

*Recognizing that healthy and productive coastal ecosystems, already increasingly stressed by land-based sources of pollution, coastal development, and habitat destruction, have a growing role in mitigating the effects of climate change on coastal communities and economies in the near term...*

*We stress the need for sustainable management of coastal and marine ecosystems, including mangrove, wetland, seagrass, and coral reefs, as protective and productive buffer zones that deliver valuable ecosystem goods and services that have significant potential for addressing the adverse effects of climate change.*

The Manado Declaration (WOC, 2009).



# ECOSYSTEM-BASED ADAPTATION AND MITIGATION

There is increasing awareness and evidence of the potential of restoring natural ecosystems as a way to mitigate climate change, but also ensuring the continued flow of ecosystem services (MA, 2005; Trumper *et al.*, 2009). These services, including, but not limited to, extreme weather and tsunami buffering effects, enhanced food supply, pollution mitigation and health issues, are mainly concentrated in the coastal zone of oceans (UNEP, 2006; 2008b). Indeed, oceans blue carbon sinks, along with coral reefs and kelp communities, all fulfil very important functions in the coastal zone while providing opportunities for jobs and coastal prosperity.

Unfortunately, blue carbon sinks are disappearing at an alarming rate. Human activities such as deforestation, pollution by nutrients and chemicals from agricultural and industrial runoff, unsustainable coastal development, overfishing, invasive species infestations, oil spills, dredging, filling or drainage that cause sediment-loading, mining, and loss of biodiversity are impacting coastal ecosystems worldwide, far exceeding the natural buffering capacity of these ecosystems (UNEP, 2006; 2008b).

## MANAGEMENT OF BLUE CARBON SINKS AND THEIR RESTORATION

Blue carbon sinks are hot spots for carbon burial in the ocean where they play a globally significant role that needs to be incorporated into current inventories of natural carbon sinks. About half of their sink capacity may have been lost already, mainly through the loss of these vegetated coastal habitats since the 1940s. Efforts to recover the capacity of blue carbon sinks need to be incorporated in current strategies to mitigate climate change, thus providing an impetus for restoration efforts. The recovery of blue carbon sinks will help countries mitigate their carbon emissions while restoring valuable ecosystem services and key natural resources. Integrated coastal management will become central in this process to ensure both the carbon binding capacity and the goods and services rendered for food security, coastal livelihoods and sustainable coastal development.

There is sufficient evidence that reversing the global decline of vegetated coastal habitats and recovering the lost area of blue carbon sinks would provide a very large improvement in the ecological status of the global coastal environment. This could result in the recovery of important services, such as their capacity to oxygenate coastal waters, serve as nurseries, helping restore world fish stocks, or shelter the shoreline from storms and extreme weather events (Hemminga and Duarte 2000; Danielsen *et al.*, 2005). At the same time by stopping the loss and degradation, we would rebuild an important natural carbon sink, thereby contributing to mitigating CO<sub>2</sub> emissions and, hence, climate change.

Because blue carbon sinks occur along the shorelines of all continents, except the Antarctic, states in regions with extensive shallow coastal areas across the world (e.g. India, south east Asia, Black Sea, West Africa, Caribbean, Mediterranean, eastern USA, Russia) could explore the potential to mitigate CO<sub>2</sub> emissions and improve their coastal resources by protecting and restoring their blue carbon sinks. Expanding blue carbon sinks is, therefore, a win-win strategy, (comparable to strategies in place to protect and rebuild the carbon sink capacity of rainforests) which, helps to address the commitments of states under both the Biological Diversity and Climate Change Conventions of the UN. For instance, the ongoing national wetland conservation action plan in China has been estimated to involve a potential for increased carbon sequestration by 6.57



Gg C year<sup>-1</sup> (Xiaonana *et al.*, 2008). Andrews *et al.* (2008) calculated that the net effect of returning of returning some 26 sq km of reclaimed land in the UK to intertidal environments could result in the burial of about 800 t C year<sup>-1</sup>.

A first step is the protection of these important blue carbon sink habitats, already in place in many countries (e.g. EU members, USA, among others). This involves the regulation of activities responsible for their global loss, including coastal reclamation, deforestation of mangrove forests, excess fertilizer application on land crops and inputs of urban organic waste, siltation derived from deforestation on land, unsustainable fishing and fixing of coastlines through coastal development (Duarte, 2002; 2009). Best practices for the management of blue carbon sinks are available to help maintain these ecosystems healthy while preserving their functions (e.g. Borum *et al.*, 2004; Hamilton and Snedaker 1984; Melana *et al.*, 2000).

