Marine Permaculture Offshore Executive Summary

Mission Statement: The Climate Foundation is committed to finding sustainable economic solutions to urgent environmental issues with an emphasis on food security, ecosystem regeneration and validating carbon export from blue carbon ecosystems such as kelp forests.

Vision: Large offshore seaweed forest cultivation fed by deep, cold, nutrient-rich water enables:

- improved fisheries, seaweed products, large carbon sinks, biofuel
- commercial cultivation operations to regenerate life in the oceans
- coral bleaching reversal with barrier reef protection
- carbon negative livestock solutions that transform declining industries
- Marine Permaculture produces seaweed at low capital cost

Marine Permaculture Arrays (MPAs) help coastal seaweed and fishing communities, commercial aquaculture and government ports, as well as ocean regeneration initiatives. MPs restore overturning circulation, cool ocean water and produce seaweed and fish, which fishers can harvest. Marine Permaculture fits within existing mariculture regulations, frameworks and markets for food, fish and seaweed products.

Seaweed: With over 29 million tons of seaweed produced globally in 2015, cultivated seaweed accounted for the largest marine aquaculture production by tonnage. However this productivity is dropping due to marine heat waves. As an example, in Indonesia, over one million people depend on seaweed farming for their livelihood. The seaweed in Indonesia is dying from warming water and associated low nutrient levels. Marine solar powered upwelling technology, a core part of MPAs, can be independently deployed to restore cool, nutrient-rich water to existing seaweed farms. Kelp forests are declining at a rapid pace, particularly in Tasmania. Western Australia has lost nearly 1000 km2 of Ecklonia kelp forest. A hundred-hectare Marine Permaculture array will restore productivity and produce ~$1 million revenue from seaweed (~3,000 tons) each year.

Fish: Marine Permaculture restores fish habitat and encourages fish populations to grow. Once the MP arrays are fully operational, we expect that the habitat will enable harvesting of several hundred tons of fish annually, generating an additional $1M in revenue per 100-hectares of Marine Permaculture per year. Without nets, some fish production is returned to the sea.

Fish feed: Aquaculture companies use supplements derived from fish oil to provide omega-3 fatty acids (DHA and EPA) to their fish stocks. Marine Permaculture produces EPA and DHA as the true source for these long-chain Omega-3 fatty acids, suitable vegetarian sources.

Aquaculture: Commercial aquaculture companies are producing several hundred-thousand tons of fish waste, reducing oxygen levels in nearby waters. Major salmon aquaculture companies now want to be seen as helping the environment by

demonstrating MPAs ability to pull >10% of the nitrogen out of the regions of fish pens via seaweed farms.

Livestock Feed: Marine Permaculture can help make livestock carbon neutral. Livestock accounts for 44% of all anthropogenic methane emissions, and methane is 28-72 times more powerful a greenhouse gas than CO_2e. By supplementing the diet of livestock with <1% of *Asparagopsis seaweed*, cattle emissions can be reduced by up to **90%** while making the cows healthier and heavier (Li et al, 2016).

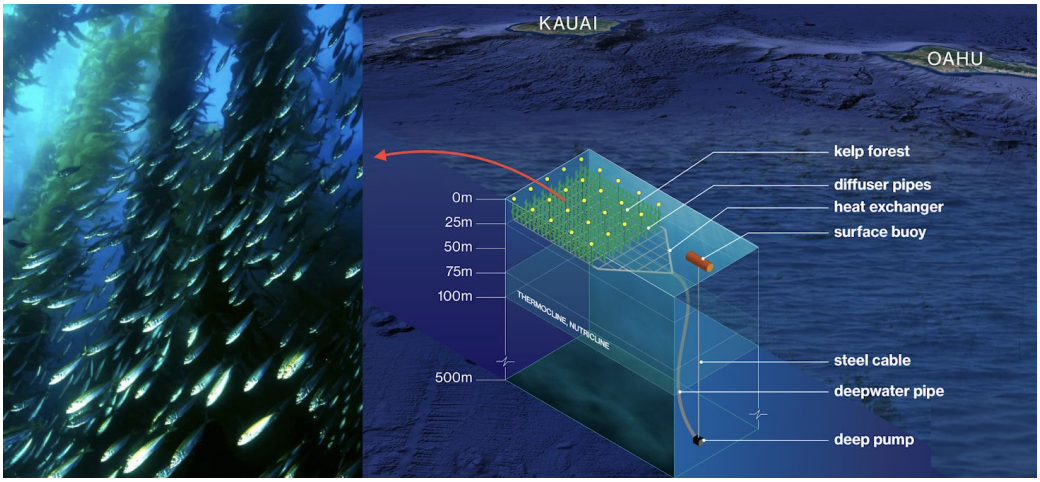
Fertilizer and Biostimulants: Mineral phosphate supply, a fundamental ingredient in fertilizer, is limited. Seaweed extracts not only provide phosphate, but also catalytic biostimulant for crops, increasing yield over the usual NPK levels.

Biofuels: Anthropogenic emissions (38 gigatons CO_2e/year) point to the obvious need for biofuels as a circular source of fuel. Fortunately, one ton of seaweed can fix one ton of carbon dioxide. Carbon fixation in kelp forests can exceed the carbon fixation per hectare of terrestrial forests. Carbon export to >1000m ocean depth can be independently verified and accounted for. To this end, our analysis of greenhouse gas reduction has revealed sustainable drawdown of CO_2 as a byproduct of producing and using seaweed as food, fish, fish feed, fertilizer and foliar biostimulants for agriculture. We are also part of the US DOE MARINER Program for biofuels to develop offshore biorefining for food, feed and fertilizer before converting remaining seaweed residuals into biocrude through hydrothermal liquefaction for oil tankers.

Marine Permaculture Approaches

Marine Permaculture™ may be our best chance to restore natural ocean circulation and life in the oceans, while mitigating climate change and offering food and economic security to millions of people who rely on the ocean for their livelihoods.

With a lightweight flexible design, Marine Permaculture can be deployed offshore, growing seaweed, attracting and feeding fish, and providing sustainable harvests and ecosystem services traditionally provided by kelp forests. Importantly, MPs pay for themselves through seafood and seaweed monetization, while drawing down carbon to the deep ocean, where it can stay for millennia.



Restoring natural ocean circulation results in cooler waters, even in tropical climates. With Marine Permaculture, we can locally cool surface water to pre-industrial era temperatures, preventing coral bleaching and moderating marine heat waves. A steady supply of affordable high-quality seaweed and fish can spur the development of new businesses and strengthen existing ones. MPs provide sustainable revenue (sales of fish, seaweed and by-products), thereby contributing to developing the local economy.