

FARMING THE OCEAN FOR CARBON MARKET PROFIT: SEAFIELDS' FAULTY PROMISES IN THE CARIBBEAN



etc
GROUP

Communiqué #121

ETC Group is a small, international, research and action collective committed to social and environmental justice, human rights and the defence of just and ecological agri-food systems and the web of life. We are aligned with diverse popular and social movements and civil society organisations who share our values, particularly in the Global South. Together we work to understand and challenge corporate-controlled techno-industrial systems based on scientism, to expose the dangers of the technological manipulation of life and ecosystems, and to build countervailing knowledge and power.



CONTENTS



| | |
|--|-----------|
| Key takeaways..... | 2 |
| Introduction..... | 3 |
| Box 1.1 Seafields' operations in the Caribbean | 6 |
| Scaling Seaweed cultivation | 7 |
| Box 1.2 The Great Atlantic Sargassum Belt (GASB) and its impacts on human ecology | 9 |
| Artificial Upwelling | 10 |
| Seaweed Sinking | 12 |
| Box 1.3 Marine geoengineering combined with other technofixes..... | 13 |
| Seafields and the 'Geoclique'..... | 14 |
| Funding and investors | 16 |
| Solutions to the climate crisis | 17 |
| Regulatory framework..... | 19 |
| Conclusions | 21 |
| Notes | 23 |

We are deeply grateful to the following for their support for this publication and to ETC: Polden Puckham Charitable Foundation, CS Fund, 11th Hour Project.

Research & editing

ETC Group

Illustrations by:

Becky Green:

beckygreenconcepts@gmail.com

Graphic design

Daniel Passarge

danielpassarge@gmail.com

This report is available in

Spanish:

<https://www.etcgroup.org/es/content/la-empresa-seafields-y-sus-irresponsables-negocios-en-el-caribe>

and French:

<https://www.etcgroup.org/fr/content/les-fausses-promesses-de-seafields-dans-les-caraibes>

May 2026

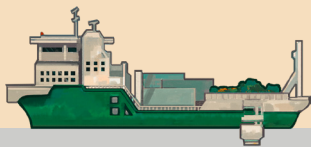
Contact:

www.etcgroup.org



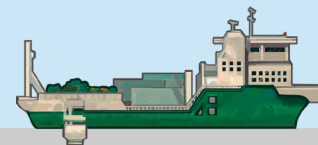
CC BY-NC-SA 4.0





KEY TAKEAWAYS

- Seafields, a UK based start-up company, plans to scale up seaweed production by growing the invasive sargassum seaweed in the Caribbean and establishing a 'giga-farm' in the south Atlantic gyre covering 0.7 million km² – an area roughly the size of Zambia.
- Seafields plans to produce up to 300 million tonnes of sargassum a year to meet its one gigaton CO₂ target. This is around 15 times more than the peak annual bloom of the Great Atlantic Sargassum Belt. But claiming to solve a sargassum crisis by growing more sargassum is a dangerous false solution that risks worsening the Caribbean's environmental crisis.
- Large scale seaweed monoculture plantations alter the biogeochemistry of the ocean, impact other marine communities (such as corals and phytoplankton), invade natural seaweed ecosystems, induce algae blooms and obstruct ships, boats etc. These impacts have already been observed and evidenced by studies of industrial seaweed farms in Asia.
- To induce macroalgal growth, Seafields aims to deploy artificial upwelling (AU), which will involve the set-up of pipes that go hundreds of metres deep into the ocean, with additional infrastructure to keep the overall mechanism working. AU is a controversial and theoretical marine geoengineering technique for which essential science has found no proof that it helps sequester carbon. However, its deployment in large areas of the ocean can pose serious risks to the ocean's integrity.
- The main intent behind Seafields' activities is to earn profit from selling carbon credits in the carbon market. To realise this, Seafields is testing the sinking of bales of sargassum in waters near Barbados, in the hope that carbon will be stored in the deep sea. The deposition of sargassum bales can potentially lead to the disarray of benthic fauna by altering the composition of deep sea ecosystems.
- The push for the deployment of Seafields' contentious marine geoengineering techniques in the Caribbean comes from research backed by a group of scientists from research institutions located in the Global North. Some of the members of this small but influential group had been involved in a controversial ocean fertilization experiment (LOHAFEX) in the past which was cancelled amidst serious concerns for the ecological integrity of the ocean.
- Natural and traditionally managed seaweed ecosystems are among the most biodiverse and productive areas in nature. Seaweed commons which are traditionally cared for by seaweed gatherers, Indigenous Peoples and coastal communities, must be protected as they are a key element of sustainable livelihoods and a crucial basis for securing food sovereignty. Communities affected by monoculture cultivation of seaweed have rejected it—because of the threat it poses to their culture and local economy.
- The UN and governments should uphold the UN Convention on Biological Diversity (CBD) moratorium on geoengineering and the precautionary approach of the London Convention and London Protocol (LC/LP) to marine geoengineering technologies. Discussions on seaweed farming and seaweed-based carbon credits should be excluded in new carbon market mechanisms in the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement (Article 6).



