Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

Integrating Blue Carbon Ecosystems into MPA management

Photo: NOAA

National Marine Protected Areas Center

Blue Carbon Ecosystems

Coastal blue carbon ecosystems -- including mangroves, tidal wetlands, and seagrasses -- absorb atmospheric carbon dioxide and store it in soils and plant tissues. These natural carbon sinks can sequester up to ten times as much carbon per area as tropical forests despite covering a relatively small area globally.

Despite their value, these ecosystems are being lost at an alarming rate due to human activities. When destroyed or degraded, the carbon stored in these ecosystems is released, contributing to climate change rather than mitigating it. The loss of these ecosystems is an major concern because of their critical role in climate mitigation, food security, health, and community well-being. Given this risk, effective management tools for these ecosystems, including marine protected areas (MPAs) are essential.

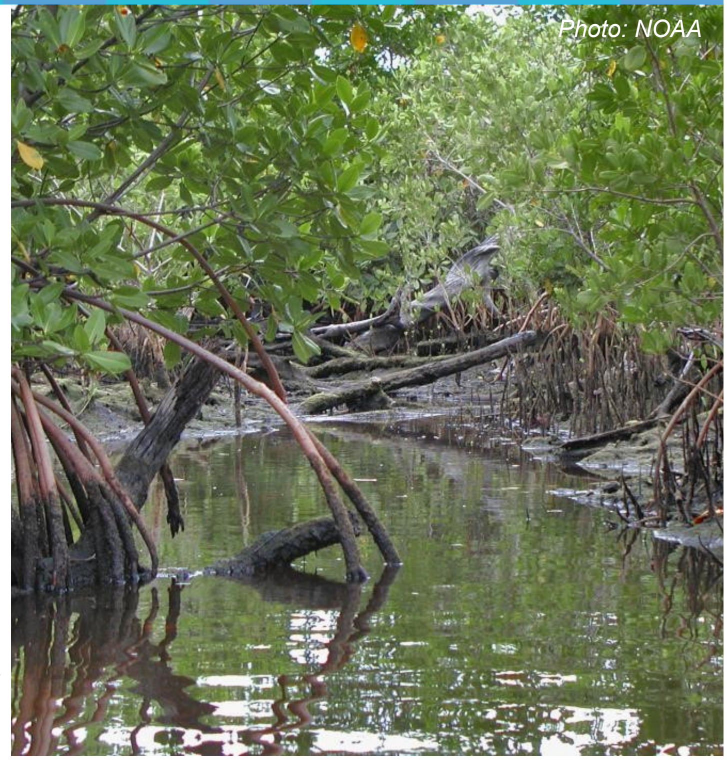

Photo: NOAA

Incorporating blue carbon ecosystems into MPA management

MPAs are effective tools to protect and restore ocean biodiversity and other ecosystem services. Coastal blue carbon ecosystems provide an abundance of ecosystem services, including protection from storms and erosion, biodiversity conservation, fisheries habitat, and climate mitigation through carbon sequestration and storage. The ecosystem services provided by all coastal ecosystems are estimated to be worth over $25 trillion annually, ranking as one of the most economically valuable ecosystem types in the world. These ecosystems have also gained recognition in recent years for their ability to act as natural carbon sinks. However, the efficacy of blue carbon for climate mitigation technique depends on management decisions and societal actions.

Financial incentives and funding for blue carbon conservation can be generated through MPAs when restoration activities are included in market-based mechanisms tied to carbon offset frameworks. The inclusion of blue carbon in Nationally Determined Contributions (NDCs) (national climate plans, including specific measures governments will implement to reduce greenhouse gas emissions) can also create a path for climate finance at national and international scales. For example, countries can establish policies that create incentives to protect and restore blue carbon ecosystems, allowing for the creation of new funding mechanisms tied to NDC targets.

While there are many advantages to considering the climate mitigation benefits of these ecosystems in MPA management, many MPAs are just beginning to initiate blue carbon-focused projects and struggle to integrate blue carbon into management as a result of capacity and data constraints.



