International Blue Carbon Scientific Working Group

October 29-30, 2013
IOC- UNESCO HQ, Paris France

WORKSHOP REPORT

Coordinating organizations:

Workshop partner organizations:

Workshop Overview

The Intergovernmental Oceanographic Commission (IOC) of the United Nations Environmental, Scientific and Cultural Organization (UNESCO) hosted the sixth Blue Carbon Scientific Working Group meeting, in Paris, France. This two-day meeting brought together the working group with members of the research community to assess the capacity of remote sensing in blue carbon ecosystems and to identify knowledge gaps and opportunities for collaborations that will accelerate research in the future, specifically global mapping of tidal marshes and seagrass meadows. Meeting attendees considered the current state of the science and future opportunities for the research community as a whole.

The IOC graciously hosted a reception on the top floor of the main UNESCO building. Funders and coordinating organizations were thanked for their support.

Key outcomes are presented for each of the five workshop sessions.

Session 1. Mapping Tidal Marshes

The importance of more accurate global mapping of tidal marshes and the methodologies for achieving this goal were discussed. Several remote sensing based methodologies and approaches were considered.

Advantages of remote sensing in coastal areas include:

- mapping is now easier than ever before due to publically available data sets and computer modeling that allows for automated analysis,
- the technology exists to update maps in real time via crowd sourced data gathering, and
- scientists are establishing more specific parameters allowing for more accurate maps that can be generated relatively quickly.

Challenges of remote sensing in coastal areas:

- the data that is most readily available is several years old, and
- there still needs to be extensive ground truthing that can be very costly.

Small groups discussed possible user groups, methodologies and validation, and capacity building. Results from this session confirmed the need for a consistent global tidal marsh map and that the technology needed to create one are currently available. The next required steps are to better define what is to be included in a tidal marsh map and how to fund the project. (See report “Tidal Marsh Mapping”)

Session 2. Recent Blue Carbon Developments

This session allowed members to update the working group on new developments in blue carbon science, ongoing projects, current knowledge gaps, and opportunities for the Blue Carbon Working Group to expand their purview. See below for more details.

Session 3. Mapping Seagrasses

Following a similar format to Session 1, Session 2 discussed the importance of accurate mapping of seagrass meadow extent and density as well as the methodologies for achieving this goal. Presentations focused on two distinct methodologies; 1) direct observation of areas selected via stratified random sampling; and 2) remote sensing techniques. Discussions centered on the advantages and disadvantages of each method and if there is a direct correlation between carbon storage and seagrass density. The group acknowledged that it is very difficult for an individual in the water to distinguish changes in seagrass density and extent beyond a small regional scale and while remote sensing can be conducted on larger scales, it is only be able to detect about 60-70% of seagrass areas. Thus, a combination of the two techniques was considered optimal. However given the large extent of unmapped seagrass areas, remote sensing may be sufficient for approximate mapping, even if there is high associated uncertainty.

Opinions differed on the accuracy of using seagrass biomass to determine carbon storage in the ecosystem. Preliminary results showed a correlation between biomass and carbon storage but others argued that biomass measurements do not take into account turnover rates and outside sources of carbon.

Small groups discussed possible user groups, methodologies and validation, and capacity building. Results from this session suggest that there is potential for crowd sourcing seagrass extent data. Additionally there is a need to build awareness of the ecological importance of seagrasses with the public and policy-makers. Also, priority for remote-sensing-based mapping should be given to areas where there are dense seagrass meadows because mapping techniques are more accurate for these locations and more progress can be made. Once best practices have been established in these areas, focus can shift to areas where the meadows are sparser. (See report "Seagrass Meadow Mapping")

Session 4. Policy Impacts

This session focused on current policy relevant scientific questions and how to integrate carbon storage, as an ecosystem service, into existing policy frameworks. Several U.S. policies were discussed where regulations already exists that would allow carbon sequestration and storage to be included as an ecosystem service; however, this is currently not being done. This session also highlighted potential opportunities to include carbon in current conservation and restoration policies as well as into calculations of ecological injury following disasters. This approach to ecological stores of carbon may provide a feasible alternative for countries where the carbon markets are not optimal. A discussion of the new IPCC 2013 Wetlands Supplement focused on the management guidelines outlined in the document and research gaps encountered by the authors. Specifically, the need for greater understanding of what land use activities are occurring and where, and where do these activities cause conversion and degradation of mangrove, marsh, and seagrass systems.

