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The coming green wave: Ocean farming to fight climate change

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Seaweed farms have the capacity to grow huge amounts of nutrient-rich food, and oysters can act as an efficient carbon and nitrogen sink.

For decades environmentalists have fought to save our oceans from the perils of overfishing, climate change, and pollution. All noble efforts -- but what if environmentalists have it backwards? What if the question is not how to save the oceans, but how the oceans can save us?

That is what a growing network of scientists, ocean farmers, and environmentalists around the world is trying to figure out. With nearly 90 percent of large fish stocks threatened by over-fishing and 3.5 billion people dependent on the seas as their primary food source, these ocean farming advocates have concluded that aquaculture is here to stay.

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But rather than monolithic factory fish farms, they see the oceans as the home of small-scale farms where complementary species are cultivated to provide food and fuel -- and to clean up the environment and fight climate change. Governed by an ethic of sustainability, they are re-imagining our oceans with the hope of saving us from the grip of the ever-escalating climate, energy, and food crises.

The Death and Rebirth of the Ocean Farm

Ocean farming is not a modern innovation. For thousands of years cultures as diverse as the ancient Egyptians, Romans, Aztecs, and Chinese have farmed finfish, shellfish, and aquatic plants. Atlantic salmon have been farmed in Scotland since the early 1600s; seaweed was a staple food for American settlers.

Unfortunately, what was once a sustainable fishery has been modernized into large-scale industrial-style farming. Modeled on land-based factory livestock farms, aquaculture operations are infamous for their low-quality, tasteless fish pumped full of antibiotics and polluting local waterways. According to a recent New York Times [editorial](#), aquaculture "has repeated too many of the mistakes of industrial farming -- including the shrinking of genetic diversity, a disregard for conservation, and the global spread of intensive farming methods before their consequences are completely understood."

Unsurprisingly, once information got out among the general public, "aquaculture" quickly became a dirty word. Industry responded with a [strategy of mislabeling seafood](#) and upping their marketing budgets, rather than investing in more sustainable and environmentally benign farming techniques.

But a small group of ocean farmers and scientists decided to chart a different course. Rather than relying on mono-aquaculture operations, these new ocean farms are pioneering multi-tropic and sea-vegetable aquaculture, whereby ocean farmers grow abundant, high-quality seafood while improving, rather than damaging, the environment.

One example is [Ocean Approved](#) in Maine, which cultivates seaweed that doubles as a nutrient-rich food source and a sponge for organic pollutants. Farmers in Long Island Sound are exploring diversifying small-scale organic shellfish farms with various species of seaweed to filter out the pollutants, mitigate oxygen depletion, and develop a sustainable source for fertilizer and fish meal. In southern Spain [Veta La Palma](#) designed its farm to restore wetlands, and in the process created the largest bird sanctuary in Spain, with over 220 species of birds.

Seaweed farms alone have the capacity to grow massive amounts of nutrient-rich food. Professor Ronald Osinga at Wageningen University in the Netherlands [has calculated](#) that a global network of "sea-vegetable" farms totaling 180,000 square kilometers -- roughly the size of Washington state -- could provide enough protein for the entire world population.

The goal, [according to chef Dan Barber](#) -- named one of the world's most influential people by Time and a hero of the organic food movement -- is to create a world where "farms restore instead of deplete" and allow "every community to feed itself."

But here is the real kicker: Because they require no fresh water, no deforestation, and no fertilizer -- all significant downsides to land-based farming -- these ocean farms promise to be more sustainable than even the most environmentally-sensitive traditional farms.

Ramping up food production without increasing greenhouse gas

emissions is vital if we are to survive the coming decades. But land-based food production is entering an era of crisis. The U.N. estimates that global grain production will plummet by 63 million metric tons this year alone mainly because of weather-related calamities like the Russian heat wave and the floods in Pakistan.

Bun Lai, world-renowned sustainable seafood chef, believes that:

If done right, this new generation of green aquaculture is poised to become the most sustainable form of farming on the planet. We need healthy food that protects rather than harms our climate and Earth. It is a key piece of the puzzle for building a sustainable future.

