

RESTORING OUR MARINE ENVIRONMENT

BIG CHALLENGES,
BIG SOLUTIONS



Every problem is a solution in disguise

A BIG CHALLENGE

The global fish catch has dropped 23% per person in the past 25 years.* This drop in productivity comes at a time when fisherpeople are exerting more effort than ever to catch fish.

In developing regions like China fishing *effort* is up a staggering 2500% over the last two decades.

What's more, over four fifths of the world's fisheries are either considered fully exploited, with no room for safely increasing the catch, or they are already overfished and in need of rebuilding.

To understand one of the reasons for this decline in catch, we have to move down the aquatic food chain. The ocean's primary productivity is the rate that plants convert carbon into organic material through the process of photosynthesis. Globally, this rate is declining, by some estimates as much as 40% since the 1950s.**

Much of this decline in productivity is thought to be caused by the warming of the oceans. Over 90% of global warming today occurs in the world's oceans in the form of a thickening layer of warm water near the surface. This layer creates an unnatural barrier to the upwelling of nutrients vital for plankton growth. In turn, plankton is a critical food source for many fish.

* J. Matthew Roney, *Taking Stock: World Fish Catch Falls to 90 Million Tons in 2012*, Earth Policy Institute.

** Polovina, J. J., Howell, E. A., and Abecassis, M. (2008), Ocean's least productive waters are expanding, *Geophys. Res. Lett.*, 35, L03618, doi:[10.1029/2007GL031745](https://doi.org/10.1029/2007GL031745).



How can we restore global marine environment and our fisheries, create a way to sequester carbon, and generate renewable energy?

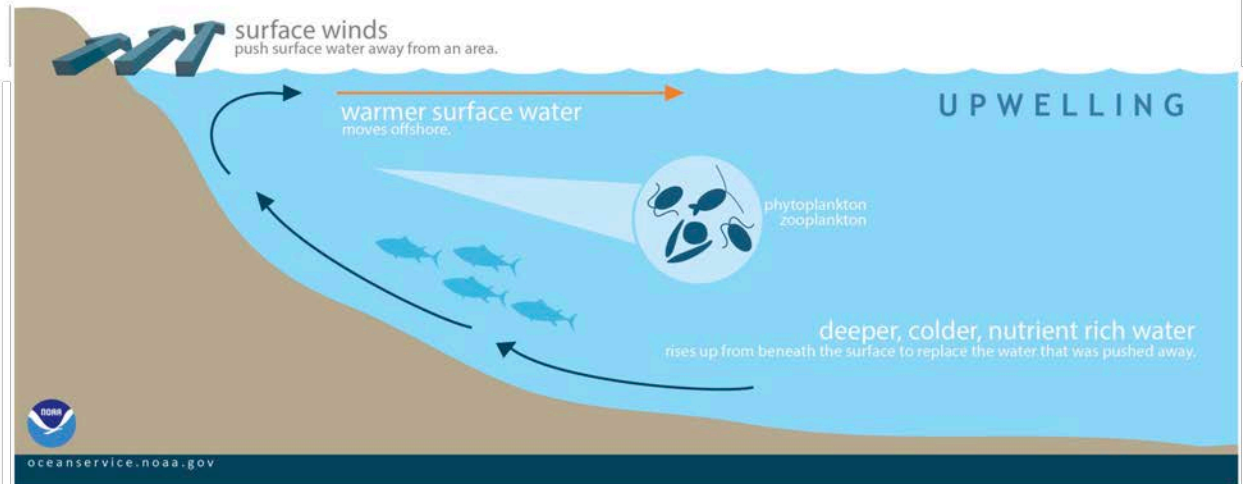
A Solution to begin with...

If we could restore the natural level of upwelling, we could help begin to restore primary production in the oceans and help restore ocean fisheries.

