IUCN

The Management of Natural Coastal Carbon Sinks

A short summary

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Introducing coastal marine carbon sink

Climate change is arguably one of the biggest issues facing humanity. World leaders now recognise that urgent and significant reductions in our emissions of greenhouse gases are needed if we are to avoid future dangerous climate change. Alongside such measures is an increasingly strong recognition that there is a need to properly manage particular habitats that act as critical natural carbon sinks.

The production of the report has been stimulated by an apparent lack of recognition and focus on coastal marine ecosystems. There is an urgent need to complement activities already well advanced on land to address the best practice management of terrestrial carbon sinks such as forests and peatland. This report is therefore timely as a number of Governments are now introducing legislation to tackle climate change and quantify carbon sinks. Interest in and actions to address the underlying causes of climate change are also growing– regulation of anthropogenic emissions of greenhouse gases into the atmosphere, avoiding deforestation, management and protection of other natural terrestrial carbon sinks, and the development of fiscal measures that place a value on carbon and therefore provide an economic incentive to reduce emissions.

(from top left to botton right): Mangroves, New Caledonia © Dan Laffoley; Close up of seagrass © Jerker Tamelander; Temperate water kelp forest © JNCC; Saltmarsh on the St Lawrence, Canada © Sarah Knox

It is important that such quantifications and processes work with the latest science and evidence.

To construct the report we asked leading scientists for their views on the carbon management potential of a number of coastal marine ecosystems: tidal salt marshes, mangroves, seagrass meadows, kelp forests and coral reefs. These ecosystems were selected because of the initial belief that they should be good at sequestering carbon, and are located in situations where management actions could secure the carbon sinks. If evidence substantiated this claim then this could expand the range of global options for carbon management, unlocking new possibilities for financing and protecting the coastal marine environment.

WCPA WORLD COMMISSION ON PROTECTED AREAS NATURAL ENGLAND LIGHTHOUSE FOUNDATION UNEP

Take-home messages

The overall take home message from the evidence and new analysis presented in this report is the globally significant role these coastal marine ecosystems (but not coral reefs – for reasons described in the main report) play in carbon fixation, complementing the already widely recognised terrestrial carbon sinks. Individual chapters set out the contribution each selected coastal marine habitat makes.

Overall, these coastal marine habitats have a far greater capacity (per unit of surface area) than land habitats to achieve long-term carbon sequestration in sediments, arising in part from the extensive belowground biomass of the dominant vegetation. The rate of carbon storage in the sediment by tidal salt marshes, mangroves and seagrass meadows is approximately 10 times the rate observed in temperate forests and 50 times the rate observed in tropical forests per unit area. Combined with the particular ways in which such habitats trap carbon, this means that they are critical components to include in future carbon management discussions and strategies.

These coastal habitats are under significant threat, and the loss of carbon sequestration capacity associated with the annual habitat destruction of mangroves and seagrass meadows is comparable to that of the annual decline in the Amazon rainforests. Since reducing carbon emissions will be a global concern for centuries, long-term carbon sequestration capacity must now also be accounted for in the benefits associated with coastal marine habitat restoration and protection.

Despite the relatively small areas of these coastal marine habitats, the capacity of coastal marine vegetated habitats for long-term carbon sequestration is comparable to terrestrial forests and may account for a visible percentage of carbon sequestrated at the country level. These values have not been accounted for, especially in assessments of the cost of degradation and loss of coastal marine habitats. Most importantly the greenhouse gas emissions that occur as a result of the management of these coastal and marine habitats are not being accounted for in international climate change mechanisms (ie UNFCCC, Kyoto, CDM, etc) or in National Inventory Submissions. Not only does this mean that countries are under-estimating their anthropogenic emissions, but also that the carbon savings from measures to protect and restore coastal and marine habitats will not count towards meeting international and national climate change commitments.

This report provides the essential evidence needed to motivate discussions and initiatives on how such coastal ecosystems should be incorporated into international and national emission reduction strategies and, potentially, carbon revenues schemes. The latter could take the marine equivalent of the Reducing Emissions from Deforestation and Forest Degradation (REDD) scheme on land to safeguard these critical coastal marine carbon sinks. International action is needed now to ensure that these coastal marine carbon sinks are also included in national greenhouse gas inventories as part of UN Framework Convention on Climate Change.

Photo: The dense assemblage of understory kelps and red algae in a giant kelp (*Macrocystis pyrifera*) forest off Santa Barbara, California, USA. © Clint Nelson

Tidal Salt Marshes — at a glance

• Intertidal ecosystems dominated by vascular plants.

• Occur on sheltered marine and estuarine coastlines from the sub-arctic to the tropics, but most extensive in temperate climates.

• Their soils store 210 g C $m^{-2}yr^{-1}$. This is a substantial rate and the carbon stored in tidal salt marsh soils of the USA comprises 1-2% of its total carbon sink.

