2012 Yeosu Workshop on "Coastal Blue Carbon"

by Gabriel Grimsditch and Ik Kyo Chung

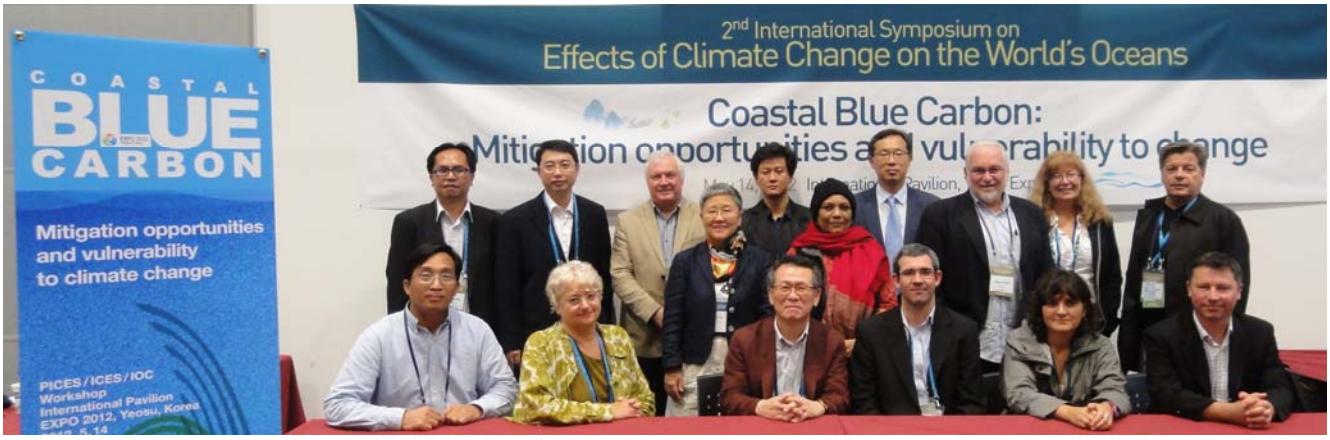
During the first week of the World Expo 2012 in Yeosu, Korea, a workshop on "*Coastal blue carbon: Mitigation opportunities and vulnerability to climate change*" was convened on May 14, 2012, at the symposium on "*The Effects of Climate Change on the World's Oceans*". The workshop was co-organized and co-sponsored by Pusan National University and the United Nations Environment Programme (UNEP).

Coastal ecosystems, in particular, mangroves, tidal salt marshes, seagrass beds, and possibly seaweed beds, hold large reservoirs of carbon in their biomass and soils and sink atmospheric CO_2 through primary production. This carbon is becoming known as 'blue carbon' because it is associated with marine ecosystems. Recent scientific syntheses have placed the global total estimated emissions from degraded and converted coastal wetlands each year at between 300 and 900 million tons of CO_2, approximately equal to the annual CO_2 emissions from energy and industry for Poland and for Germany, respectively (Murray *et al*., 2011). The rates of carbon sequestration and storage in these coastal ecosystems are comparable to, and often higher than, the rates in carbon-rich terrestrial ecosystems such as tropical rainforests or freshwater peatlands. Unlike most terrestrial systems, which reach soil carbon equilibrium within decades, deposition of CO_2 in coastal ecosystem sediment can continue over millennia. However, when degraded or destroyed, these systems can become sources of carbon dioxide emissions, due to oxidization of biomass and organic matter stored in the soil. The rate of emissions is particularly high in the decade immediately after disturbance, but continues as long as oxidation of sediment occurs. Current rates of loss of mangroves, seagrass beds and salt marshes, driven largely by human activities such as conversion, coastal development and over-harvesting, estimated to be between 0.7 and 2% a year, are among the highest rates of loss of any ecosystem on the planet. This is of considerable concern with respect to their role in carbon sequestration and emissions (Duarte *et al*., 2005; Crooks *et al*., 2011).

Seaweed beds and kelp forests are also ecosystems of interest for blue carbon sequestration and storage. However, unlike other blue carbon ecosystems, seaweed and kelp do not have soil substrates and thus do not retain large amounts of carbon in sediments, although they can act as carbon sinks by reducing dissolved inorganic carbon. Korean researchers are exploring the inclusion of seaweed and kelp in Clean Development Mechanisms.

As nature-based approaches for the mitigation of climate change are increasingly seen as part of the solution, blue carbon has recently been receiving greater international attention. This has stimulated renewed interest in better management, conservation and restoration of coastal ecosystems including mangrove forests, seagrass meadows, tidal salt marshes, and seaweed beds for the purpose of climate change mitigation. However, this has also highlighted a number of gaps in our scientific knowledge of these issues which are critical to developing blue carbon projects for the international carbon market, be it voluntary or regulated. The workshop in Yeosu focused on some of these important questions.