A Promising Solution

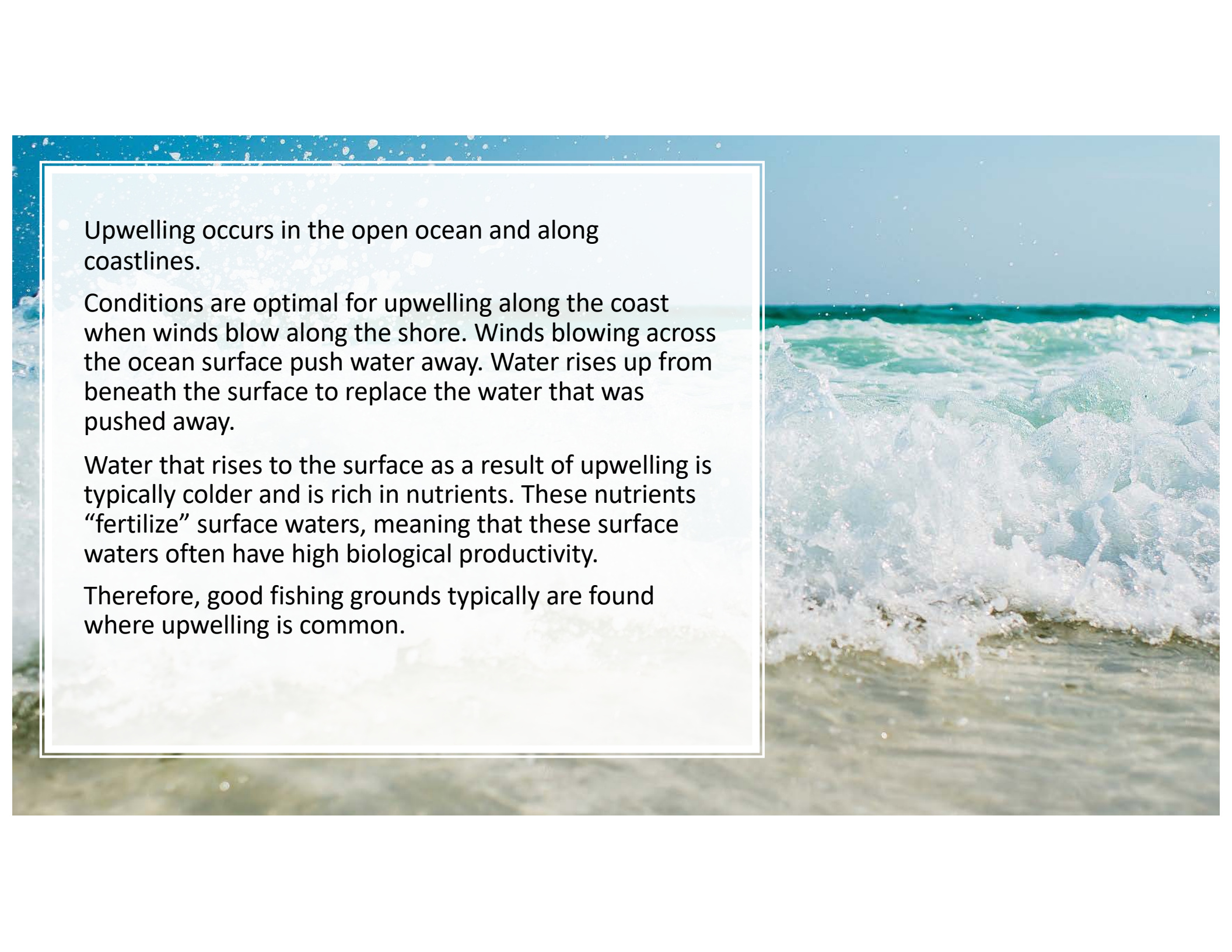
What is upwelling?

Upwelling is a process in **which deep, cold water rises** toward the surface.



This graphic shows how displaced surface waters are replaced by cold, nutrient-rich water that “wells up” from below. Conditions are optimal for upwelling along the coast when winds blow along the shore.

For more on projects using upwelling, see: <http://www.climatefoundation.org/marine-permaculture.html>



Upwelling occurs in the open ocean and along coastlines.

Conditions are optimal for upwelling along the coast when winds blow along the shore. Winds blowing across the ocean surface push water away. Water rises up from beneath the surface to replace the water that was pushed away.

Water that rises to the surface as a result of upwelling is typically colder and is rich in nutrients. These nutrients “fertilize” surface waters, meaning that these surface waters often have high biological productivity.

Therefore, good fishing grounds typically are found where upwelling is common.

MARINE REGENERATION

CARBON SEQUESTRATION THROUGH SEAWEED AND KELP

Our oceans absorb almost all of the excess heat in the atmosphere - about 90% of it - and this means they too are warming rapidly.

They are also becoming more acidic because they also absorb excess carbon dioxide.

Ocean heating is causing mass coral bleaching and threatening marine ecosystems.

Even if we stopped pumping more carbon into the atmosphere, the oceans are already too warm and are in need of an innovative solution. Luckily, there is one incredible organism that can change all of this - seaweed!