INTRODUCTION



The seaweed industry, which began with the large-scale commercial production of seaweed to meet material, food and energy demands across the world, has now come up with a new business model, primarily to profit from the global carbon market – large-scale seaweed cultivation for carbon sequestration.¹

While seaweed has historically been part of traditional cultures, particularly in Asia, and integral to the livelihood of fisher communities, the large-scale farms of today's seaweed industry have already led to serious environmental degradation. Some documented impacts include – toxic algae blooms,² the contamination of wild seaweed ecosystems,³ the jeopardizing of regional socio-ecological systems,⁴ and other serious negative environmental impacts.⁵

This new model of large-scale seaweed farming is particularly concerning as it introduces new unproven technologies in the ocean, for so-called 'carbon dioxide removal' (CDR). These include sinking the seaweed in the deep sea and establishing Artificial Upwelling (AU) infrastructure to bring deep ocean water to the surface. Both seaweed sinking and AU are forms of marine geoengineering technologies, which involve techniques aiming to alter the earth's oceans to mitigate some of the impacts of climate change. Some of these include: ocean fertilization techniques, marine cloud brightening, solar radiation modification (SRM), and ocean alkalinity enhancement. Marine geoengineering techniques are highly controversial because of their potential to negatively impact the oceanic ecosystem.⁶

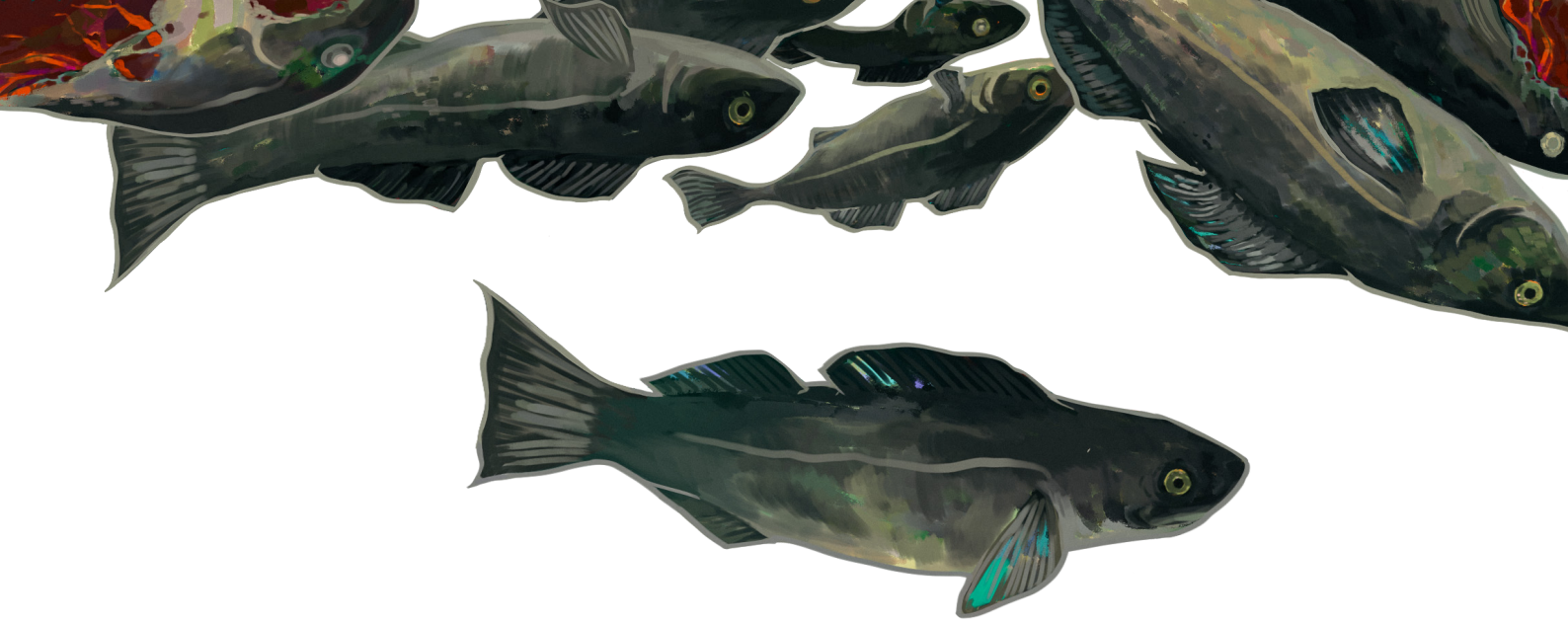
Geoengineering broadly refers to the deliberate, large-scale technological manipulation of Earth's systems. These technologies are posed as a technological 'fix' to the climate crisis but in reality do nothing to address the root causes of climate change.

