed to address the drivers of degradation in BC areas.

First, best practices must consider additionality, particularly in mangrove or other protected wetland ecosystems, going beyond RAMSAR protections and forest laws that already protect these habitats, at least in theory.

Best practices will need to be ecosystem-based. For mangrove ecosystems, this means considering the need to restore hydrology and the "mud engine," and for seagrasses, enhancing water quality in nearshore habitats. Further articulating best practice principles, such as those outlined in the "High Quality Blue Carbon Principles and Guidance" will be critical (Conservation International 2022), but perhaps even more critical will be evaluating the success of BC projects at scale and over the long term, and teasing from that the elements that make for increased resilience of BC ecosystems and durable climate change mitigation.

Marine Spatial Planning will prove to be key, particularly integrated coastal/marine planning that includes restoration (some 80 countries are developing national or subnational marine plans). Broad-scale, comprehensive MSP and ocean zoning may be needed, both to avoid leakage,[20] and to ensure that protection and restoration measures mandated by government policies are undertaken at the site level by government, NGOs, and communities working in concert. Such MSP should be multisectoral and integrative, ecosystem-based, and climate smart (Frazao-Santos et al. 2020; Gregg 2017). According to a global survey designed by Catarina Frazao-Santos and Tundi Agardy aiming to understand the role of MSP in mitigating climate change and laying the foundation for adaptation, 67 percent of respondents (out of over 200) indicated that the MSP initiative that they were working on identified areas for BC capture and storage.[21] This suggests that MSP is not only a powerful planning approach for ecosystem-based management that can lead to sustainability, but that MSP can and does specifically catalyze BC initiatives.

MSP and subnational coastal and marine policies should therefore be centered on NBS to the maximum extent possible, to ensure long-term sustainability. New tools are available to achieve

20 Leakage would be minimized since MSP can and should consider displacement and its effects across a wide land-scape/ seascape.

21 Paper in press, figures published in Carr 2022.

this, including the newly developed Coastal Resilience Tool put forward by The Nature Conservancy. Seddon and colleagues suggest that a third of climate emissions reductions could come from NBS, especially mangrove and peatlands (Seddon 2019). Furthermore, MSP must be climate-smart (Frazao-Santos et al. 2024; Frazao-Santos et al. 2022), adapting to changing conditions to deliver improved ocean health and continued delivery of benefits from BC and other marine systems.

Much specific guidance also is available on how to design optimal MPAs and MPA networks, including MPAs targeting BC habitats, as well as MPAs that ensure that overall ocean productivity and health is maintained. It will be crucial to link MPA planning, MSP, NBS, and climate policies together in a coherent grand strategy, within the context of NDCs.[22]

Finally, the World Bank and other development banks and multilateral agencies should catalyze public and private investments to maximize climate finance driving BC ecosystem conservation, through policies supporting not only MSP, but also coastal zone management, fisheries, sustainable tourism development, and trade. Regarding the latter, much effort has been spearheaded by UNCTAD in providing guidance on expanding Blue Biotrade that is environmentally, socially, and economically sustainable (Agardy et al. 2018).

In efforts to mainstream biodiversity and to support attainment of SDGs, as well as GBF targets, blue carbon projects could be used to deliver lasting revenue streams for conservation and restoration. As an incentive for reducing pressures on ecosystems, and a means for putting more power in the hands of local communities to steward and respect nature, projects generating BC credits constitute a powerful force for nature-positive change (Carr 2022).

[22] This is especially true in the context of SDG and CBD commitments that could drive some MPA agendas in a direction away from climate mitigation or sustainable use.

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Appendix A

BC Credit Suppliers reporting to EM (note BC reporting in any category that has fewer than 3 projects is not counted by EM, so as to keep data anonymized).