Growing up to half a meter a day, seaweed removes carbon dioxide from the water, restoring the alkaline balance. It can draw down huge amounts of carbon from the atmosphere and help restore marine ecosystems (Plus it has so many other uses!).



WHY IS THIS SOLUTION IMPORTANT

Marine permaculture is the ocean farming of kelp and seaweeds. It is a win/win/win/win solution when it comes to taking positive steps to help the planet. It turns out that kelp and seaweed are nature's climate warriors and cultivating them at scale could counteract ocean acidification, climate change and loss of biodiversity.

Seaweed and kelp can also be a source of biofuel, feed for cattle and could provide food security for millions. Our oceans have absorbed over 90% of the heat from global warming to date. This has created a layer of warm water near the surface which acts as a barrier to upwelling which is the movement of nutrient rich water from the deep ocean to the surface. Plankton rely on upwelling for nutrients and, in turn, many fish rely on plankton as a food source. As a result, we have seen the collapse of 13 out of 17 major fisheries.

The ocean has also been absorbing much of the carbon dioxide that we have been pumping into our atmosphere and this is causing the acidification of our oceans. It's time for us to give our oceans a much needed leg up! Marine permaculture requires no fresh water, no deforestation, and no fertiliser. It simply sets up the conditions that are needed for these natural process to take over that will help restore balance to our oceans.

SEAWEED FARM

MARINE PERMACULTURE



WHAT NEEDS TO HAPPEN BY 2040

Researchers estimate that if 9% of the world's ocean surfaces were used for seaweed farming, we would be removing 53 billion tonnes of CO₂ per year from the atmosphere. The key technology required for these ocean farms comes in the form of a lightweight, latticed structure that is roughly a square kilometre in size. It is submerged about 25 metres below sea level where kelp can attach to it. Kelp forests are an amazing carbon sink and draw more CO₂ from the atmosphere by area than land-based rainforests! They will even grow in ocean "dead zones" and, remarkably, will restore these areas. Here's how it works.

The floating platforms use wave energy to pump nutrients from the cooler, deep waters so plankton and kelp have the food they need to thrive. Once the kelp becomes established, it forms the basis of an ecosystem by providing habitat for forage fish who will feed off plankton. Game fish will then join the party because they eat these forage fish, and on and on, up the food chain to tuna and sharks. What was once an ocean dessert, now becomes a productive and thriving community.

Marine permaculture has the potential to provide 200kg per year / per person for 10 billion people. Kelp is also a fantastic food source in itself. Filled with vitamins, Omega-3s and 46 minerals, kelp contains more calcium than milk, more iron than spinach and more fibre than brown rice! Some companies are already developing fibres and bio plastics from seaweed too.



THERE ARE MANY REASONS THAT A POORLY DESIGNED SYSTEM TO PRODUCE ARTIFICIAL UPWELLING COULD BE DAMAGING TO OUR MARINE SYSTEMS, THEREFORE RIGOROUS SCIENTIFIC MODELING NEEDS TO BE CONDUCTED BEFORE IMPLEMENTING ANY SYSTEM.

FOR MORE ON THE CHALLENGES OF GEOENGINEERING ARTIFICIAL UPWELLING, GO TO <http://www.geoengineeringmonitor.org/2018/06/artificial-upwelling/>

WHO NEEDS TO BE INVOLVED

Like any large project, marine permaculture needs investment to be deployed at scale. Potential funding sources include industry, organisations and governments. Marine permaculture could provide food, fuel and fertiliser for the 9 billion people that are likely to inhabit the planet by 2040. It has the potential to improve the livelihoods of local marine communities and bolster their economy by creating an entire industry around kelp and seaweed farming.

Because industry needs people - we'll need fishermen, seaweed farmers and skilled workers for the manufacture and deployment of the pontoons. We will also need people to harvest and commercially manufacture the seaweed products for various uses. These platforms could also potentially become amazing ecotourism destinations, considering the abundant and diverse sea life that will be found in and around them. Once marine permaculture gets a kick start and becomes a self-supporting system, these projects can and will very quickly provide returns on investment.

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Kelp and high-value shellfish, like seaweed and mussels grow on floating ropes, from which hang baskets filled with scallops and oysters. The technology allows for the production of about 40 tonnes of kelp and a million bivalves (two-shelled animals like scallops or clams that can open and close like doors) per hectare per year.