Geoengineering technologies have proven so dangerous that they have been placed under a *de facto* **global moratorium** by the **United Nations Convention on Biological Diversity (CBD)**. This moratorium was first introduced in **2010** and reinforced in **2016** and **2024**, because of the global concern over the potential dangers these technologies pose to ecosystems and biodiversity.⁷

Despite the CBD's moratorium and precautionary approach towards geoengineering activities, including marine geoengineering, several commercial projects are moving forward with large-scale seaweed farming projects aimed at carbon removal.

One of them is Seafields – a UK-based aquaculture business⁸ with the main goal of growing massive amounts of sargassum in the ocean for CDR purposes. Their promise to remove CO₂ from the atmosphere is based entirely on the premise that algae is an effective carbon sink. This claim has been challenged by the scientific community, which has demonstrated that seaweed ecosystems may not be an effective carbon sink, but that they may instead emit carbon.⁹ In this scenario, where science itself hasn't settled on the role of seaweed in mitigating the impacts of global warming, are these techniques worth the documented impact and the potential risk? Several factors are worth considering to answer this question.

First, these technologies would need to be established at massive scales to have any climate relevant impact. Since 2021, Seafields has scaled up seaweed production in the Caribbean. They aim to establish a 'giga-farm' in the South Atlantic gyre (a large-scale system of rotating ocean currents), covering 0.7 million km², an area almost equal to the size of Zambia. The sheer scale of such a project will shade a significant portion of the ocean's surface, and also



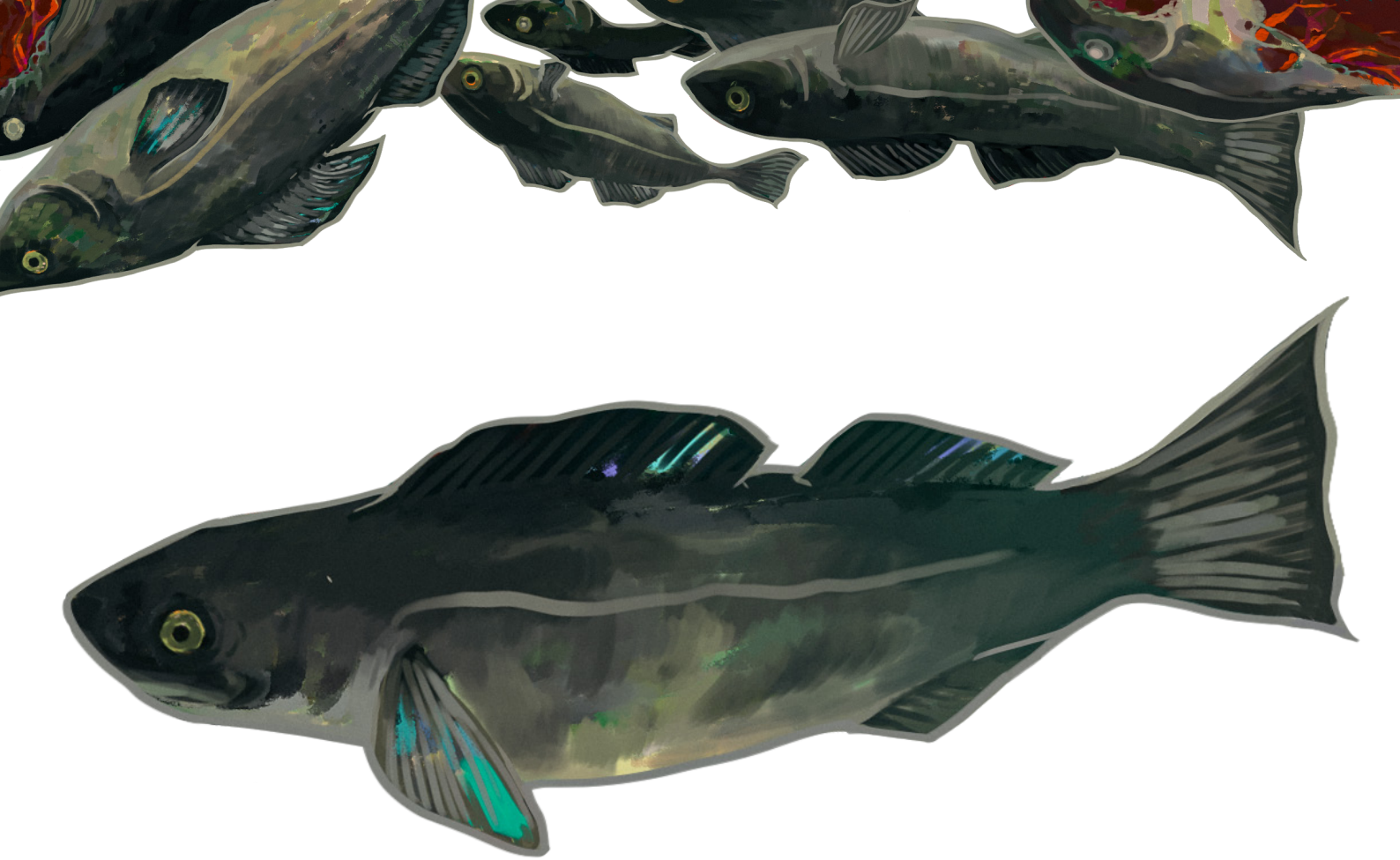
potentially alter the natural oceanic ecosystem. Seaweed has been found to emit bioaerosols that can act as potent greenhouse gases, and seaweed cultivation can rob nutrients from other organisms such as phytoplankton.¹⁰