• Each molecule of CO_2 sequestered in soils of tidal salt marshes and their tropical equivalents, mangrove swamps, probably has greater value than that stored in any other natural ecosystem due to the lack of production of other greenhouse gases. In contrast to freshwater wetland soils, marine wetlands produce little methane gas, which is a more potent greenhouse gas than CO_2. The presence of sulphates in salt marsh soils reduces the activity of microbes that produce methane.

• Extensive marsh areas have been lost from dredging, filling, draining, construction of roads, and they are now threatened by sea level rise.

• Restoration of tidal salt marshes can increase the world's natural carbon sinks. Returning the tides to drained agricultural marsh can also significantly increase this carbon sink.

• Sustainability of marshes with accelerating sea level rise requires that they be allowed to migrate inland. Development immediately inland to marshes should be regulated through establishment of buffer zones. Buffer zones also help to reduce nutrient enrichment of salt marshes, another threat to this carbon sink.

Photo: Marsh near the head of the Bay of Fundy, New Brunswick, Canada. © Dr. Gail Chmura

Some of the main findings of this report

• These key coastal marine ecosystems are of high importance because of the significant goods and services they already provide, as well as (but not for coral reefs) the carbon management potential recognised in this report, thus providing new convergent opportunities to achieve many political goals from few management actions.

• The carbon management potential of these selected coastal marine ecosystems compares favourably with and, in some respects, may exceed the potential of carbon sinks on land. Coral reefs, which rather than act as 'carbon sinks' are found to be slight 'carbon sources' due to their effect on local ocean chemistry, thus heightening the need for strict controls on carbon dioxide emissions.

Mangroves — at a glance

• Salt-tolerant, mainly arboreal, flowering plants growing in the intertidal zone of tropical and sub-tropical shores.

• Global area of 157,000 km^2 - 160,000 km^2.

• Global carbon burial of ~18.4 Tg C yr^{-1} .

• Mangrove forests are estimated to have occupied 75% of the tropical coasts worldwide, but anthropogenic pressures have reduced the global range of these forests to less than 50% of the original total cover.

• These losses are largely due to over-harvesting for timber and fuelwood production, reclamation for aquaculture and saltpond construction, mining, oil spills, pollution and damming of rivers that alter water salinity levels.

• Rehabilitation/restoration or plantation of mangrove forests are not only to be encouraged based on ecological or socio-economical considerations, but also have the potential of providing an efficient sink of CO_2.

Photo: Complex root structure of *Rhizophora mucronata* stand, Gazi Bay, Kenya © Steven Bouillon, K.U.Leuven

Some of the main findings of this report
• The chemistry of some specific coastal marine sediments (for example tidal salt marshes) suggests that whilst such habitats may be of limited geographical extent, the absolute comparative value of the carbon sequestered per unit area may well outweigh the importance of equivalent processes on land. This is due to the high sediment accretion rates with associated organic matter, often under anoxic conditions, coupled with a lower potential for the emission of other powerful greenhouse gases such as methane.

Seagrass Meadows — at a glance

• Flowering marine plants that form extensive meadows and are globally distributed. Found in shallow waters of all continents except the Antarctic.

• Responsible for about 15% of total carbon storage in the ocean.

• Global extent of seagrass now estimated to be about 0.3 million km^2.

• Turnover time of seagrass biomass is long (2 weeks to 5 years for leaves and roots an rhizomes can sometimes persist for millennia) relative to that of phytoplankton, making the role of seagrasses in the oceanic carbon budget proportionally more significant than expected from their areal cover.

• Long-term carbon burial of 83 g C m^{-2} yr^{-1}. This translates to global storage rates of between 27 and 40 Tg C yr^{-1}.

• The seagrass *Posidonia oceanica* is currently thought to be the most effective species in terms of long-term carbon storage. It is endemic to the Mediterranean and locally widespread. The capacity of it's meadows to accumulate carbon exceeds that of many terrestrial ecosystems such as boreal forests and show values commensurate with wetlands.

• However, two-thirds of seagrass meadows of the world within inhabited areas have been lost through human activities due to eutrophication and siltation.

• Management plans aimed at reducing the nutrient loads and preserving water clarity of coastal waters are a priority.

Photo: Shallow *Thalassodendron ciliatum* bed mixed with corals, Zanzibar Tanzania © Mats Björk

• Alongside the carbon management potential of these ecosystems, another key finding is the lack of distributional data for some coastal marine habitat types. Having comprehensive habitat inventories is critically important. This research highlights the urgent need, alongside recognising the carbon role of such ecosystems, to ensure that such inventories are completed for salt marsh and kelp forests, and then all such inventories are effectively maintained over time.

• These coastal marine ecosystems are also vital for the food security of coastal communities in developing countries, providing nurseries and fishing grounds for artisanal fisheries. Furthermore, they provide natural coastal defences that mitigate erosion and storm action. Therefore, better protection of these ecosystems will not only make carbon sense, but environmental sense as the co-benefits from ecosystem goods and services are clear.