Session 5. Ongoing Developments of the Working Group

This session reviewed some of the achievements of the Blue Carbon Scientific Working Group over the past few years and then focused on immediate priorities for the working group. Looking forward, the following actions are a priority for the group:

- Capacity building by developing well-coordinated regional blue carbon leaders around the world (regional champions)
- Development of regional case studies and guidance on national implementation
- Promote longer term monitoring initiatives that will increase our knowledge of how carbon stocks change over time
- Increase efforts to recognize other ecosystem services in our communication efforts using climate mitigation as an entry point for talking about adaptation.
- Finalize and disseminate the field manual "Methods for Assessing Carbon Stocks and Emissions Factors in Mangroves, Tidal marshes and Seagrasses"

Historically the Blue Carbon Scientific Working Group has focused on ecosystem conservation and the role of blue carbon as a climate change mitigation tool. However there is also a need to talk about blue carbon's role in ecosystem restoration and what knowledge gaps still remain (e.g., how long does it take to restore a wetland and rebuild lost carbon stores, what is the real rate of loss, etc.). There is also a growing need to increase analysis of social science and economic impacts.

Resources from the Meeting, including speakers' presentations can be found at the workshop web site: http://thebluecarboninitiative.org/france-october-2013/

Attendees

Coordinators

Valdes, Jorge Luis – Intergovernmental Oceanographic Commission, United Nations
Isensee, Kirsten – Intergovernmental Oceanographic Commission, United Nations
Pidgeon, Emily – Moore Center for Science and Oceans, Conservation International
Howard, Jennifer – Moore Center for Science and Oceans, Conservation International

Working Group Members

Cifuentes, Miguel – Tropical Agriculture Research and Higher Education Center
Copertino, Margareth – FURG
Crooks, Stephen – Phillip Williams & Associates, LTD
Duarte, Carlos – Instituto Mediterráneo de Estudios Avanzados
Emmer, Igino – Silvestrum
Fourqurean, Jim – Florida International University
Giri, Chandra – United States Geological Survey
Hutahaean, Andreas – Agency for Research and Development of Marine and Fisheries, Indonesia
Kairo, James – Kenya Marine and Fisheries Research Institute (KMFRI)
Kauffman, Boone – Oregon State University
Kennedy, Hilary – University of Bangor
Laffoley, Daniel – International Union for Conservation of Nature
Lovelock, Catherine – University of Queensland
Marbà, Nuria – Instituto Mediterráneo de Estudios Avanzados
Megonigal, Patrick – Smithsonian Environmental Research Center
Morris, Jim – University of South Carolina
Murdiyarso, Daniel – Center for International Forestry Research
Quesada, Marco – Conservation International
Rahman, Faiz – University of Indiana
Ralph, Peter – University of Technology Sydney
Saintilan, Neil – Dept of Environment, Climate Change and Water, New South Wales
Simard, Marc – Jet Propulsion Laboratory, NASA
Telszewski, Maciej – Independent Consultant
Zimmerman, Richard – Old Dominion University

Guests

Balke, Thorsten – Deltares
Bondo, Torsten – European Space Agency
Chung, Ik Kyo – Pusan National University
Kang, Do-Hang – Korea Institute of Ocean Science and Technology
Kim, Tae-Goun -- Korea Maritime University
Schile, Lisa – Smithsonian Environmental Research Center

Stares, Stephanie – Waterloo Foundation
Sutton-Grier, Ariana – National Oceanic and Atmospheric Administration
Tonneijck, Femke – Wetlands International
Van Bochove, Jan Willem – United Nations Environment Programme, World Conservation Monitoring Programme
Woo, Seonock – Korea Institute of Ocean Science and Technology

Funding and Supporting Organizations

Walton Family Foundation, NASA, Waterloo Foundation, Conservation International, IUCN, IOC-UNESCO, Korea Institute of Ocean Science and Technology

The International Blue Carbon Scientific Workshop participants at IOC- UNESCO HQ, Paris France. October 29, 2013. Photo courtesy of CI.

Session 1 – Mapping Tidal Marshes

<u>Presentations:</u>

Challenges to salt marsh mapping

Neil Saintilan (Dept of Environment, Climate Change and Water, New South Wales) presented the current state of tidal marsh maps and described possible approaches for updating/filling in the maps we currently have. Ultimately there needs to be a clear and consistent definition of tidal marsh that can be used to set mapping parameters. The next steps are to develop a consistent and comprehensive tidal marsh program based on satellite imagery that can be verified by local experts. We can do this, the technology and need is there, now is the time to initiate this effort.