Nature's Climate Warriors: Seaweed and Shellfish

Rather than finfish, the anchor crops of the emerging green ocean farms are seaweed and shellfish -- two gifted organisms that might well be mother nature's secret weapons to fight climate change.

Considered the "tree" of coastal ecosystems, seaweed uses photosynthesis to pull massive amounts of carbon from the atmosphere - - with some varieties capable of absorbing five times more carbon dioxide than land-based plants.

Seaweed is one of the fastest growing plants in the world; kelp, for example, grows up to 9-12 feet long in a mere three months. This turbo-charged growth cycle enables farmers to scale up their carbon sinks quickly. Of course, the seaweed grown to mitigate emissions would need to be harvested to produce carbon-neutral biofuels to ensure that the carbon is not simply recycled back into the air as it would be if the seaweed is eaten. The Philippines, China, and other Asian countries, which have long farmed seaweed as a staple food source, now view seaweed farms as an essential ingredient for reducing their carbon emissions.

Oysters also absorb carbon, but their real talent is filtering nitrogen out of the water column. Nitrogen is the greenhouse gas you don't pay attention to -- it is nearly 300 times as potent as carbon dioxide, and according to the journal Nature, the second worst in terms of having already exceeded a maximum "planetary boundary." Like carbon, nitrogen is an essential part of life -- plants, animals, and bacteria all need it to survive -- but too much has a devastating effect on our land and ocean ecosystems.

The main nitrogen polluter is agricultural fertilizer runoff. All told, the production of synthetic fertilizers and pesticides contributes more than one trillion pounds of greenhouse gas emissions to the atmosphere globally each year. That's the same amount of emissions that are generated by 88 million passenger cars each year.

Much of this nitrogen from fertilizers ends up in our oceans, where

nitrogen is now 50 percent above normal levels. According to the journal Science, excess nitrogen "depletes essential oxygen levels in the water and has significant effects on climate, food production, and ecosystems all over the world."

Oysters to the rescue. One oyster filters 30-50 gallons of water a day -- and in the process filters nitrogen out of the water column. Recent work done by Roger Newell of the University of Maryland shows that a healthy oyster habitat can reduce total added nitrogen by up to 20 percent. A three-acre oyster farm filters out the equivalent nitrogen load produced by 35 coastal inhabitants (PDF).

About 50 percent of seaweed's weight is oil, which can be used to make biodiesel for cars, trucks, and airplanes.

There is an array of projects sprouting up that use a mix of seaweed and shellfish to clean up polluted urban waterways and help communities prepare for the effect of climate change. One initiative, spearheaded by Dr. Charles Yarish of the University of Connecticut, is growing kelp and shellfish on floating lines in New York's Bronx River to filter nitrogen, mercury, and other pollutants out of the city's toxic waterways, with the goal of making them healthier, more productive, and more economically viable.

Then there is the emerging field of "oyster-tecture," dedicated to building artificial oyster reefs and floating gardens to help protect coastal communities from future hurricanes, sea level rise, and storm surges. Architect Kate Orff from the design firm SCAPE is developing urban aquaculture parks that use floating rafts and suspended shellfish long-lines to build more urban green space while improving the environment. She envisions the new urban ocean farmer as part shell fisherman tending to oysters reefs, and part landscaper, tending the above-surface floating parks.

In Connecticut, advocates are pushing for an expansion of the state's existing nitrogen credit trading program to include shellfish farms, thereby reimbursing oystermen for the nitrogen they filter from Long Island Sound each year. With new oyster operations sprouting up all around the country, rewarding "green fishermen" for the positive effect their farms have on the environment could be a model for how to stimulate job growth while saving the planet.

