Seagrass Ecosystems

Benjamin Eovaldi and Robert Eovaldi
Californiametalphoto.com

Widely dispersed throughout our shallow and protected waters lies one of the world's most efficient carbon sinks; seagrass ecosystems.

Seagrasses are perennial flowering plants that grow in patchy distributions making up underwater meadows known to provide shelter for juvenile fishes and marine nurseries thereby supporting aquatic biodiversity and local fisheries (Torre-Castro, 2014). Over the past five years seagrass ecosystems have gained additional recognition as key players in the carbon cycle of the coastal ocean (Bauer, 2013 and Mcleod, 2011). As photosynthetic autotrophs, seagrasses are dependent on energy from the sun and dissolved CO_2 from nearshore and estuary waters to produce food in the form of plant carbohydrates, mainly glucose and fructose, through a process known as "blue carbon".

Photo: Peter Macreadie

Seagrasses have been found to be up to 35 times more efficient than tropical rainforests at storing carbon and are estimated to account for 10 percent of the total carbon buried on the ocean floor (Duarte et al., 2010 and Mcleod, 2011). Why are seagrasses so good at storing carbon? Their ability to outperform terrestrial carbon sinks can largely be attributed to the combined effect of seagrasses' rapid growth rates, comparable to corn and sugar cane, paired with their ability to sequester the majority of organic carbon as compacted sediment for thousands of years on the ocean floor (Lo Iacono, 2008 and Mateo, 1997). However, estimates of seagrass carbon burial should still be viewed with caution as the methods for collecting relevant empiric data are still being refined. In 2014 Macreadie et al. reported that the edge of seagrass meadows contained less buried carbon relative to the centers and that research protocols tend to overestimate the total quantity of carbon stored in seagrass meadows by assuming uniform distribution of carbon burial per unit area. Additional factors such as seagrass species, status of connected habitats, and overall health of the seagrass ecosystem also likely effect carbon sequestration rates (Macreadie. 2014).

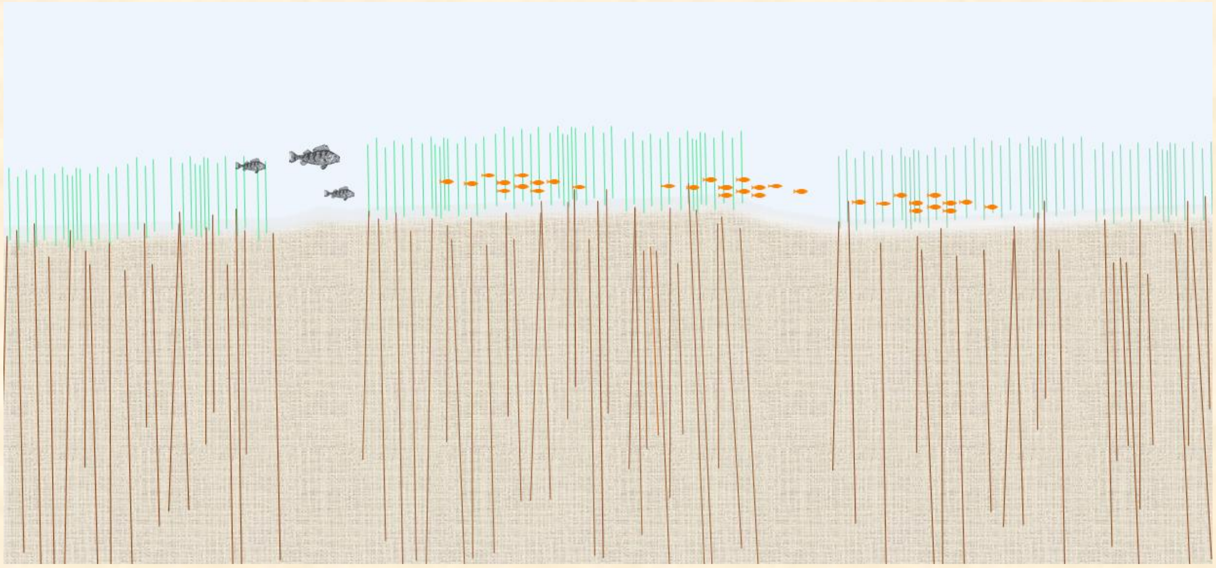

Figure 1: The composition of a seagrass meadow can be conceptualized as four specialized components that work together to support long term organic storage. First, the above-ground plant mater: seagrass leaves, stems, and branches. Second, the below-ground living biomass consisting of seagrass roots and rhizomes. Third, the below-ground nonliving biomass composed of dead seagrass plant matter and external sources organic sediment originating from connected ecosystems such as mangrove forests (Kennedy, 2010). And fourth, the below-ground predominately anaerobic microbial community which is responsible for the slow rate of decay that is seen in undisturbed seagrass ecosystems.