A second step should involve efforts for the large-scale restoration of the lost area, which is probably of the same order (if not larger) than the area currently still covered by these

aquatic habitats (Duarte 2009; Waycott *et al.*, 2009). For instance, some countries in SE Asia have lost almost 90% of their mangroves since the 1940s (Valiela *et al.*, 2001). Large-scale restoration projects have been successfully conducted for mangroves. The single largest effort probably being the afforestation of the Mekong Delta forest in Vietnam, completely destroyed by the use of Agent Orange in the 1970's and replanted by the Vietnamese people (Arnaud-Haond *et al.*, in press). Salt-marsh restoration is also possible and has been applied largely in Europe and the USA (e.g. Boorman and Hazelden 1995). Restoring lost seagrass meadows is more complex, as the labour required to insert transplants under the water increases cost. Seagrass restoration projects have consequently remained comparatively limited in size (a few hectares) and number. However it is a viable option provided the benefits of seagrass restoration can be used strategically, for example to catalyze the great potential for natural recovery. This is a slow process when unassisted (Duarte *et al.*, 2005b), so has to be supported in parallel with actions to remove the pressures that caused the loss in the first place. Such efforts would provide initial sources of growth and subsequently benefit from the

exponential capacity of seagrass meadows to expand, through the growth of their rhizomes, over the seafloor. While green forest can only grow upwards, seagrasses can spread horizontally at exponential rates.

The sequestration capacity of individual marine ecosystems varies substantially (Table 1). Not all blue carbon sinks are equally effective, with salt marshes having the highest carbon burial rate per unit area, followed by mangroves and seagrass. Our current understanding of what drives a high capacity for blue carbon sink ecosystems includes high biomass and production, where the plants produce large surplus of organic carbon (Duarte and Cebrián, 1996), and their location in an area where land-based materials can be intercepted, adding to the self-derived surplus to result in large carbon burial rates (Bouillon *et al.*, 2008). Restoration efforts must focus on the recovery of blue carbon sinks with high sequestration capacity, considering these drivers and catalyzing the capacity of these ecosystems to act as efficient carbon sinks. Additional research on the conditions that result in high carbon sink capacity of vegetated coastal habitats can help guide successful restoration projects.

Most efforts to restore blue carbon sinks have been driven by the need to restore coastal protection by vegetated habitats and their value as habitats for key species (Boorman and Hazelden, 1995; Fonseca *et al.*, 2000; Danielsen *et al.*, 2005). It is time that their beneficial role as carbon sinks is also taken into account and to include this in economic assessments of the benefits of restoring blue carbon sinks.

## INTEGRATED ECOSYSTEM APPROACHES

Improving the resilience of the coastal and oceans communities, both human and aquatic, to the impacts of climate change will be key to sustaining the role of the oceans as providers of food and livelihood security. Comprehensive and integrated ecosystem approaches to managing coasts, oceans, and uses of aquatic resources should form the basis for climate change adaptation and mitigation strategies as they address the social, economic, ecological and governance aspects underlying vulnerability to climate change. Such integrated approaches would help to link the multiple sectors depending on coastal and ocean resources to those organizations with climate change and disaster risk management responsibilities; thereby assisting in climate proofing sector-specific development strategies as well as 'mainstreaming' the aquatic-based sectors into climate change strategies.



### **The management of coastal carbon sinks – a forthcoming IUCN/Natural England/UNEP report**

The issue of marine carbon sequestration is attracting growing attention globally, and a new collaborative report titled 'The management of coastal carbon sinks' by the International Union for the Conservation of Nature and Natural England, further examines the issue in closer detail. This report documents the latest information from world-leading scientists on the carbon management potential of a number of coastal ecosystems: tidal salt marshes, mangroves, seagrass meadows, kelp forests and coral reefs. It explores the latest science for each ecosystem, explores their role in the carbon cycle, and outlines management options that would maintain and enhance the carbon sinking capability of each ecosystem. This report is planned released later this year (2009).

As is the case in land-based sectors, many mutually reinforcing synergies and benefits exist among mitigation actions and overall development goals for coastal and ocean resources. These benefits include, for example, improved fisheries and aquaculture production systems, biodiversity conservation through increasing mangrove populations, and increased energy efficiency in the shipping sectors. Efforts should include areas of mutual benefit to food and livelihood security and the responsibilities of these sectors to reduce and avoid emissions as well as to enhance natural removals of greenhouse gases.

In order to avoid negative trade-offs between adaptation and mitigation within and among sectors, an ecosystem approach and system-wide evaluation and planning of mitigation and adaptation strategies will need to include downstream impacts on other sectors. It is very clear from this report, that the carbon sink capacity of these valuable coastal ecosystems should provide massive additional impetus for improved integrated coastal zone management, protection and restoration.