

Joanna,

As the attached flyer indicates, Kelp Pods can be effective mitigation for offshore sewage discharges and urban runoff impacting ocean water quality.

Kelp serves to sequester carbon by uptake in the marine life food chain or is buried overtime to supply offshore oil wells. Multiple benefits include improved ocean water quality and increased fish biomass as NOAA Fish Aggregation Devices.

Aquapod manufactures are interested in partnering for a pilot demonstration project.

Please contact me for more details and many thanks for your efforts to improve California's ocean water quality.

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Installing kelp forests/seaweed beds for mitigation and adaptation against global warming: Korean Project Overview

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Abstract

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Seaweed beds can serve as a significant carbon dioxide (CO₂) sink while also satisfying global needs for food, fodder, fuel, and pharmaceutical products. The goal of our Korean Project has been to develop new baseline

and monitoring methodologies for mitigation and adaptation within the context of climate change. Using innovative research approaches, we have established the Coastal CO₂ Removal Belt (CCRB), which comprises both natural and man-made plant communities in the coastal region of southern Korea. Implemented on various spatial-temporal scales, this scheme promotes the removal of CO₂ via marine forests. For example, when populated with the perennial brown alga *Ecklonia*, a pilot CCRB farm can draw down ~10 t of CO₂ per ha per year. This success is manifested by an increment in biomass accumulations and a decrease in the amount of dissolved inorganic carbon in the water column.

Key words [blue carbon](#) [carbon sink](#) [Coastal CO₂ Removal Belt \(CCRB\)](#) [kelp forest seaweed](#)

Introduction

Covering 71% of the earth's surface, seawater plays a dominant role in regulating climate, offering great potential for fixing and removing atmospheric carbon dioxide (De Vooys, 1979; Raven and Falkowski, 1999; Falkowski *et al.*, 2000; Pelejero *et al.*, 2010). Although they account for <2% of the sea surface, macro-vegetated marine habitats contribute ~210–244 Tg C year⁻¹ or ~50% of all carbon sequestered in the global coastal oceans (Duarte *et al.*, 2005).

The potential for coastal marine vegetation, mangroves, salt marshes, and seagrass meadows to store carbon can be husbanded and enhanced through various management approaches, including marine area protection, marine spatial planning, area-based fisheries management techniques, regulated coastal development, and ecosystem restoration (Laffoley and Grimsditch, 2009). This important vegetation, also known as blue carbon, is cycled through food chains and metabolic processes in seas and oceans, where it becomes bound or sequestered in natural systems (Nellemann *et al.*, 2009). Knowing the scale of conversion of inorganic carbon into biomass, its subsequent sinking to the seabed and its sequestration over thousands of years are basic to our understanding of the ocean as a potential sink for increasing levels of atmospheric CO₂. The other modes of fate of seaweed biomass depend on natural processes. This seaweed can be consumed by herbivores, whose faeces sink to the bottom and may remain there for a while. Moreover, distal portions of the fronds disintegrate during the summer season and those fragments enter the detritus food chain. Exudation as a dissolved organic material can be a critical loss. Therefore, some of the seaweed carbon will return to the water column and be either recaptured during photosynthesis or eventually returned to the atmosphere.

However, depending on location, currents, etc., a significant fraction of the algal carbon can be sequestered on the sea floor for a long period, perhaps centuries. This has been suggested for microalgae, where “about half of (... phytoplankton ...) bloom biomass sank to depths of 1,000 metres or more, well below the upper mixed layer ... Carbon sunk in this way can stay stored for centuries, until deep, slow ocean currents eventually bring it back to the surface” (Smetacek *et al.*, 2012). Sun *et al.* (2008) have reported that, in a massive algal bloom of three million tonnes fresh weight along the coast of China, an estimated two-thirds settled into deep waters. Thus, there is reason to deduce that a massive removal of algal carbon to deep water and to the sea floor can result from a large-scale CCRB that could be positioned on the surface over relatively deep water. Because the Clean Development Mechanism (CDM) project does not allow harvesting for any economic income, the lifespan of seaweeds in the CDM farm might be ~5 years before it dies (such as for *Ecklonia*). In addition to carbon sequestration, seaweed could be harvested to produce biofuels, thereby ensuring that CO₂ is not simply recycled back into the air, but instead replaces fossil fuel with renewable fuel.

Seaweed cultivation is among the many measures that have been introduced for mitigating global warming through enhanced natural sinks. Matthews (1996) has reviewed several climate engineering proposals and has provided a comprehensive resource and ideas for countering this environmental problem. Seaweed has loomed large in those early ocean algae proposals. There, kelp farms are designed to encompass tens of thousands of square kilometres of the open ocean. Seaweed beds act as effective sinks by drastically reducing the level of dissolved inorganic carbon (DIC). To determine the extent of transfer between air and sea, a rigorous assessment of the CO₂ fluxes that are driven by kelp/seaweed beds requires a comprehensive survey of the partial pressure of CO₂ ($p\text{CO}_2$) in the surrounding waters, coupled with an appraisal of water mass advection (Delille *et al.*, 2009) and other carbon sources and sinks in coastal regions.

Although kelp forests are important for metabolizing and cycling carbon, they have received little consideration within the context of sequestration (N'Yeurta *et al.*, 2012). Unlike other blue carbon sectors (mangroves, seagrasses, and salt marshes) that accumulate and retain large amounts of carbon in sediments, kelp forests and seaweed beds do not have such sedimentary substrata. Instead, their carbon-rich biomass detaches and is broken down in food chains by organisms that range in scale from grazing animals to pelagic and seabed bacteria. Because sediment is absent from kelp forests and seaweed beds, such that they lack functionality as large carbon sinks, it is unlikely that the benefit of these marine resources can be addressed through carbon markets and management strategies that are

strictly based on long-term (centennial) sequestration. However, there is substantial potential to develop seaweed CDM methodologies by capturing carbon through algal photosynthesis and using the resulting biomass as a substitute for fossil hydrocarbons. Moreover, although shallow nearshore waters are the natural habitat of most cultured macroalgae, their range can be easily extended to the open sea (Buck *et al.*, 2004). This has been suggested as a win-win mitigation strategy for encouraging sustainable and environmentally sound ocean-based production of plants such as algae and seaweed (Laffoley and Grimsditch, 2009).