Why Map Salt Marshes

Patrick Megonigal (Smithsonian Environmental Research Center) discussed the large uncertainty surrounding the current global estimates of tidal marsh extent emphasizing the need for more advanced mapping techniques. He warned that as we progress we need to keep in mind resolution and scale (global, regional, political, and socioeconomic) as well as associated spatial data (tidal range, suspended sediments, salinity, and disturbance).

The Test!

Prior to the workshop maps of tidal marsh from the northern coast of New South Wales, Australia were distributed to three working group members (Faiz Rahman, Marc Simmard, Chandra Giri). These maps were digitized from high resolution aerial photography. They were also sent details of a verification site from the southern coast of NSW. They were tasked with developing techniques for mapping tidal marsh, and to try their techniques out on northern coast maps and verify their results using the verification site.

Results:

Opportunities for saltmarsh mapping

Chandra Giri (United States Geological Survey) was kept from completing the challenge due to the government shut down that occurred in the weeks leading up to the workshop. Instead he presented on using LANDSAT data (which has a long history and is free to the public) to create tidal marsh maps. He also highlighted the need for an official definition of tidal marsh and guidance on the scale and the number of classes to include in a mapping system. He urged the scientific community to not overlook less than perfect data (e.g., maps with 20% cloud cover still have 80% usable area) and to utilize technology to automate as much of the analysis as possible.

Mapping tidal marshes remote sensing challenges: methodologies, results and limitations

Faiz Rahman (University of Indiana) addressed the challenge by analyzing spectral reflectance and ISODATA classifications to map tidal marshes in the shape files he was provided. His technique utilized and/or logic to include or exclude data, a statistical approach that determined the diversity between classes, and elevation maps to filter out non-marsh areas. His results were very promising, and he was able to accurately map tidal marsh at the verification site.

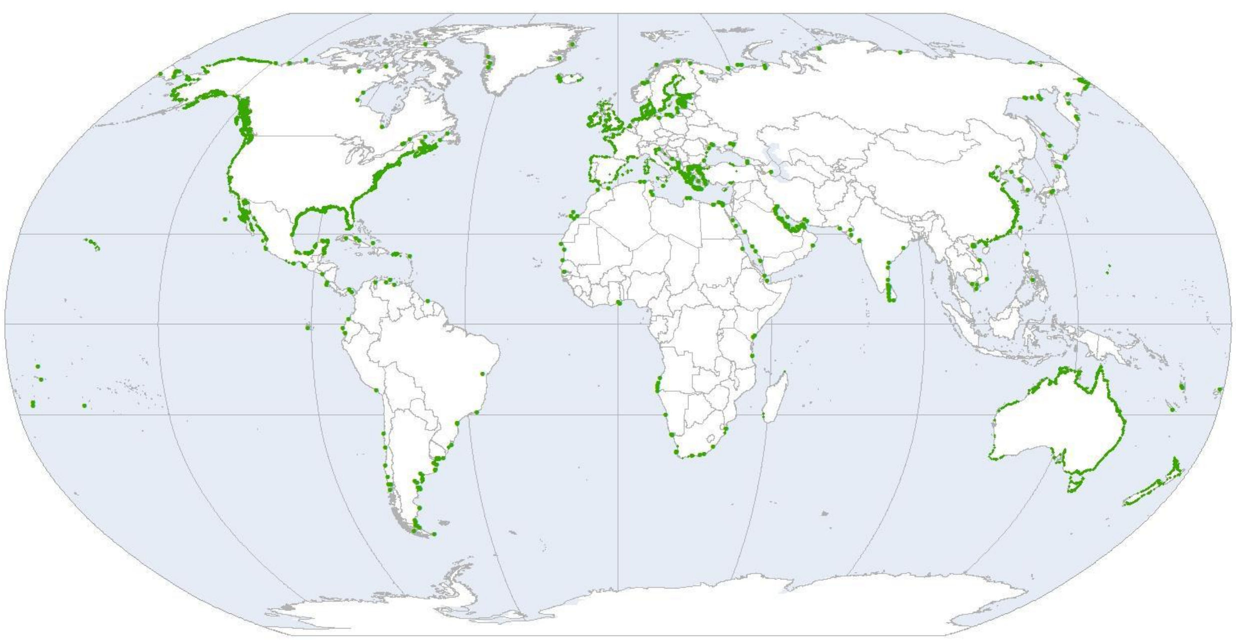
Remote sensing of salt marshes: a demonstration