Seagrasses' role in the carbon cycle has been hypothesized to be more elaborate that than simply storing carbon in living plant matter. Previous research has suggested that the loss of seagrass habitats may have far greater impacts; in the same way that burning of fossil fuels releases prehistoric carbon from the earth mantle, destruction of seagrass ecosystems has been thought to release vast quantities of ancient carbon from seagrass beds to the atmosphere (Duarte, 2005). Recently reported in Proceedings B, Dr Peter Macreadie and colleagues investigated the losses and recovery of organic carbon from an Australian seagrass ecosystem that sustained well defined losses from seismic testing performed within seagrass beds during the 1960s. The study found that in areas disturbance, where seagrasses did not recover, contained 72% less stored organic carbon relative to undisturbed areas (Ricart. 2015). An additional finding of the study was that soil collected from areas of partial seagrass recovery contained a greater abundance of anaerobic microbial flora relative to undisturbed areas; possibly because of higher oxygen concentrations in disturbed soils. An ominous conclusion that can be drawn from the study's findings is that the high rate of carbon sequestration seen in established seagrass ecosystems is trivial when compared to the, likely orders of magnitude higher, rate of carbon release to the atmosphere following destruction of seagrass habitats.

$$Atmospheric\ CO2\ \rightleftharpoons Disolved\ CO2\ \rightarrow Organic\ Carbon\ Sequestored\ in\ Seagrass\ Beds$$

(non-spontaneous reaction requiring energy input from a healthy ecosystem)

$$Organic\ Carbon\ Sequestored\ in\ Seagrass\ Beds\ \rightrightarrows\ Disolved\ CO2\ \rightleftharpoons\ Atmospheric\ CO2$$

(spontaneous reaction requiring the catalyst of destruction)

In many respects it is unfortunate that seagrasses' disproportionate role in the carbon cycle is only now being realized because considerable seagrass losses have already occurred. The global and consistently extensive destruction of our coastal landscapes for recreational, urban, and industrial purposes has accelerated at an alarming pace since the turn of the 19th century. In 2009 Waycott et al. reported that 30% of the world's seagrasses are already gone. Perhaps more alarming, the current rate of seagrass losses has accelerated from 0.9% per year before 1940 to 7% per year since 1990 (Waycott et al., 2009). Further, the wide range of estimated global seagrass abundance, 200,000 - 600,000 km^2, makes accurately quantifying overall seagrass losses/recoveries difficult and adds uncertainty to the status of seagrasses. (Duarte 2005b, Charpy-Roubaud, 1990).

Photo: Peter Macreadie

Many examples of seagrass destruction have obvious causes; for example, coastal dredging prior to construction of a boat marina. Other causes of destruction may not be so obvious; soil and fertilizer runoff from agricultural sites to the ocean reduces water clarity and pollutes the nearshore with chemical nutrients. Under certain geologic conditions eutrophication occurs naturally; unfortunately, that is not case for coastal seagrasses. Fertilizer run off is a major cause of seagrasses destruction. Elevated levels of nitrogen and phosphorus favor uncontrolled algae growth. And productive algae blooms further reduce water clarity thereby limiting seagrass photosynthesis setting up a tipping point for the rapid transition from a seagrass to algae dominated system (Green and Short 2013, Neverauskas 1987, Selkoe 2015). The loss of connected habitats also likely negatively impact seagrasses; for example, the predatory shark recently gained considerable attention for its positive indirect effect on seagrasses (Atwood, 2015).

Seagrass hopefuls, what can be done? First, because eutrophication is such a problem for vegetative coastal landscapes conservation efforts should address the problem of fertilizer run off. An example where changes to environmental law positively impacted seagrasses can be seen in Florida; efforts aimed to reduce nitrogen and phosphorus run off to coastal waters lead to a 55% improvement in water clarity and a 27 km^2 increase seagrass area since 1992 (Greening and Janicki 2006). Seagrass conservation is a complex topic. Building on the importance of biodiversity and connected systems we believe that further efforts should be made to expand protected seagrass areas that intentionally include connected habitats.

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