MPAs have long protected and managed coastal wetlands for the wealth of ecosystem services they provide. MPAs that contain blue carbon ecosystems are generally designed and managed to protect and enhance biodiversity conservation, and often provide fisheries, tourism, and cultural benefits, among others. As a result, carbon sequestration and storage is often overlooked in MPA design and management, in part due to the inability to easily quantify the value of carbon stocks. Many MPAs are now beginning to consider the blue carbon services provided by these ecosystems and the role they can play in management objectives. However, there remains an overall lack of understanding of how to manage these places for enhanced carbon sequestration and storage.

A common first step is the completion of an inventory and assessment of the coastal blue carbon within an MPA. Such an assessment allows managers to determine existing carbon stocks and identify areas with the potential to sequester additional carbon. Blue carbon inventories generally require five pieces of information:

1. Carbon sequestration rates of the blue carbon habitats of concern
2. Current carbon stocks and the stability and permanence of these stocks
3. Geographic area covered by the blue carbon habitats
4. Anthropogenic drivers of habitat loss leading to the release of carbon
5. Greenhouse gas emission rates from both degraded and intact areas

Carbon sequestration rates of blue carbon habitats of concern

Understanding carbon sequestration rates can be an important factor in allocating protection to certain areas. Analyzing the sequestration potential of particular areas can be accomplished through the use of tools such as the Coastal Blue Carbon Model from the Integrated Valuation of Ecosystem Services (InVEST) open source tool suite, which can be used to evaluate future carbon sequestration by wetland soils. This tool combines existing data on carbon sequestration potential and government maps to create spatial estimates of carbon sequestration under various management practices. The International Blue Carbon Initiative -- led by Conservation International, IUCN, and the International Oceanographic Commission -- also provides a manual that can guide managers and scientists with recommendations and techniques for carbon measurement and analysis.

Current carbon stocks and the stability and permanence of these stocks

Determining current carbon stocks as well as their carbon storage efficiency is important in preventing the release of additional carbon. If an MPA manager desires to protect carbon storage, then coastal blue carbon ecosystems including mangroves, salt marshes, and seagrasses, and the carbon stocks found within, should be given priority for protection. However, there is often a lack of site-level information regarding carbon sequestration and storage. Region-specific data can often be used, but may also be limited in many parts of the world. Available tools and techniques, including the Coastal Blue Carbon Model and the Blue Carbon Initiative Manual, can be utilized to assess the stability of carbon stocks.

Photo: NOAA

Geographic area covered by the blue carbon habitats/Monitoring programs

Many MPAs are working to understand the distribution of carbon stocks through mapping efforts, a critical step in obtaining the information needed to restore blue carbon ecosystems to their full potential. Restoration may also require the analysis of historical ecosystem extents in order to determine restoration potential. However, in many regions it is not possible to restore coastal wetlands to their historic extent due to coastal development and land use change. Some general factors to identify through mapping include: prioritizing large, persistent seagrass species that have a high allocation of biomass below the ground; prioritizing old-growth mangroves over younger stands; and prioritizing saltmarshes in fluvial sites.

Monitoring programs are also important to track changes in habitats, providing information to inform adaptive management. Such programs are most effective when MPA managers partner with other organizations to map and monitor blue carbon areas outside the MPA boundaries.

Photo: NOAA

Management practices

Analyzing human actions that lead to the destruction or degradation of coastal blue carbon ecosystems can help managers address these stressors. Major drivers of the loss of blue carbon ecosystems vary by region, but generally include coastal development, infrastructure expansion, energy development and extraction. For example, mangrove forests are often converted to aquaculture and agriculture. The effects of climate change due to human activity are also contributing to losses in blue carbon ecosystems globally due to sea level rise and rising temperatures.

Management practices to protect blue carbon ecosystems should focus on minimizing human impacts that damage and disturb them. As climate change impacts increase, adaptive management will be an increasingly important tool to evaluate the efficacy of management strategies. Examples of such strategies include regulatory protection for blue carbon ecosystems, including through specially protected zones; and integrating blue carbon protection into existing policies. Restoration of blue carbon ecosystems is also an effective tool. For tidal wetlands, this can include practices such as revegetation, breaching levees and reestablishing tidal connectivity, raising soil surface levels with dredged material, increasing sediment supply by removing dams, lowering water levels on impounded former wetlands, rewetting of drained wetlands, and improving water quality. Other activities that can enhance carbon sequestration include supporting hydric soil functions, removing undesired species, and planting desired species, which can mean replacing species that sequester low amounts of carbon with species that sequester higher amounts of carbon.