Marc Simard (Jet Propulsion Laboratory, NASA) used open source data and available data sets (LANDSAT, SRTM, Google Earth) to map tidal marshes. He masked for elevation, water, and biomass and determined that tidal marsh mapping is achievable but difficult and somewhat subjective. His technique of combining spatial segmentation, masking, and visual interpretation makes the task doable. He suggested starting with a test country to determine best practices but the contextual conditions will differ greatly by location.

Supporting global blue carbon mapping and assessment

Jan-Willem van Bochove (UNEP, World Conservation Monitoring Centre) presented on the suite of on- and off-line tools available through the UNEP World Conservation Monitoring Centre to visualize and validate coastal marine datasets. They are currently developing a global blue carbon mapping portal that will integrate global spatial data and allow for the crowd-sourcing based data synthesis and validation of blue carbon resources. In their mapping efforts they define tidal marsh as "Any coastal ecosystem in the intertidal zone that is dominated by salt-tolerant grasses, herbs, and low shrubs that are regularly flooded by the tides." They created a global saltmarsh layer that they feel is relatively current and accurate but there are still significant gaps for the Arctic region.

Saltmarshes - Global Coverage
(Polygons, Lines and points)



<u>Session 1 Discussion:</u>

The discussion began with highlighting the efforts of the IPCC and UNFCC to include wetlands in their analysis and guidance. Those efforts, along with many others, have propelled this issue of carbon sequestration and storage as a valuable ecosystem service in to the policy realm. There is a growing need to reduce the uncertainty in the global extent and rate of loss of tidal marshes so that policy can be better informed. However, global maps will require a large number of individual field verification efforts to complete and within these projects careful consideration should be taken to address sea level rise (erosion, landward movement), time line, and feasibility. The group discussed the merit of global maps but also emphasized that regional maps might be more helpful in informing decisions.

Before mapping efforts can continue the group identified areas that require additional guidance:

- Is there going to be a standard definition of what should be called tidal marsh? And if so what will that entail?
- Currently mapping efforts break systems into classes, some maps may contain upwards of 20 classes and this makes the maps difficult to compare and explain. What guidance needs to be provided on the number of classes and class structure?

Breakout Groups:

The larger group was divided into three small working groups. The groups were asked to discuss the rationale for developing a global map, the methods to achieve this goal, and networks that we can draw from. For a complete synopsis of this discussion please see the workshop report "Tidal Marsh Mapping".

Session 2 – Recent Blue Carbon Developments

Presentations:

Recent and ongoing carbon stock assessments in mangrove and related ecosystems

Boone Kauffman (Oregon State University) presented on the importance of mangroves to sequester and store carbon. He highlighted the differences in mangrove structures globally (species, climate, tree densities, salinity, carbon sequestration, storage). He also talked about the implications of various land uses on carbon emissions. Data suggests current estimates of emissions associated with mangrove conversion to shrimp ponds are very conservative and in reality as much as a ton of CO_2 may be released per every pound of shrimp produced.

Seagrass meadows as globally significant carbonate reservoir

Nuria Marba (Instituto Mediterráneo de Estudios Avanzados) presented her research results which showed that 1/3 of particulate inorganic carbon (PIC) is buried in sediments, of which ½ is in coastal sediments. Global assessments put the range of PIC in top meter of soil at 100-1200 Mg/ha, with an average of 733 Mg/ha. However, significant variation in PIC exists between species and with latitude. Her results suggest that global PIC accumulation rate in seagrasses is comparable with coral reefs and other marine ecosystems and thus these ecosystems deserve similar study and attention.