Name	First year reporting	Latest year reporting
ALLCOT	2022	2022
Anew Climate	2021	2021
BeZero	2021	2021
ClimateSeed	2021	2021
Compensate	2021	2021
Conservation International	2021	2023
Cool Effect	2020	2023
Ecosphere+	2020	2022
Forest Carbon (Indonesia)	2020	2022
FORLIANCE-CO2OL	2021	2023
Livelihoods Venture	2020	2023
Louis Dreyfus Company	2022	2023
Nordic Offset	2023	2023
Respira International	2022	2022
South Pole	2022	2022
Worldview International Foundation	2020	2022
ZeroMission	2021	2023

Appendix B

A Snapshot of an Emerging Blue Carbon Projects Pipeline

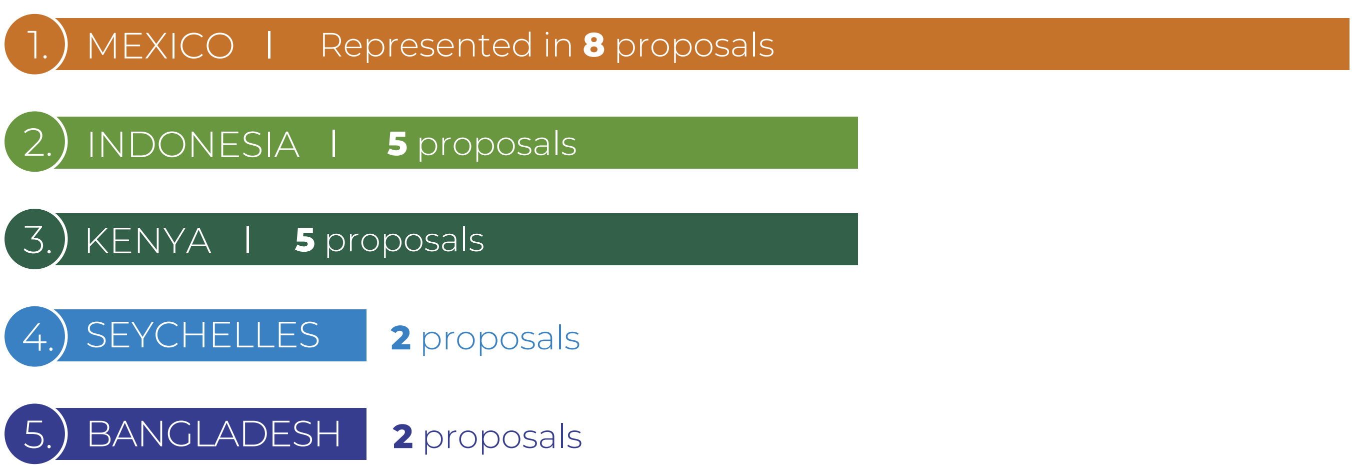
The Blue Natural Capital Financing Facility (BNCFF) ran a BC project call in 2020 and received a total of 37 proposals from numerous lower income countries.[23] By far the best represented region among the applications was sub-Saharan Africa, accounting for roughly 40 percent of all submissions. Two of those were eventually among the grant winners. Latin America (dominated by Mexico) comprised around a quarter of submissions, while Asia was responsible for roughly one in five applications (Figure 9). On a country level, most submissions were received from Mexico with eight, followed by Indonesia and Kenya with five each.

The main aim of the BNCFF call was to identify projects with a promising trajectory towards successful carbon asset generation. The call did not prioritize any particular coastal habitat type. However, from the set of applications received, none focused on salt marshes— a rare habitat type in the regions represented —while 20 percent addressed seagrass conservation or restoration (fairly evenly split between those with a mangrove component and those without). The vast majority (some 86 percent of projects) targeted mangroves (Figure 10), and a few projects targeted both mangroves and seagrass beds.

The majority of projects (nearly two-thirds) combined conservation with restoration activities. By contrast, 15 percent of project proposals were directed exclusively at restoration (Figure 11). The state of degradation across the portfolio shows stark differences, with approximately 25 percent of projects being undertaken in largely intact ecosystems, while some are in highly degraded ecosystems.

A large proportion of the projects (46 percent) fell in an area range between five hectares (ha) and 5,000 ha, while about 14 percent of projects had a prospective size of between 5,000 ha and 10,000 ha. Three projects are proposing BC implementation on larger tracts of between 10,000 ha and 15,000 ha. These three groups account for around 90 percent of all project submissions (seven projects did not stipulate the size of the area).