Management practices that reduce erosion can also benefit blue carbon ecosystems by significantly increasing their longevity in the face of sea level rise and other threats. Another potential solution is to apply innovative engineering solutions for coastal protection from sea-level rise through infrastructure. Examples include the use of wave energy converters, artificial reefs, floating breakwaters, modified seawalls, artificial tidal pools, increasing the overtopping resistance of dikes, and the targeted use of beach nourishment and dredging operations (including beneficial use).

Photo: NOAA

Carbon strategies as a source of revenue

Once an MPA is established, the area contained within is protected indefinitely, which could allow the MPA to generate funds through carbon sequestration financing mechanisms. Additionally, management activities that protect the health and quality of blue carbon ecosystems will benefit other ecosystem services, and could make such projects eligible for adaptation and biodiversity funding. Some MPAs are exploring international collaboration by implementing blue carbon strategies as a source of revenue, generating credits through the carbon they have sequestered and stored, and selling them to global buyers seeking to offset their carbon emissions. However, to claim carbon credits, MPAs must be able to verify that the carbon stored would otherwise be at risk, a requirement known as “additionality.” As such, projects are generally unable to claim credits for carbon reduction achieved through conservation or restoration actions that are already mandated by existing legislation or management requirements.

Case studies

Padilla Bay National Estuarine Research Reserve


Photo: NOAA

Some MPAs have implemented explicit management practices and projects to address blue carbon sequestration and storage. Padilla Bay National Estuarine Research Reserve (PBNERR) in Washington State acknowledges carbon sequestration as an integral ecosystem service of seagrasses in their most recent management plan, and identifies this service as a topic for future research. PBNERR plans to conduct an in-depth evaluation of the carbon sequestration potential of this ecosystem by linking the planned buildout of this sentinel site and System-Wide Monitoring Program (SWMP) biomonitoring, which will focus on understanding the impacts of anthropogenic and climate stressors on coastal ecosystems and data collection on specific climate change issues. The sentinel site build out will include investments in coastal monitoring and environmental data collection as well as training and tools. Site-based monitoring will provide data to determine how conditions are changing within the reserve. These programs will allow managers to prioritize coastal restoration and development activities by accurately calculating the value of eelgrass carbon storage potential, especially since Padilla Bay is an erosional system where carbon sequestration may be overestimated. Other MPAs can establish similar monitoring programs to accurately assess the carbon storage potentials of their blue carbon ecosystems.

Waquoit Bay National Estuarine Research Reserve

Waquoit Bay NERR in Massachusetts is implementing "Bringing Wetlands to Market: Nitrogen and Coastal Blue Carbon." This project brings together a multidisciplinary team of scientists, policymakers, economists, and managers to identify scientific and policy issues related to blue carbon in order to bring salt marsh restoration within the reserve to carbon markets. In the first phase of this project, the relationship between salt marshes and climate change was analyzed to predict carbon fluxes, generating information that can be used to protect and restore salt marshes and revealing the importance of the carbon sequestration potential of this ecosystem. The team is currently in the second phase of this project, working to predict greenhouse gas fluxes across a wide range of coastal wetlands through the use of a limited number of environmental and ecological variables.


Photo: NOAA

Kenya's National Mangrove Ecosystem Management Plan

Kenya has developed a management plan to address the climate benefits that mangroves provide. As a part of this plan, Diani-Chale Marine National Reserve initiated an innovative project in 2013 to restore and protect mangroves in Gazi Bay through the sale of carbon credits, with similar initiatives being planned in other regions. The intrinsic value of mangroves, including carbon sequestration, is difficult to quantify through market mechanisms, which makes mangroves vulnerable to decisions that balance conservation and development. To address this challenge, Kenya is implementing payment for environmental services (PES) schemes, a market-based mechanism that provides payments to landowners to manage their lands in a way that ensures ecosystem protection and continued provision of ecosystem services. The Gazi Bay community entered into a PES agreement, allowing the project to be successfully implemented through the collection of revenue from the sale of credits, which has been reinvested into project implementation (planting and conserving mangroves) and community development. In addition, the MPA's management plan describes programs to conserve and restore mangroves. The resulting Mangrove Forest Conservation and Utilization program was established to conserve and protect mangroves for climate mitigation, promote sustainable harvesting of mangrove wood products, rehabilitate degraded mangrove forest areas, and improve policing and protection from human activities, demonstrating a merger of management considerations targeting blue carbon services with other benefits provided by this ecosystem.