Beyond blue carbon: coastal engineers discover a new material

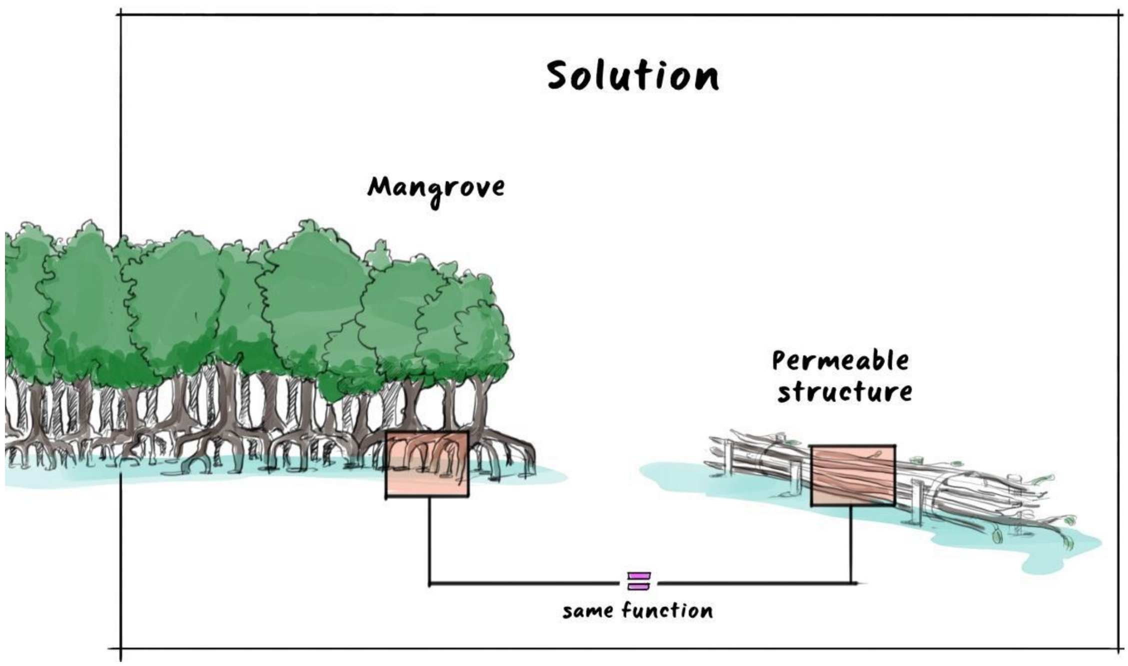
Carlos Duarte (Instituto Mediterráneo de Estudios Avanzados) began by outlining ecosystem services provided by seagrass meadows (e.g., coastal protection and defense, refugia from ocean acidification, coastal protection value). Seagrasses are unique in the efficient way that they trap and retain particles and recognition of the value of coastal wetlands has been steadily increasing. He drew attention to the fact that the Blue Carbon Scientific Working Group has not addressed the role of kelps and seaweeds and called for consideration of these systems in future endeavors.

Using blue carbon science in seaweed aquaculture industry

Ik Kyo Chung (Pusan National University) educated the group on the many uses of seaweed and kelp (including wall paper and biofuels). Aside from the products for human use that can be manufactured from seaweed, it also provides ecosystem services such as CO_2 removal. Seaweed and kelp should be considered in blue carbon efforts because it can be produced beyond shallow areas in the deep ocean (providing income without habitat destruction) and healthy seaweed beds are estimated to absorb 15 tons of CO_2/year/ha.

Building with nature: Indonesia

Femke Tonneijck (Wetlands International) presented a project that WI is leading in Indonesia where they use permeable structures made from natural materials to guard against coastal erosion.



The project utilizes techniques that were successfully implemented in the Dutch saltmarshes for over a 100 years. The program has had positive results in Indonesia but the structures are new and will need to be tested over time. This presentation stressed the need for better integration of hard (gray) and soft (green) infrastructure when planning for coastal restoration.

ESA activities in ecosystem services assessment: coastal ecosystems

Torsten Bondo (European Space Agency) presented ESA activities that are utilizing earth observations to map ecosystems. They currently have projects in the Yucatan and Australia that include a seagrass and coral reef mapping activity. Projects are planned to start mapping the Philippines and Mozambique in

2014. Their goal is to use habitats as surrogates for ecosystem services. They hope to use these techniques to map additional areas and perform similar assessments.