Kelp Forests — at a glance

• Assemblages of large brown algae in the Order Laminariales.

• Kelps dominate the autotrophic biomass and production of shallow rocky substrates in temperate and arctic regions of the world but a complete survey of the world's kelp forest has never been done.

• Carbon cycling within kelp forests is characterized by rapid biomass turnover that can be as high as 10 times per year. There are few data on the fraction of kelp carbon that is incorporated into long-term carbon reservoirs such as marine sediments.

• It is likely that carbon storage by kelp dominated ecosystems will mainly be a function of the size of the standing biomass of kelp and associated understory algae. This means that the limit of carbon storage in these systems will be a direct function of the amount and condition of suitable habitat.

• The global kelp standing crop can be estimated to be from ~7.5 Tg C and (if modelled predictions of distribution are accurate) could be as much as 20 Tg C.

• Applying a conservative estimate for kelp forest net primary production of 1000 g C m^{-2} yr^{-1} to the area of shallow coastline with significant kelp yields a global kelp production of 15 Tg C yr^{-1}. If deep tropical areas of potential kelp are accounted for, then global kelp production approaches 39 Tg C yr^{-1}.

• Land use practices that alter the amount and constituents of runoff and the coastal discharge of municipal, agricultural and industrial wastes negatively impact kelp forests by increasing turbidity, sedimentation and nutrient loads. Human harvests of top predators such as lobster, fish, and sea otters have been implicated as a cause of kelp forest degradation world wide.

• To protect kelps, it is necessary to implement policies that restrict the chronic discharge of municipal and industrial waste waters into the nearshore, and land use practices that elevate the concentrations of sediments, nutrients and pollutants in runoff delivered to the ocean. Fishing damage is best managed by restricting the harvest of kelp and associated biota, which can be done using traditional fishery management practices in combination with the establishment of marine protected areas.

Photo: The elkhorn kelp *Pelagophycus porra* growing off Santa Catalina Island, California USA © Ron McPeak

Some of the main findings of this report

• Significant losses are occurring in the global extent of these critical coastal marine ecosystems due to poor management, climate change (especially rising sea levels), coupled to a lack of policy priority to address current and future threats. Sustained degradation of coral reefs may further threaten some of these habitats, such as mangroves and seagrass beds, by removing protection from erosion and wave action.

• Certain human impacts – notably nutrient and sediment run-off from land, displacement of mangrove forests by urban development and aquaculture, and over-fishing - are degrading these ecosystems, threatening their sustainability and compromising their capacity to naturally sequester carbon. The good news is that with strong political will such impacts can be mitigated by effective management intervention and establishment of effective management regimes.

Coral Reefs — at a glance

"Smith and Gattuso show from ocean chemistry that coral reefs are not a sink for the greenhouse gas carbon dioxide. The point is we cannot count on reefs to clean the atmosphere of our carbon dioxide emissions. We have to act decisively and do it right now, before it is too late." – Richard B. Aronson, Florida Institute of Technology and President of the International Society for Reef Studies.

Research published in this report shows that rather than being a carbon sink, coral reefs are a source of approximately 50 Tg C yr-1 for the reasons explained in the text.

'The ocean is the blue heart of the planet. Over millennia it has shaped our lives and as climate change and ocean acidification take hold it will touch our lives again in new and unexpected ways. This work to understand, better value, and strongly protect coastal marine carbon sinks has to be a central component of our future actions, helping place the ocean back at the centre of life on Earth.'

Dan Laffoley, Marine Vice Chair
IUCN's World Commission on Protected Areas

Photo: Pemba, Tanzania © Jerker Tamelander/ IUCN

- Management approaches already exist that could secure the carbon storage potential of these ecosystems, and most governments have commitments to put such measures in place for other reasons. These include biodiversity protection and achieving sustainable development. Agreed management actions that would be effective include Marine Protected Areas, Marine Spatial Planning, area-based fisheries management approaches, buffer zones to allow inland migration of coastal carbon sinks, regulated coastal development, catchment management, and ecosystem rehabilitation.

About the report

The origin of this report lies back in 2006 with IUCN's World Commission on Protected Areas and Natural England in the UK, and a joint enthusiasm to address this novel issue. This initial enthusiasm sparked the interest of many global partners and scientists when it became apparent that evidence is available that could change the emphasis on the management of carbon sinks.

Over the past three years we have sought out and worked with leading scientists to document the carbon management potential of particular marine ecosystems. This report documents the latest evidence from these leading scientists on these important coastal habitats.

We are grateful to the following experts who freely gave their time and expertise to turn the original idea into reality:

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For a copy of the full report go to publications at:
www.iucn.org/marine

Thalassia hemprichii at Paje lagoon, Zanzibar Tanzania