Second, the large-scale dumping of seaweed biomass on the ocean floor is a novel proposition. Scientists have cautioned that it is moving ahead of both science and ethics.¹¹ Studies have shown that large-scale dumping of biomass in the deep ocean can alter the ocean's biogeochemistry, negatively impacting benthic (deep ocean) organisms. The decomposition of seaweed biomass creates and intensifies hypoxic (low oxygen) conditions, decreasing the survival rate of benthic communities.¹²

Third, the use of AU, the upwelling of nutrient-rich deep ocean water to the surface of the ocean in an attempt to induce macroalgal growth, can introduce risks to the oceanic ecology. One of them is the danger of 'termination shock' – a negative reaction caused by the abrupt halting of a change in progress. This would occur if the intervention of AU was suddenly stopped due to mechanical failure, human error, or incomplete knowledge of data or natural phenomena (like tsunami, storms or earthquakes). Such an event would worsen the effects that they intended to address in the first place.

Finally, these adverse effects on the marine environment would have negative social and economic implications. Shifts in the marine food web and changes in fish populations would impact the fisheries sector, which provides food and employment to millions of people across the world. It would particularly impact coastal communities such as traditional fishers or seaweed gatherers that have historically relied on the integrity of the ocean and have cared for it, to ensure their livelihoods and their future as peoples. Seaweed growers and harvesters, and fisher communities, along with scientists, academics and civil society, have rejected the market-driven approach to 'protecting' oceans and called out the commodification of oceans by business interests.¹³

Despite these grave concerns, companies continue to push for the deployment of so-called marine carbon dioxide removal (mCDR) technologies to profit from the carbon market. Seafields had stated its intent to "become the global leader" in "producing the highest quality carbon removal credits", and it promises to remove over one gigaton (or one billion metric tons) of CO₂ from the atmosphere each year by 2032. However, this promise runs contrary to the reality of carbon credits in the carbon market,¹⁴ which have proved to be highly unreliable. Many carbon reduction claims have been found faulty or unrepresentative of actual carbon reductions.¹⁵



Big climate polluters, including fossil fuel, agribusiness and Big Tech companies, along with giant financial and asset management companies, are pushing for the perverse mechanism of carbon offsetting because it allows polluters to continue emitting on the basis that these emissions could then be artificially ‘removed’ through CDR technologies.

Looking at the wider picture, these proposals are extremely worrying since they take the onus away from focusing on real solutions which aim to work towards cutting direct emissions reductions at source. They

perpetuate false solutions which allow affluent states and corporations to green-wash their polluting activities. A large group of civil society organisations is already pushing for stronger moratoria on these technologies and calling these states and corporations out for distracting real climate solutions at UN climate negotiations.¹⁶

With the effects of climate change growing more severe, we urgently need to address the root causes of the climate crisis with real solutions. Instead of quick technological fixes that protect polluters from being held accountable we need strong frameworks and regulations for environmental protection. We need to ensure the participation of Indigenous Peoples, farmers, fishers, pastoralists, women, youth and other marginalized communities who will be worst hit by climate change in decision-making processes. We need to back strong, informed science that upholds a holistic assessment of the social, political, economic, ecological, ethical and other dimensions of climate change.

Box 1.1: Seafields' operations in the Caribbean

Since 2021, Seafields has been cultivating invasive species of sargassum seaweed in multiple locations, including off the coasts of St. Vincent and the Grenadines and Mexico. They had previously attempted to establish farms in the Fram Strait and off the southern coast of the UK, but these projects were cancelled.¹⁷ In addition to selling carbon credits, Seafields plans to extract 'valuable products' from the sargassum to feed into the biofossil fuel industry – such as biofertilizers, bioplastics and biofuels. They launched their project by claiming it would address the problem of excessive sargassum washing up on beaches, a crisis which is linked to the Great Atlantic Sargassum Belt (GASB) that affects coastal regions across the Atlantic, the Caribbean, and the Gulf of Mexico (you can find more information in Box 1.2). They aim to scale up their activities as soon as a revenue stream from selling carbon credits and seaweed-based products has been established.