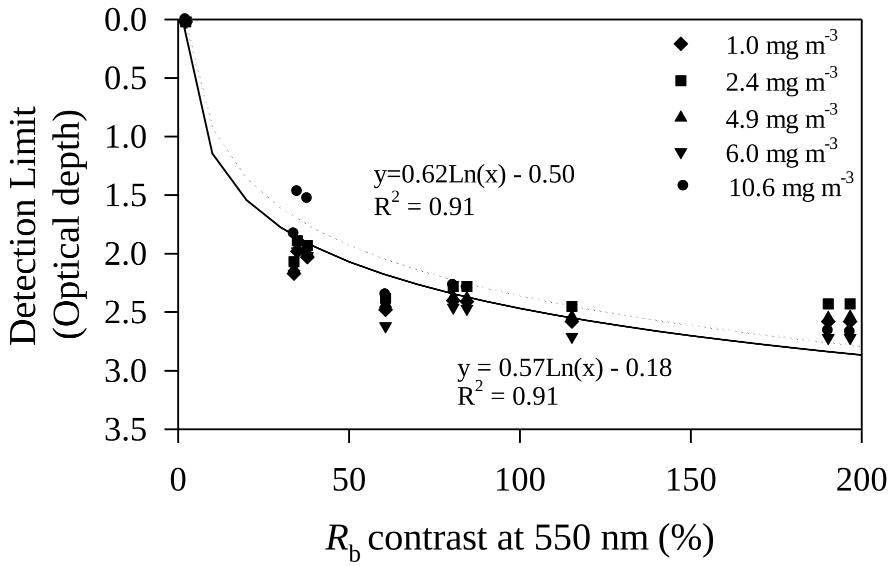
Session 3 – Mapping Seagrasses

Presentations:

Why don't we have better estimates of the global extent of seagrass beds?
Jim Fourqurean (Florida International University) presented a direct observation technique developed in his lab for mapping seagrass beds at regional scales. Observation areas are determined via stratified random sampling (this is proven to allow for good coverage). Direct observations (extent and % cover) are repeated over time and every 5 years the observer returns to the same spot and this creates a comparable time series. This technique allows the observer to assess grasses covered in algae that distort their spectral analysis and observers can monitor sparse meadows that would not normally show up on satellite imagery. This technique has been successfully used to map seagrasses surrounding the islands of Bermuda.

Exploiting remote sensing technology for characterizing and quantifying aquatic vegetation
Richard Zimmermann (Old Dominion University) expressed the need to go beyond just determining the presence/absence of seagrass meadows to actually quantifying what is there. He presented results that suggest there is a correlation between abundance of blue carbon in a system and the biomass of that system. High density meadows are easier to map and once the density drops to around 10% it becomes very difficult to distinguish between seagrasses and sand flats. Bathymetry, spatial scale, and resolution are vital to accurately quantifying biomass and carbon stores. Global coverage can be expensive but there are some free public data sets that can be mined and used to start making a global seagrass map.

Session 3 Discussion:
The two presentations showed two very different approaches (direct observation vs. satellite imagery). The group discussed the merits of both options. It is very difficult for an individual in the water to distinguish changes and seagrass extent and density beyond a regional scale. However, satellite imagery only captures about 60-70% of the total seagrass extent and discriminating between seagrass, algae, and coral is difficult. The best approach may be a combination of both. Satellite imagery will provide a good foundation and in areas where currently no data exist an increase in 60-70% is extremely valuable. Passive remote sensing can achieve and optical depth that is reasonably consistent with the depth distribution of the vast majority of seagrasses worldwide (see figure below). Direct observations can then be used to fill in the other 30%. Concerns were raised about the feasibility of remote sensing because the Bermuda case study, presented by Jim Fourqurean, relied heavily on local efforts and described features that no remote sensing product would have the capacity to resolve. There is a growing concern that the level of uncertainty that results from satellite imagery might create a lack of confidence that leads to stalls in policy implementation.



The relationship of bottom reflectance (R_b)contrast (%) at 550 nm and the detection limit (optical depths) between modeled remote sensing reflectance (R_{rs}) spectra for overlying water columns with different concentrations of Chl *a* (symbols). Detection limit was based on a minimum 4% difference in remotely sensed reflectance (R_{rs}) at 550 nm. The R_b contrast between seagrass leaves and the underlying sediment is in the range of 100% An optical depth of 2.5 corresponds to the 8% isolume. From Wittlinger and Zimmerman (in prep), not shown at the workshop.

The group also discussed the relationship between carbon quantification and leaf area index (LAI). If sediment Blue Carbon is positively correlated with above ground seagrass abundance, remote sensing should provide a useful tool for mapping blue carbon resources in shallow coastal environments worldwide. But it was argued that leaf area alone would not account for allochthonous carbon.

Remote sensing determination of seagrass biomass, in combination with carefully planned field campaigns could easily reduce uncertainty, representing a useful contribution to the assessment of blue carbon stocks.