Farm Your Fuel, Power the Planet

Finding a clean replacement for existing biofuels is becoming increasingly urgent. A report commissioned by the European Union found biofuels from soy beans can create up to four times more climate-warming emissions than equivalent fossil fuels. Biofuels have also forced global food prices up by 75 percent -- far more than previously estimated -- according to a confidential World Bank study. And a recent report from the International Food Policy and Research Institute, warned that U.S.

government support for corn ethanol was a major factor behind this year's food price spikes.

Seaweed and other algae is increasingly looking like a viable substitute. About 50 percent of seaweed's weight is oil, which can be used to make biodiesel for cars, trucks, and airplanes. Scientists at the University of Indiana recently figured out how to turn seaweed into biodiesel four times faster than other biofuels, and researchers at the Georgia Institute of Technology have discovered a way to use alginate extracted from kelp to ramp up the storage power of lithium-ion batteries by a factor of ten.

But unlike land-based biofuel crops, seaweed farming does not require fertilizers, forest clearing, water, or heavy use of fuel-burning machinery -- and, as a result, according to the World Bank, has a negative carbon footprint. While the technology is still in development, farmers are eager to begin growing their own fuel and create some of the first closed energy loop farms on the planet.

The U.S. Navy has already developed the Riverine Combat ship and Seahawk helicopters powered by seaweed-based bio-diesel. The Pentagon views seaweed and other algae as a key component in their efforts to reduce their carbon footprint. According to Alan Shaffer, the Pentagon's principal deputy director of defense research and engineering:

The beauty with algae is that you can grow it anywhere and to grow it needs to absorb carbon dioxide, so it's not only a very effective fuel, in theory it's also a carbon sink. That's a pretty good deal.

The DOE estimates that seaweed biofuel can yield up to 30 times more energy per acre than land crops such as soybeans. According to Biofuels Digest,

Given the high oil yield from algae, some 10 million acres would be sufficient ... to replace the total petro-diesel fuel in the United States today. This is about one percent of the total amount of acreage used in the United States today for grazing and farming.

The world's energy needs could be met by setting aside three percent of the world's oceans for seaweed farming. "I guess it's the equivalent of striking oil," says University of California, Berkeley microbial biology professor Tasios Melis.

The Bitter Reality of Climate Change

These are urgent times, demanding creative and bold solutions. In his best-selling book Eaarth: Making Life on a Tough New Planet, Bill McKibben breaks the news that climate change is no longer a future threat -- it is here and now and we had better get our affairs in order.

Our oceans are already locked in a death spiral. According to the

International Program on the State of the Ocean (IPSO) -- a consortium of 27 of the top ocean experts in the world -- the effects of climate change, ocean acidification, and oxygen depletion have already triggered a "phase of extinction of marine species unprecedented in human history." Simultaneously, greenhouse gas emissions are breaking records, exceeding even the worst-case scenario envisioned by scientists four years ago.

We face a bitter new reality: Mitigating the effects of climate change may force us to develop our seas to save them -- and planet. This re-imagining of the oceans will be heart-wrenching and controversial. Our waters are revered as some of the last wild spaces on Earth -- ungoverned and untouched by human hands. If we develop our oceans, farms will some day dot coastlines, mirroring our agricultural landscape. But in the face of the escalating climate crisis, we have little choice but to explore new ways of sustaining humanity while protecting the planet.

As we search for new solutions, we cannot afford to repeat the errors made on land, subsidizing industrial-scale factory farms at the expense of environmental and food quality. Simply substituting destructive fishing fleets with destructive fish farms will only hasten the demise of our oceans.

Instead, we can learn from our mistakes and chart a new course guided by principles of sustainability and meeting social needs. This means dedicating portions of ocean to farming -- while reserving large swaths for marine conservation parks. And rather than building sprawling ocean factories, we need create decentralized networks of small-scale food and energy farms growing food, generating power, and creating jobs for local communities. While no panacea, ocean farming -- carefully conceived -- could be a vital part of reversing course and building a greener future.

All of us who hold dear the deep blue sea need to confront the brutal reality that if we ignore the largest environmental crisis of our generation, our wild oceans will be dead oceans.

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