Photo: Zachary Cannizzo

Madagascar: Tahiry Honko Project

The Tahiry Honko Project in Madagascar aims to conserve and restore mangrove forests within the Velondriake Locally Managed Marine Area and to provide economic security in the region. The project conserves and restores over 1,200 hectares of mangrove forests, thus generating over 1,300 carbon credits per year. The project began in 2018 and is projected to receive an annual income from carbon credit sales of $27,000 USD. Half of this revenue is reinvested in local villages for infrastructure, education, and healthcare, and 23% is invested in the local marine management association in support of MPA management.

Challenges

While the importance of preserving and protecting blue carbon ecosystems is widely recognized, many managers need more guidance and tools to do so. MPA managers have recently begun to expand their knowledge of blue carbon ecosystems and the many ecosystem services they provide. Finding the balance between managing different ecosystem services can be challenging, which may lead to tradeoffs and potential gaps in managing various ecosystem services.

Photo: NOAA

Societal awareness

Lack of societal awareness of the importance of the carbon sequestration and storage ability of blue carbon ecosystems is a challenge for coastal and MPA managers. As a result, blue carbon ecosystems may be mismanaged and release carbon into the atmosphere instead of sequestering it. Broader public understanding of the carbon benefits of blue carbon ecosystems will help build support for the management actions needed to ensure their effective management for carbon and other ecosystem services.

Lack of data and research

While mangroves are better studied, there is a relative lack of blue carbon data and research pertaining to seagrass, particularly related to robust spatial estimates of these habitats.


Photo: NOAA

There is also a need for more research on the sequestration potential of blue carbon habitats and the factors that affect it. Blue carbon can also contribute substantially to NDCs. However, many countries lack measurable targets for blue carbon within their NDCs due to the difficulty of quantifying carbon storage and sequestration. Despite the challenge, some countries, like Belize and the Bahamas, have successfully quantified blue carbon targets in their NDCs.

Funding

Restoration can offer opportunities to develop market-based mechanisms that use frameworks for carbon offsets and represents the most likely strategy to expand the climate mitigation potential of blue carbon ecosystems. Insufficient funding for blue carbon restoration and conservation is a major challenge faced by nearly all MPAs.

Case study: Indonesia

While Indonesia has the largest area of mangroves of any country, and potentially also possesses the largest seagrass habitat on the planet, the country's MPAs largely focus on coral reefs and mangroves rather than seagrasses. Further, the spatial extent of seagrass in Indonesia is declining as a result of human activity, exacerbated by a lack of law enforcement. To address these shortfalls and meet the increasing need to improve seagrass conservation, Indonesia's MPA framework will also promote seagrass restoration and conservation.

MPAs in Indonesia face a multitude of challenges to meeting their seagrass conservation goals including a lack of awareness of the importance of seagrasses among both the public and MPA managers, a lack of sufficient laws and regulations on seagrass management for climate change mitigation, limited long-term data on seagrass habitat quality and extent, and a lack of capacity to conduct community-based management of seagrass.

Solutions to protect and restore seagrass habitats in Indonesia include efforts to improve seagrass monitoring. A new method using molecular technology to detect the condition of seagrass could be implemented along with well designed seagrass restoration programs in areas where they have been degraded. Increased funding is likely necessary to ensure that successful conservation and restoration programs are maintained. Seagrass restoration is costly and has a lower success rate than other coastal ecosystems, but considering the extent of Indonesia's seagrass population, experts suggest that efforts should be made to advance towards seagrass restoration in the country.

Community involvement can also aid in increasing awareness of the importance of seagrass and other blue carbon ecosystems, with incentives provided to communities for blue carbon protection. PES schemes may be effective if payments are sufficient to compensate communities for their conservation actions and lost income.