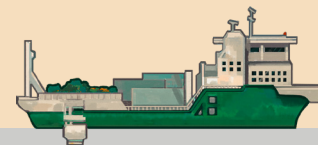
In the Caribbean, Seafields intends to scale up seaweed production in stages. The company aims to complete these operations by the end of 2030, with claims to establish large-scale farms as early as 2026. Their plans include the following:

- To keep up with their claim of addressing the problem of excessive sargassum washing up on beaches from the GASB, they will establish five 1,000m² (total 5,000m²) barriers in the ocean to catch the sargassum. The caught sargassum will then be transported to their various partners from the biofuel industry.
- Simultaneously, they will scale up sargassum production by establishing 60 paddocks (modular farms) covering an area of 60,000m² to maintain supply. These farms will be built at both nearshore and offshore locations.
- As their operations expand, they will scale up to 360,000m² nearshore farms which they plan to grow to 10,000km² (roughly the same size as Jamaica) and claim it will abate 100 megatonnes of CO₂.
- Finally, they will establish a 'Giga Farm' in the South Atlantic Gyre by 2030, which will consist of modular farm components covering an area of approximately 0.7 million square kilometers. Artificial upwelling will be deployed in the open ocean to feed nutrients to this gigantic farm.¹⁸

They have also started their biomass sinking experiments in the Caribbean. In 2024, they deployed bales of sargassum off the coast of Barbados under their SeaSINC project. SeaSINC is a biomass sinking project in collaboration with the National Oceanography Centre, Integrated Environmental Solutions and CERMES University of the West Indies.¹⁹ These experiments were carried out at two sites – one at 1,000 metres depth and another at 4,000 metres – both within Barbados' Exclusive Economic Zone. Site 1 lies off Barbados' western coast, while Site 2 is further to the southeast.²⁰ Baseline assessments for these trials were conducted from the research vessels RRS James Cook and RRS Discovery, with support from deep-sea specialists at the National Oceanography Centre (NOC).²¹

Their offshore aquafarm infrastructure includes: floating paddocks with a 'barrier technology'; monitoring technologies (including GPS and drones equipped with sensors) which track their farms; electric aquatic drones for harvesting the biomass; and a ship where sargassum will be collected and 'valuable products' extracted.

Seafields has not provided further details on whether it has conducted trials of artificial upwelling. Any deployment of artificial upwelling technologies will require the installation of large infrastructure such as pipes which will go hundreds of metres deep, and floating platforms for the necessary energy infrastructure.



SCALING SEAWEED CULTIVATION

HOW LARGE-SCALE SEAWEED FARMS CAN THREATEN MARINE ECOLOGY IN THE CARIBBEAN

While the potential of seaweed to draw down carbon dioxide is well known, its ability to sequester carbon permanently has been overhyped by proponents of industrial seaweed farming in order to bolster their plans of scaling up. In fact, a recent study has debunked this claim, demonstrating that the carbon released by seaweed ecosystems could be as high as 150 tonnes per km² every year. Moreover, seaweed's behaviour is important in relation to other organisms and the entire biogeochemistry of the ocean. The expansion of seaweed can impact other organisms and affect the ocean's natural capacity to sequester carbon.²² Some of these impacts include:

Impacts on other organisms, such as plankton and corals: Seaweed consumes nitrogen and phosphorus from the surrounding waters. A booming seaweed population would deprive other organisms such as microalgae or phytoplankton, which are the largest global source of oxygen, of these nutrients. It could ultimately reduce microalgae activity, cancelling out some of the carbon sequestration achieved by seaweed.²³ Seaweeds also produce compounds that have been observed to inhibit the growth of corals.²⁴

Changing the biogeochemistry of water, and decreasing oxygen levels: Seaweed naturally falls to the seafloor, but the introduction of large amounts of

decomposing biomass would increase carbon levels and create conditions of low oxygen (hypoxia) in the area. This would have a negative impact on benthic ecosystems, decreasing their ability to survive. The descending seaweed may also transport pollutants and noxious compounds from the surface of the ocean into the deep sea.²⁵

Impacting the climate and weather: Seaweed ecosystems are also known to produce bromoform and other gases such as halomethanes, which contribute to ozone depletion. It is likely that large scale seaweed cultivation would lead to an increase in the emission of these gases.²⁶

Increasing heat uptake of oceans: The presence of large amounts of macroalgae on the surface decreases the ocean's albedo (its natural capacity to reflect sunlight), resulting in reduced sunlight reflection and increased heat absorption by surface waters.²⁷

Impacting oceanic communities through the shading of light: The installation of large farms on the surface of the ocean will block light from reaching kelp beds and seagrasses. The shading of the seabed also affects natural biological communities such as corals.²⁸

Seafields validates the scale up of their

farms by harping on another claim of industrial seaweed proponents, that artificial seaweed farms will provide 'ecosystem services' by serving as habitats for marine life. A survey of over 20 experts alongside a review of almost 300 research papers found little evidence for these benefits.²⁹ Artificially created industrial farms do not perform the same function as natural seaweed ecosystems, just as afforestation practices cannot replace the ecological role of natural forests. Natural sargassum ecosystems play a crucial role in the oceanic environment – but the introduction of commercial sargassum species is more likely to have negative ecological and economic consequences.³⁰