Breakout Groups:

The larger group was divided into three small working groups. The groups were asked to discuss the rationale for developing a global map, the methods to achieve this goal, and networks that we can draw from. For a complete synopsis of this discussion please see the workshop report “Seagrass Mapping”.

Session 4 – Policy Impacts

Presentations:

Coastal blue carbon in U.S. Federal policies: opportunities and science needs

Ariana Sutton-Grier (NOAA) discussed the ongoing efforts within the U.S. Federal government to move toward increased consideration for ecosystem services in its policies. Recognition of “coastal carbon” as an important and valuable ecosystem service could influence the outcomes of federal statutes and policies that affect coastal ecosystems. Upon analyzing several U.S. policies they found that existing regulatory and policy frameworks require consideration of ecosystem services (but there is little consideration of coastal carbon services), and the carbon sequestration and storage services of coastal habitats could easily be incorporated into the implementation of existing federal policies. The inclusion of coastal carbon in federal policy implementation could lead to outcomes that might be significantly different from those that focus only on living biomass.

Vegetated coastal ecosystems in the IPCC Wetlands 2013 Supplement
Hilary Kennedy (University of Bangor) presented the guidance laid out the new IPCC Wetlands Supplement. Chapter 4 provides guidance for management of specific human activities that impact coastal wetlands. Activities specifically mentioned include aquaculture, salt production, extraction, drainage, and restoration. The supplement can be found here:
http://www.ipcc-nggip.iges.or.jp/home/wetlands.html

<u>Session 4 Discussion:</u>
The discussion focused on integrating carbon in preexisting policies. The group felt that by doing this carbon stocks can impact policy outside the carbon market system, and thinking about how the scientific community can support this is important. In recent years there have been several large disasters (natural and human driven) which could be opportunity to set precedence where ecosystem injury sustained in one country can be mediated through carbon conservation in another country (this could include purchasing carbon credits). Deep water horizon is a great example of the need for more creative answers.

Pressing science needs include:

- Expertise in the agencies (federal employees) to push carbon storage as a valuable ecosystem service;
- Expertise in addressing the challenges associated with coastal restoration;
- Data on how long will it take to restore the carbon stock once its lost;
- Increased consideration of the impacts of climate change so that proposed actions are meaningful not only in the immediate but also in 50-100 years; and
- Peer reviewed guidance on standard best practices for monitoring and evaluating of carbon stores in mangroves, tidal marshes, and seagrass meadows.

<u>Session 5 – Ongoing Development of the Working Group</u>

<u>Presentations:</u>

Ongoing development of the working group
Emily Pidgeon (Conservation International) provided background on the Blue Carbon Scientific Working Group. The original goals of the group included synthesizing current and emerging science on blue

carbon and provide a robust scientific basis for coastal carbon conservation, management, and accounting. Over the years great strides have been made towards creating awareness of blue carbon, developing standards for quantifying and monitoring carbon, support for blue carbon research, and collaboration between sectors. Given the groups past successes, the discussion focused on what remains to be done related to the original objectives and more importantly what goals should be set for the future.

Session 5 Discussion:

Discussion focused on updating the goals and objectives of the Blue Carbon Scientific Working Group. Everyone agreed that capacity building via well-coordinated regional blue carbon leaders around the world (regional champions) would be key and development of regional case studies and guidance on what national implementation might look like is needed. Efforts of this group and others have pushed blue carbon as a valuable ecosystem service into the policy realm, and while the conversations have focused largely on its role in climate mitigation there are opportunities to include blue carbon in climate adaptation discussions as well.

Longer term goals included increasing the amount of crossover between policy and science. For example, what are the information needs and the technical requirements for including blue carbon in REDD+ procedures. Emphasis should also be placed on longer term monitoring initiatives because information on changes in the carbon stock over time is lacking but will be increasingly valuable for funding and conservation purposes. Historically the Blue Carbon Scientific Working Group has focused on ecosystem conservation and the role of blue carbon as a climate change mitigation tool. However there is also a need to talk about blue carbon's role in ecosystem restoration and what knowledge gaps still remain (e.g., how long does it take to restore a wetland, what is the real rate of loss, etc.). There is also a growing need to increase analysis of social science and economic impacts. And while implementation will depend on what each individual nation needs, there is a need to start demonstrating how blue carbon can be integrated into policies and projects at the subnational level.