As primary producers in the marine ecosystem, seaweeds fix abundant CO₂ through photosynthesis (Smith, 1981; Orr and Sarmiento, 1992; Ritschard, 1992; Gao and McKinley, 1994). Macroalgal communities are very successful; those dominated by *Laminaria hyperborea* can have annual production rates of up to 3 kg C m⁻² (Abdullah and Fredriksen, 2004). Gao and McKinley (1994) and Muraoka (2004) have also reported algal carbon capture rates of >3 kg C m⁻² year⁻¹. Nearly 0.7 million tonnes of carbon are removed from the sea each year within commercially harvested seaweeds (Turan and Neori, 2010). Although seaweed communities occupy only a very small area of the coastal region, they are essential because of their biotic components, valuable ecosystem services, and high primary productivity (Mann, 1982). The unique three-dimensional habitats of kelp forests also make them biodiversity hotspots in cold waters (Christie *et al.*, 2003; Graham, 2004; Coleman *et al.*, 2007).

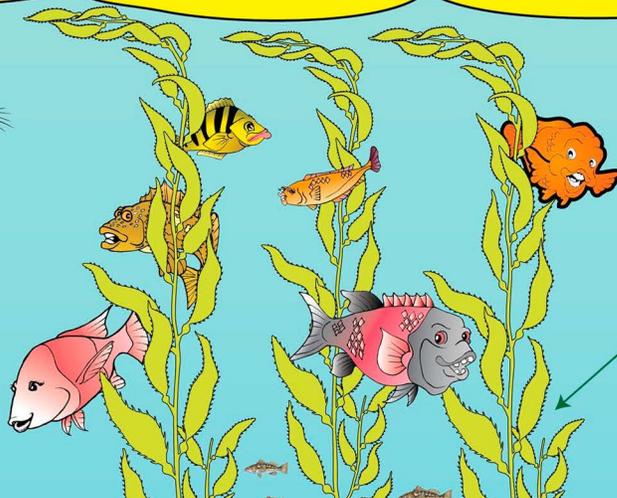


KelpPod



MARINE LIFE

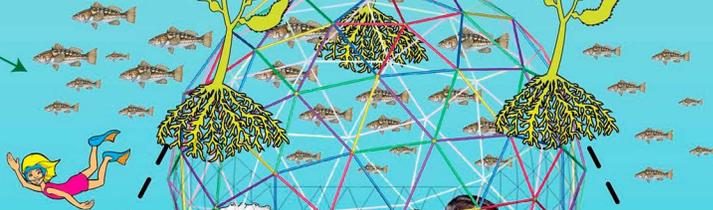
+ Local fish populations increase due to restored habitat



KELP

- + Kelp forest provides habitat for native marine life
- + Kelp levels become sustainable for harvest and sale
- + Water quality improvement through nutrient uptake
- + Increases biomass and carbon sequestration

FREE RANGE FISH



ABALONE

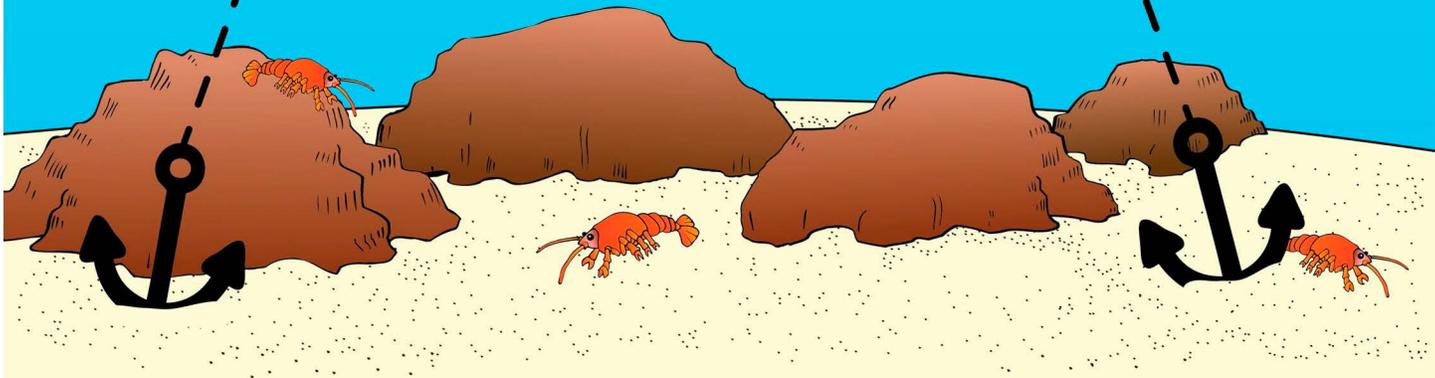
+ Abalone is farmed inside Aquapod

MUSSEL

+ Mussel is farmed inside Aquapod

MODIFIED PRE-ENGINEERED AQUAPOD™

- + Provides elevated structural housing for kelp growth above polluted sediments
- + Mesh is removed from upper half of aquapod to allow fish to freely swim in and out



Artwork by Coast Cartoon Studio www.coastcartoonstudio.com

Aquapod™ is a patented containment system for marine aquaculture developed by Ocean Farm Technologies www.oceanfarmtech.com