One of the serious ecological impacts artificial seaweed farms can have is the introduction of invasive seaweed species to the natural ecosystem. Seafields is growing the invasive sargassum (both *fluitans* and *nattans*) in nearshore and offshore locations which can threaten native species of sargassum. Commercially introduced sargassum can invade native seaweed and natural seagrass ecosystems which have little natural resistance to commercial species. With decreased resistance of natural ecosystems over time, it could lead to further spread of the invasive sargassum. Marine scientists predict that if introductions of commercial seaweed in the ocean environment continue they will have a major ecological impact on the biodiversity of the ocean in the future.³¹

Industrial seaweed cultivation is also susceptible to diseases and pest outbreaks and can impact natural seaweed populations. Seafields claims that seaweed from their farms will not escape due to their 'barrier technology', but they have failed to undertake a full consideration of escape risks in the context of disease and the growth of pests, which can harm other marine life.³² Moreover, the infrastructure required for massive seaweed-farming operations can obstruct and disturb marine life both during construction and throughout its use.

Seaweed farming is most viable in coastal areas, and it is likely that Seafields's operations will be concentrated near or on the coasts. Coastal areas are high-biodiversity zones which are already subjected to pressures by many coastal and ocean proposals such as hydrocarbon projects (referred to as 'blue economy projects'), mineral extraction, tourism and military activities.³³ In addition, coastal areas are not empty – they are the basis of traditional fisher people's livelihood and cultural practices, and are at the heart of social, cultural, traditional and religious practices, as well as livelihoods.³⁴ The establishment of such farms can clash with existing local forms of resource governance and utilisation mechanisms, raising human rights concerns for traditional coastal communities.

Seafields has plans to expand its operations in the Caribbean, which would intensify and worsen the serious environmental problem of excessive sargassum beaching on the coasts and nearshore waters. Every year, this problem greatly impacts marine life and the livelihood of local fisher peoples, with implications for both the environment and for human health.³⁵

Seafields aims to maintain a year-long supply of sargassum stock for seaweed-related industry, which would require them to produce as much as 300 million tonnes of sargassum a year.³⁶ For the sake of comparison, the yearly peak bloom of the Great Atlantic Sargassum Bloom (a massive sargassum bloom that stretches from West Africa to the Gulf of Mexico) produces 14 million tonnes of sargassum. This means that Seafields would need to produce an amount of biomass 15 times larger than the GASB to fulfil their yearly quota of one gigaton of CO₂ sequestration.

While these numbers are still hypothetical, Seafields aiming to address the problem of excessive sargassum by growing more sargassum is a dangerous tactic disguised as a 'solution'. This would distract attention away from actual solutions to solving the sargassum crisis and if implemented in the future would lead to disastrous exacerbation of the ongoing environmental crisis in the Caribbean.

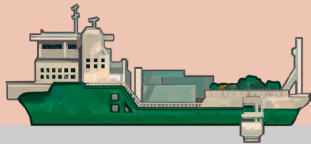
Box 1.2: The Great Atlantic Sargassum Belt (GASB) and its impacts on human ecology

The Caribbean experiences seasonal influxes of sargassum from the Sargasso Sea. In recent years however, an unprecedented sargassum bloom called the Great Atlantic Sargassum Belt (GASB) has formed in the Atlantic Ocean. Excessive sargassum from the GASB beaching on the shores, is causing serious environmental degradation. The crisis has negatively impacted marine ecosystems such as seagrass meadows, fish, benthic organisms, corals and other marine life.³⁷ Human health has also been impacted, with the production of hydrogen sulphide and ammonia from decomposing algae causing cardiovascular and neurological problems.³⁸ It has also significantly affected the livelihoods of coastal people, especially fisher communities who face increased difficulties accessing the sea.

The GASB, which weighed approximately 5.5 million metric tonnes in 2023, covered an area of 8,000km² and stretched from the waters of West Africa to the Gulf of Mexico. The GASB has been found to have less biodiversity compared to the Sargasso Sea, from which it is distinct.³⁹ In June 2023, scientists from the Florida Atlantic University Harbor Branch Oceanographic Institute issued a warning about the presence of flesh-eating *vibrio* bacteria on the macroalgae, which presents a risk to wildlife and humans.⁴⁰

This new phenomenon was previously understood to have been the result of nutrient run-off from the Amazon, alongside the natural upwelling processes occurring in West African waters. More recently, research has led to further insight and a new assessment of the phenomenon's multiple causes: global pollution, deforestation along river banks, fertilizer run off from fields, and wastewater and sewage flowing to the ocean, among others.⁴¹





ARTIFICIAL UPWELLING



HOW AN UNPROVEN TECHNOLOGY CAN CAUSE CHAOS IN THE OCEAN

Seafields intends to use artificial upwelling in their open-ocean farms and specifically for their 'Giga Farm'. Seafields is adapting the oceanographic theory of Henry Stommel's 1956 'perpetual salt fountain' concept.⁴² They will be creating 'custom-designed pipes' which are intended to manipulate ocean circulation by combining upwelling and downwelling movements. There is currently no publicly available data about whether they have already started experiments in the open ocean.