Figure 9. Top Five Countries Represented in Blue Carbon Proposals Submitted to the Blue Natural Capital Financing Facility



[23] The BNCFF analysis was kindly shared by IUCN and put together by Jürgen Zeitlberger, Nathalie Roth, and Moritz von Unger.

The BNCFF also asked its applicants to specifically share their thoughts on how to monetize the credits and asked which standard would be used. More than half considered using Verra's Verified Carbon Standard (VCS), among others, and approximately a quarter stated it was the only standard considered. Some 13 percent intend on pursuing the Plan Vivo standard. A large number (24 percent) did not provide any specific information (see Figure 12).

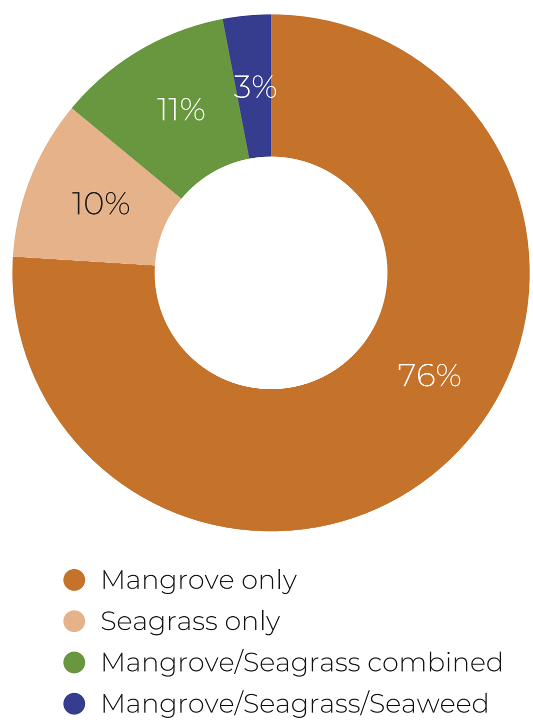
Regarding anticipated emissions reductions, among the 17 projects that have a project area of 5,000 ha or less, only nine reported preliminary emissions reductions estimates, with a combined cumulative volume of close to 10 million tCO_2e (over project duration). Of the five projects having an area between 5,000 and 10,000 ha, four reported preliminary emissions reductions estimates of a combined 18 million tCO_2e (over their total project duration). Approximately another 12.5 million tCO_2e of emissions reductions estimates are indicated by three projects that are active in conservation, restoration, and afforestation in projects with large areas between 10,000 and 20,000 ha, with generation periods of 25-30 years. Altogether, 16 projects out of the 37 submitted projects that have indicated an emissions reductions potential indicated a combined minimum volume of about 40.5 $MtCO_2e$ of cumulative emissions reductions over full project duration.[24]

As many more BC projects enter the pipeline, answers to the crucial question, "At which scale can BC initiatives be viable and cost-effective over the long term?" will be within reach.

It was impossible during evaluation of the project proposals to verify the expected carbon proceeds given the lack of data and methodological guidance. Instead, BNCFF reviewers checked the calculations against broad plausibility assumptions (mainly based on carbon stock and carbon stock change data published for mangroves and conservation/restoration activities across regions). They also considered project-specific management and context questions, including the experience of the developer; the general suitability of the proposed activities to curb the pressures of degradation; legal and regulatory issues (land tenure, structuring, licensing requirements); control and enforcement of (protected) areas; as well as governance, ESG aspects, and the prospect of alternative income streams to fund the measure in question.

While project size was not a selection criteria and small-scale projects were a priori deemed just as suitable as large-scale projects, the project proposals were ranked according to the viability and credibility of carbon asset generation. This resulted in a shortlist of ten projects with a combined potential of 26 $MtCO_2e$.

Figure 10. Ecosystems Represented in Blue Carbon Proposals Submitted to the Blue Natural Capital Financing Facility



[24] These emissions reductions estimates are given as very rough indications and are to be used with extreme caution, as the project periods over which they are calculated vary from between 5 to 30 years, with most of them being reported over a duration of between 15 and 25 years.