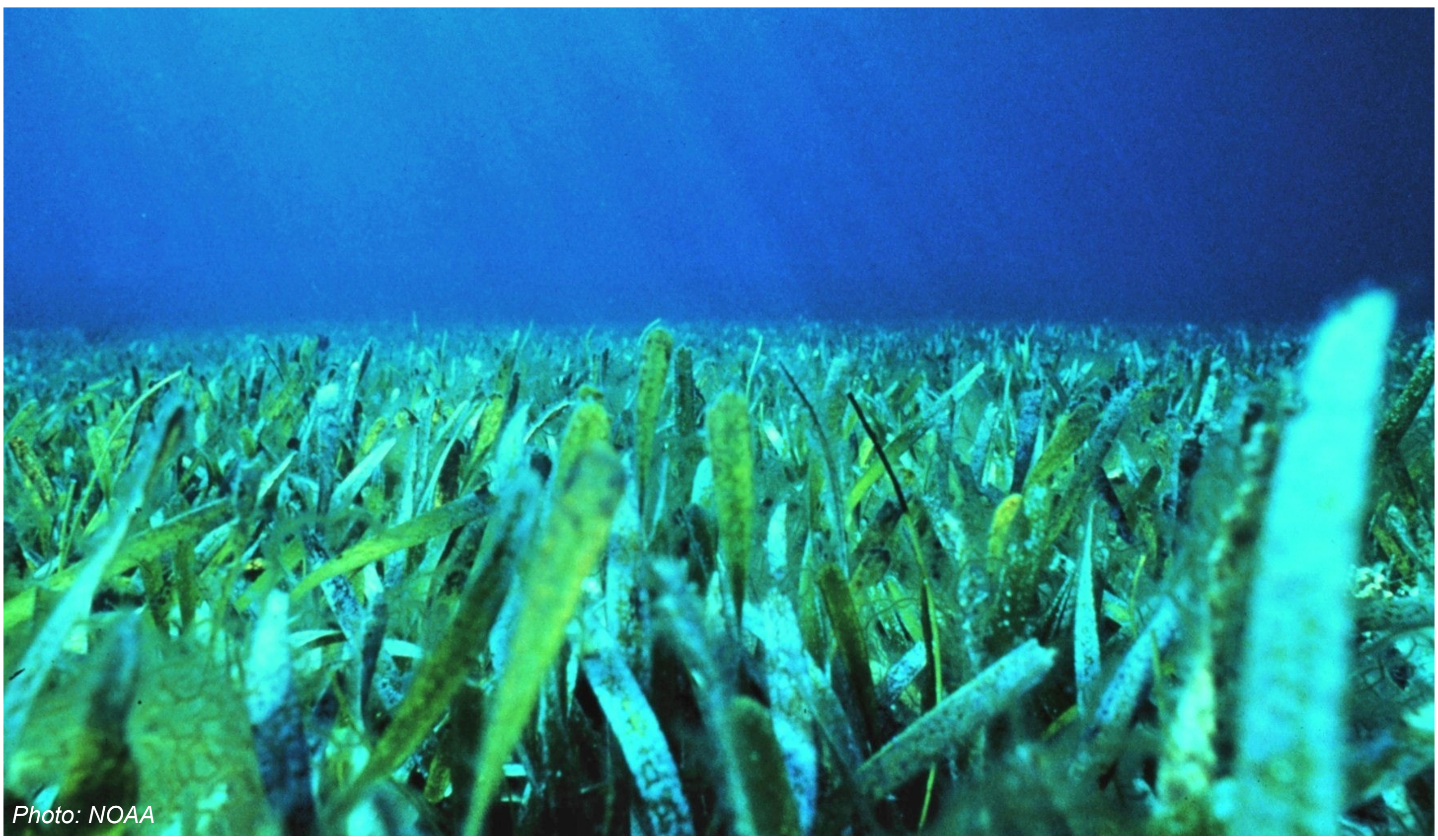


Photo: NOAA

Conclusion

The benefits associated with blue carbon ecosystems are increasingly recognized by MPA managers and deserve significant attention on a global scale. Increasing awareness of these benefits among MPA managers and the public can play a key role in promoting effective management and associated co-benefits.

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