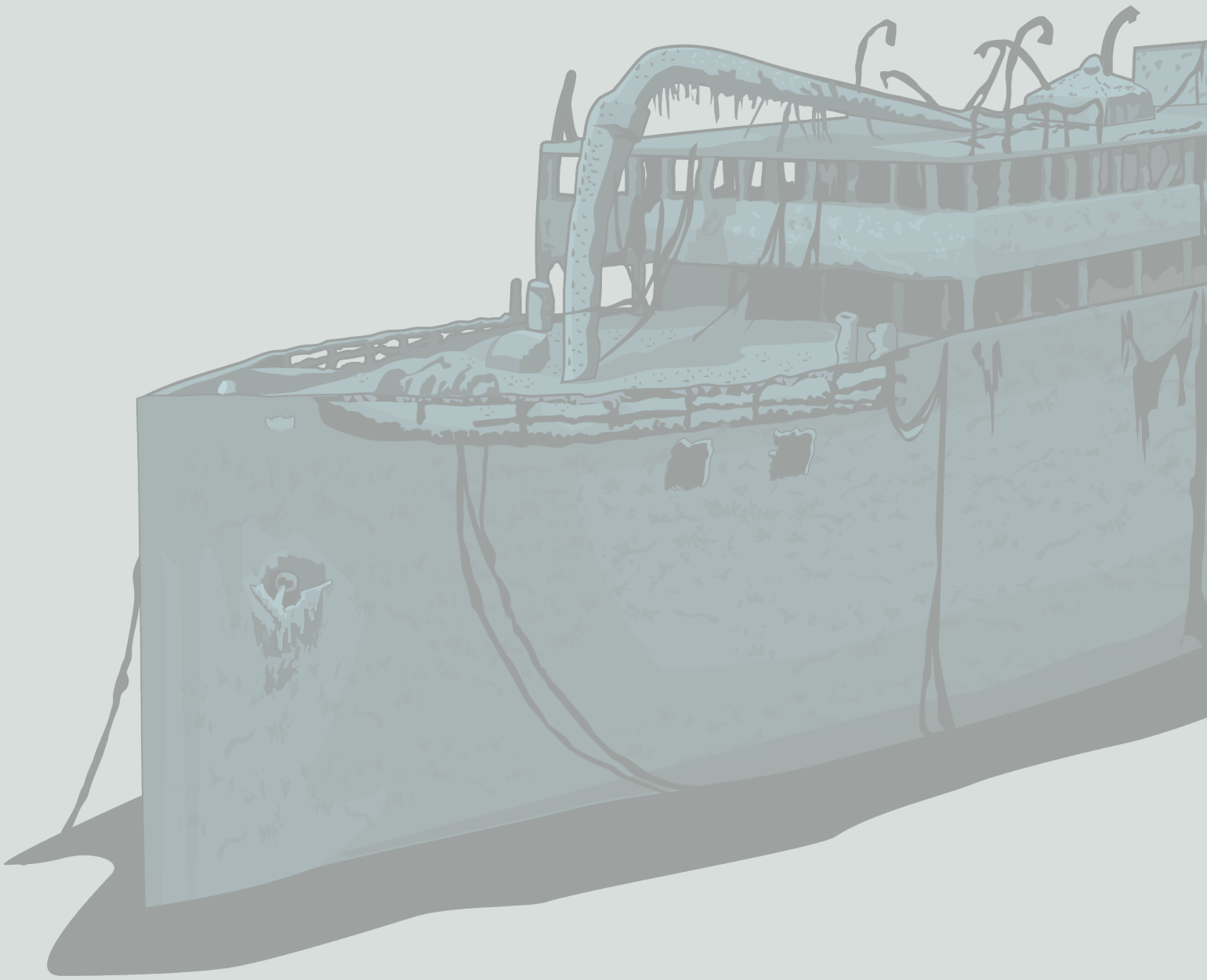
Upwelling in the ocean is a natural oceanic phenomenon, wherein cold nutrient-rich water and various gasses from the deep ocean, including CO₂, are driven towards the ocean's surface and into the atmosphere. Artificial upwelling (AU) is the imitation of this process, and requires a great deal of infrastructure including pipes that reach hundreds of metres deep in the ocean, and appropriate energy sources to keep the machinery running.⁴³

AU is at best a theoretical approach. Artificially pumping deep ocean water in an attempt to provide nutrients to the seaweed farms can have negative consequences. First, AU only redistributes nutrients, gases and heat. So any carbon claimed to be captured from the surface of the ocean and stored in the deep ocean is speculative. The upwelled water also carries dissolved inorganic carbon from the deep ocean to the surface, not just nutrients. Also, while the extra nutrients can fuel more plant growth, the eventual decay of the plant in the ocean uses up a lot of oxygen, which can lead to deoxygenation and ultimately harm marine life.⁴⁴