In the invited talk on "Vegetated coastal habitats as intense carbon sinks: Understanding and using blue carbon strategies", Nuria Marba (Institut Mediterrani d'Estudis Avançats, Spain) gave an overview of current scientific



Group photo of the workshop participants, left to right, back row; Calvyn Sondak, Yun-Xiang Mao, Luis Valdés, Jin Ae Lee, Jong Gyu Kim, Manipadma Jena, Kwang Seok Park, Jim Davie, Elvira Poloczanska, Andy Steven, front row; Guanghui Lin, Gail Chumura, Ik Kyo Chung,, Gabriel Grimsditch, Núria Marbà, Stephen Crooks.

knowledge including gaps and uncertainties in the data. She pointed out that a replanted seagrass meadow selling credits on the carbon market could recoup the costs of restoration within 50 years.

In his presentation on "The UNEP Blue Carbon Initiative", Gabriel Grimsditch (UNEP) reviewed UNEP's efforts to support the development of methodologies for assessing blue carbon stocks, ongoing scientific research and pilot projects around the world and noted that the Global Environmental Facility (GEF) has pledged support to a global project on blue carbon science and on-the-ground action.

In his talk on "Predicting the response of coastal marshes and mangroves to sea level rise and human impacts: State of science and information needs", Stephen Crooks (Philip Williams and Associates, USA) explored the carbon dioxide emissions from drained wetlands, provided options for restoring these wetlands in order to restore carbon sequestration functions, and presented a set of potential restoration metrics he has developed through this work.

The talk on "Effects of tidal regimes, mariculture and restoration on carbon pools and fluxes in subtropical mangrove ecosystems of China: Implications for blue carbon management" by Guanghui Lin (Tsinghua University, China) reviewed mangrove conservation efforts and carbon fluxes in China. He indicated that the invasive saltmarsh species *Spartina* and its competition with mangroves was a threat to the ecosystem in the country, but also noted that mangrove restoration efforts in China have been relatively successful.

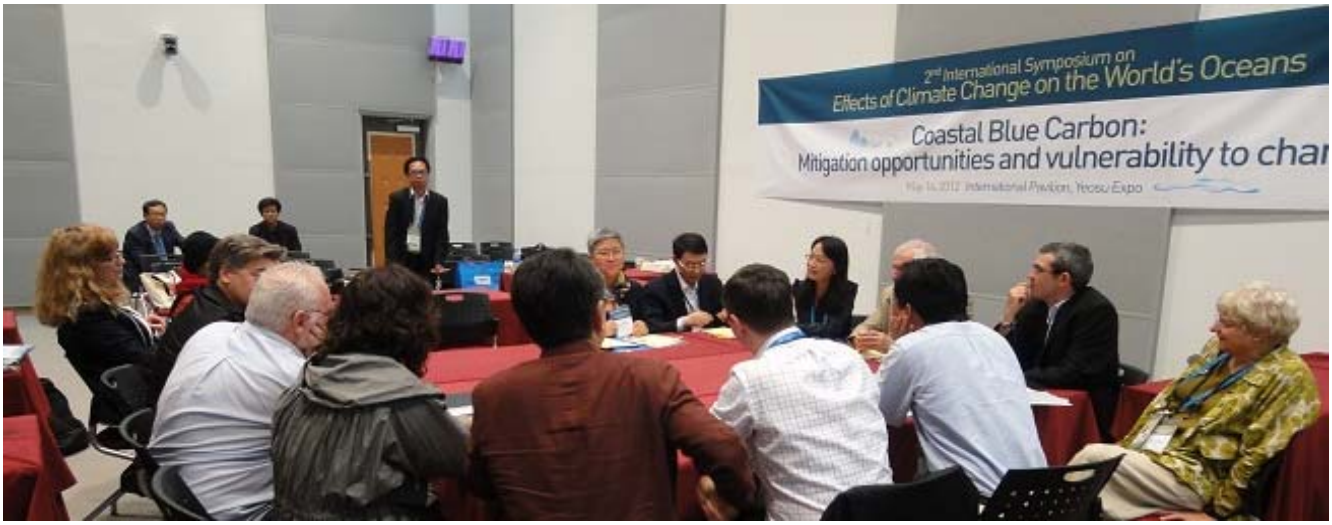
In her presentation on "Assessing the permanence of blue carbon sinks with rising sea levels", Gail Chmura (McGill University, Canada) examined the vulnerability of tidal wetlands to sea-level rise and coastal squeeze, and consequently the permanence of their carbon stocks. She pointed out that Lidar technology is a cost-effective and accurate method to collect data for assessing the vulnerability of coastal ecosystems to changes in sea level.

In his talk on "The potential of ecological mangrove rehabilitation to contribute to reduced greenhouse gas emissions from deforested and degraded mangrove areas in Indonesia", James Davie (Mangrove Action Project, Indonesia) described the challenges and successes surrounding a mangrove restoration project aimed at creating carbon benefits in Indonesia, and noted that maintaining local hydrology in restoration areas was crucial for the success of these types of projects.