Figure 11. Interventions to be Utilized in Blue Carbon Proposals Submitted to the Blue Natural Capital Financing Facility

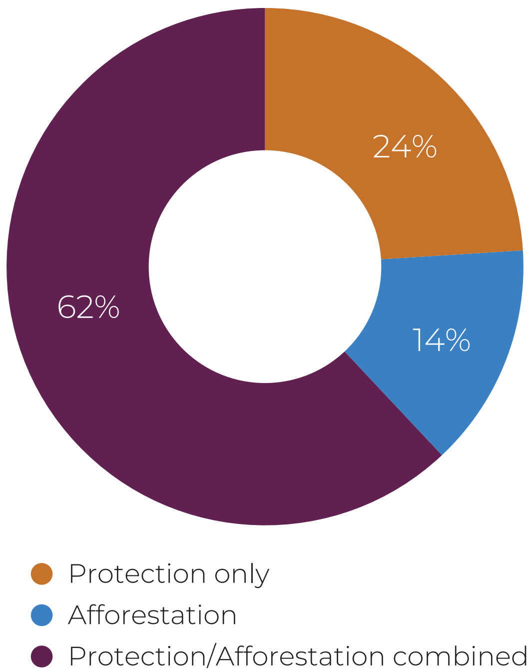
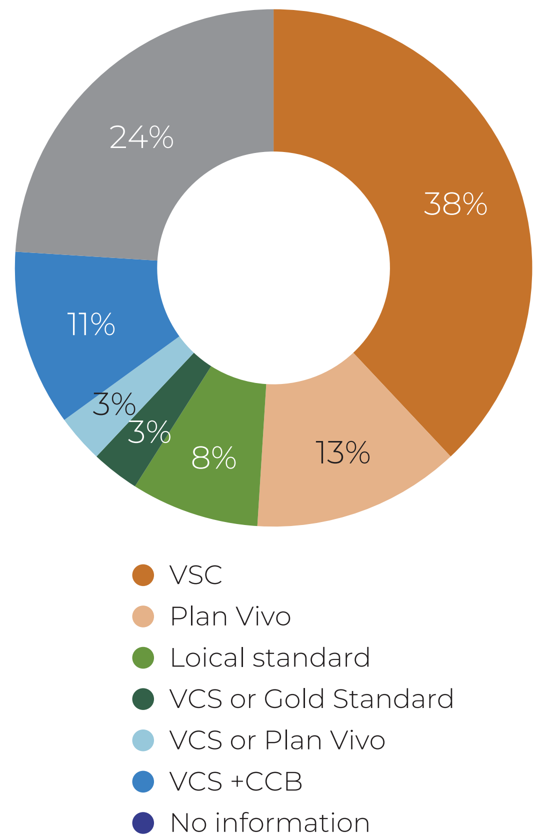


Figure 12. Choice of Carbon Standard Among Blue Carbon Proposals Submitted to the Blue Natural Capital Financing Facility



FOREST TRENDS

Pioneering Finance for Conservation

Biodiversity Initiative

Promoting development of sound, science-based, and economically sustainable mitigation and no net loss of biodiversity impacts

Coastal and Marine Initiative

Demonstrating the value of coastal and marine ecosystem services

Communities Initiative

Strengthening local communities' capacity to secure their rights, manage and conserve their forests, and improve their livelihoods

Ecosystem Marketplace

A global platform for transparent information on environmental finance and markets, and payments for ecosystem services

Forest Policy, Trade, and Finance Initiative

Supporting the transformation toward legal and sustainable markets for timber and agricultural commodities

Public-Private Finance Initiative

Creating mechanisms that increase the amount of public and private capital for practices that reduce emissions from forests, agriculture, and other land uses

Supply Change

Tracking corporate commitments, implementation policies, and progress on reducing deforestation in commodity supply chains

Water Initiative

Promoting the use of incentives and market-based instruments to protect and sustainably manage watershed services

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