The kelp draw in so much carbon dioxide that they help de-acidify the water, providing an ideal environment for shell growth. The CO₂ is taken out of the water in much the same way that a land plant takes CO₂ out of the air. But because CO₂ has an acidifying effect on seawater, as the kelp absorb the CO₂ the water becomes less acid. And the kelp itself has some value as a feedstock in agriculture and various industrial purposes.

How farming giant seaweed can feed fish and fix the climate

Kelp can help de-acidify oceans and provide a feedstock for agriculture and industrial purposes.



Bren Smith, an ex-industrial trawler man, operates a seaweed farm in Long Island Sound, Connecticut (Image: [Thimble Ocean Farm](#))



HEALTH BENEFITS OF SEAWEEDS

The science of seaweeds is gathering momentum as studies repeatedly underscore the natural health and nutritional benefits of dietary macroalgae.

Consumption of a variety of seaweeds has a positive impact on human brain health, through the gut/microbe/brain axis, and through neuroprotection.

This helps in the defense of human cognitive disorders, such as dementia, Alzheimer's disease, depression, bipolar diseases, and adverse conditions characterized by progressive neurodegeneration.

Psychological benefits associated with the moderate consumption of a diet fortified with macroalgae may reduce depressive symptoms and improvements in sexual function.

Cornish, M.L., Critchley, A.T. & Mouritsen, O.G. *J Appl Phycol* (2017) 29: 2377.
<https://doi.org/10.1007/s10811-016-1049-3>

BENEFITS OF HEALTHY WATER SYSTEMS

The benefits of “blue space” — the sea and coastline, but also rivers, lakes, canals, waterfalls, even fountains (being by water) — is good for body and mind.

Proximity to water — especially the sea — is associated with many positive measures of physical and mental wellbeing, from higher levels of vitamin D to better social relations.

Many of the processes are exactly the same as with green space — Marine and coastal environments have been shown to increase happiness indicators.

Although living within 1km (0.6 miles) of the coast — and to a lesser extent, within 5km (3.1 miles) — has been associated with better general and mental health, it seems to be the propensity to visit that is key.

People who visit the coast at least twice weekly tend to experience better general and mental health.

Even sea views have been associated with better mental health.

SOURCE: <https://bluehealth2020.eu/>



BLUE HEALTH

There are three established pathways by which the presence of water is positively related to health, wellbeing and happiness:

- First, there are the beneficial environmental factors typical of aquatic environments, such as less polluted air and more sunlight.
- Second, people who live by water tend to be more physically active – not just with water sports, but walking and cycling.
- Third (and this is where blue space seems to have an edge over other natural environments), water has a psychologically restorative effect.

Support for the idea of “blue” or “green” prescriptions for individuals is growing, e.g. prescribing “surfing for mental health” is one example of how “nature-based interventions” can work.

“Blue infrastructure” – the coast, rivers, inland lakes – can help tackle major public health challenges such as obesity, physical inactivity and mental health disorders. A 2016 white paper put the monetary value of the health benefit of engaging with the marine environment at \$277 million.

SOURCE: <https://bluehealth2020.eu/>





CONTACT WITH NATURE BUILDS ENVIRONMENTALLY-FRIENDLY BEHAVIORS

The benefits of marine environments for our wellbeing are tied to the health of those environments, and that conservation efforts need to factor in the “natural capital” of blue space in supporting our wellbeing. There is a link between a sense of personal connection to the sea and environmentally-friendly behaviors.

SOURCE: <https://bluehealth2020.eu/>

ADDITIONAL BENEFITS

Phytoplankton also take in CO₂ in the same way that land-based plants do. So increased phytoplankton production, generated by upwelling, can theoretically be an upwelling multiplier to grow our “carbon handprint.”

A *handprint* refers to the beneficial environmental impacts that we can achieve by providing products that reduce our carbon footprint.

A *carbon handprint* is the reduction of the carbon footprint.

Vegetarian fish are considered to be among the healthiest proteins, and the potential demand for seaweed and kelp food sources is huge.





Researcher Tim Gordon deploys an underwater loudspeaker on a coral reef.

Scientists used speakers to make dead coral reefs sound healthy. The fish came back

Gordon, T.A.C., Radford, A.N., Davidson, I.K. *et al.* Acoustic enrichment can enhance fish community development on degraded coral reef habitat. *Nat Commun* **10**, 5414 (2019) doi:10.1038/s41467-019-13186-2



WHAT ELEMENTS DO YOU THINK ARE IMPORTANT FOR
DESIGNING A HOLISTIC MARINE RESTORATION EXPERIENCE?