On behalf of Gordon Ajonina (Wildlife Conservation Society, Cameroon), Gabriel Grimsditch gave a talk on "Mangroves and carbon in west and central Africa" to describe research being undertaken on carbon and ecosystem services in mangroves of Central Africa, and suggested that this was the first time that carbon was being quantified for mangroves in this region, and that the results would advise national REDD (Reducing Emissions from Deforestation and Forest Degradation) strategies.

The presentation on "Kelp forest/seaweed beds as a mitigation and adaptation measure: Korean project overview" by Ik Kyo Chung (Pusan National University, Korea) examined the role of seaweed ecosystems in carbon sequestration. He indicated that seaweed had so far not been considered in the international blue carbon debate because these ecosystems do not store carbon in soil, yet seaweed is highly productive and grows at fast rates thus accumulating carbon in its biomass.

The roundtable discussions following the presentations focused on two important and innovative blue carbon issues. The first issue concerned best practices for developing carbon market projects based on coastal ecosystems and their abilities to sequestrated carbon. As



Round table discussion in the afternoon session.

methodologies for carbon market projects in mangroves and salt marshes either have been approved or are in the process of development, we are beginning to see the emergence of projects to manage and restore these ecosystems for carbon credits. However, best practices for feasibility assessments, landscape and permanence considerations, leakage, baselines, future scenarios and restoration practices are often not implemented in these fledgling carbon market projects, increasing their likelihood of failure. Appropriate guidance for assessing the feasibility and then implementing the activities either do not exist or have yet to be recognized by project developers. The need and potential for this type of guidance for coastal blue carbon market projects was apparent, and this workshop explored how such guidance could be developed and disseminated to ensure that project developers have the best information available.

Another important, and regionally pertinent, issue discussed was the potential for macroalgae such as kelp or seaweed to act as a carbon sink. Although macroalgae naturally photosynthesize and absorb carbon dioxide through primary production, growing up to 0.6 m per day in some cases, it is not clear whether this carbon is sequestered and stored for the long term and whether it is thus effective for climate change mitigation. This is because seaweeds do not put down deep sediments and instead grow on rocky substrates. Most of the carbon is stored in the fast-growing biomass, and the long-term fate of this carbon is often unclear. However, it only takes 3 to 5 years to develop the climax stage for newly established macroalgal habitats in the marine environment, compared to terrestrial ecosystems which take more than 50 years.

Seaweed farming for food, fertilizer, paper and biofuel is a growth sector, especially in East Asian countries such as Korea, and the possibilities for the carbon market should be explored. Ik Kyo Chung showed that farmed seaweed (*i.e.*, not a natural community) sequestered between 15.7 and 16.6 tons of CO_2 per hectare per year, clearly indicating its potential as a carbon sink. Questions can be raised, though, about the permanence of this carbon sequestration, and we need to explore the fate of the carbon if seaweed is used as biofuel, fertilizer, paper or food. A global issues paper outlining the current state of knowledge and the necessary questions to address would be an interesting step in raising the profile of this innovative form of blue carbon. Professor Chung even proposed the Coastal Use and Coastal Use Change Aquatic Vegetation as the coastal equivalent of the UNFCCC/IPCC category Land Use and Land Use Change Forests.

The workshop was thought-provoking, and showed once again that the full potential of blue carbon is still a long way from being realized. A workshop report has been posted on the "Blue Carbon Blog" (http://bluecarbonblog.blogspot.kr/2012/05/blue-carbon-at-world-expo-2012.html), and reported by Ms. Manipadma Jena of the Inter Press Service (http://bluecarbonblog.blogspot.kr/2012/05/can-blue-forests-mitigate-climate.html).

Gabriel Grimsditch (Gabriel.Grimsditch@unep.org) has been a Programme Officer with the UNEP (United Nation Environmental Programme) Freshwater and Marine Ecosystems Branch for the last 3 years where he specializes in climate change and oceans. Before joining UNEP, Gabriel worked for the IUCN (International Union for Conservation of Nature) Global Marine Programme and was based at the Coastal Oceans Research and Development in the Indian Ocean (CORDIO) office in Mombasa, Kenya. There he worked with partners to study coral reefs, resilience and climate change and has published various peer-reviewed articles and grey literature with the main focuses being coral reef resilience, carbon storage and sequestration in coastal ecosystems, and ecosystem-based adaptation. Gabriel obtained a B.S. degree from Manchester University and an M.S. degree from University College London.

Dr. Ik Kyo Chung (ikchung@pusan.ac.kr) has been a professor at the Department of Oceanography, Pusan National University, since August 1988. His research areas are seaweed ecophysiology and aquaculture. Recently, Ik Kyo led the project on "Greenhouse gas emissions reduction using seaweeds" from the Korean Ministry of Land, Transport and Maritime Affairs (2006–2011). As a member of the Korean Society of Phycology since 1987, he was the Editor-in-Chief of Algae from 1999-2005. Presently Ik Kyo serves as President of the Korean Chapter of the World Aquaculture Society. He obtained his B.S. and M.S. degree in Botany from Seoul National University in 1976, and his M.S. degree in Marine Environmental Science in 1985 and Ph.D. degree in Oceanography from the State University of New York at Stony Brook in 1987.