AU can temporarily cool surface waters by bringing colder, deeper water upward. When the upwelling stops, any carbon stored in the ocean is rapidly released, resulting in a net increase in ocean warming.⁴⁵ Computer models run in Kiel, Germany indicated that artificial upwelling would do little to cool the oceans, and could have a negative impact on the overall health of the ocean.⁴⁶ Artificial upwelling is also expected to disrupt ocean circulation, which can change weather patterns.⁴⁷

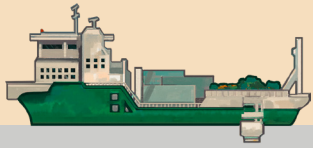
For the past 50 years, upwelling technologies have been tested in labs and in the field, but small-scale trials have shown only limited success. Electrically powered pumps are too expensive to be practical, while systems that use temperature or salinity differences have turned out to be inefficient.⁴⁸ In any case, upwelling technology would need to be deployed over a large area of the ocean to have any impact on global climate and such a deployment could perturb the biogeochemistry of the ocean and cause unforeseen or unwanted consequences.⁴⁹

Expert groups and marine environmental scientists have warned against the potential risks of the technology, and have raised serious questions about its potential for carbon sequestration. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), which advises the UN system to base its work on a solid scientific foundation, has outlined severe environmental and socio-political risks linked to artificial upwelling.⁵⁰ They have called



for a precautionary approach to deploying climate geoengineering technologies, which include ocean upwelling, not only because of the potential risks but because the benefits touted by marine industries have so far been unproven.⁵¹ They also warn that the combination of both AU and seaweed farming will intensify the above mentioned risks for marine

life, fisheries, the environment and socio-political well-being.⁵² Such significant changes in the ocean will impact terrestrial food production and possible transboundary effects. Global fish production will be impacted, and traditional fisher people and coastal communities who depend on a healthy ocean for their livelihood will be the most severely affected.



SEAWEED SINKING



A THREAT TO DEEP SEA BIODIVERSITY

Under the SeaSINC project, Seafields has been testing the sinking of sargassum bales near Barbados at depths of 1,000 and 4,000 metres, within the country's Exclusive Economic Zone. Though framed as research, these trials aim to pave the way for Seafields and other companies to deploy such technologies commercially.

Seaweed sinking in the deep sea for the purposes of carbon storage is an unproven technique, primarily pushed by proponents of the seaweed industry. Dumping seaweed into the deep ocean is neither an ecological, nor ethical solution for climate change mitigation through carbon sequestration.

In light of insufficient evidence demonstrating any tangible benefits for the climate or environment, marine scientists and academics have cautioned that proposals to sink seaweed are advancing prematurely and raise significant ethical concerns. Such initiatives are not in step with the necessary progression of scientific research and, indeed, are moving ahead of it.⁵³ Moreover, our understanding of the deep sea is very limited as only 5% of the seabed has been explored by humans in detail.⁵⁴

The dumping of biomass in a large area of the ocean would certainly alter the biogeochemistry in the local area. An increase in nutrients due to the degradation of the organic matter in the water columns will reduce oxygen levels, creating hypoxic

conditions and negatively impacting organisms in the area. Other noxious gases would also be released, such as hydrogen sulphide, methane and nitrous oxide.⁵⁵

The worst impact of seaweed sinking would be in the deep sea, as the deposition of sargassum bales in the seabed will introduce organic matter in a typically food-poor environment and disrupt the existing ecosystem. The smothering of benthic fauna (organisms that live on the bottom of the ocean) would occur as a result of the loss of oxygen and the release of noxious gasses.⁵⁶

The disruptions to the physical and biogeochemical composition of the ocean is also likely to reduce biodiversity. It will alter the makeup, density and overall biomass of marine life. Infaunal organisms – those living in the seabed – are expected to be completely wiped out in places where the macroalgal waste accumulates. It will also provide an environment for fast-growing, opportunistic species that thrive on organic material which may become more dominant and reshape local food webs.⁵⁷

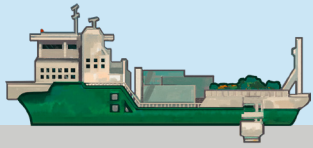
To validate the proposal of sinking seaweed in the ocean, Seafields argues that Caribbean countries are already dumping seaweed in landfills which releases greenhouse gases and impacts the climate. However, moving the dumping of biomass from land to the ocean doesn't solve the problem. Rather, it just moves the problem to the ocean.

Box 1.3: Marine geoengineering combined with other technofixes

Seafields' biofuel projects are a way of generating funds for their marine geoengineering technology. But their claim that “when our partners turn it into biofuels and bioplastics, we replace the need for fossil fuels” does not guarantee it will displace other climate unfriendly sources. The argument that it will ‘replace’ fossil fuel is unfounded since global fossil fuel production in 2024 was calculated at 37.4 billion tonnes, up 0.8% from 2023.⁵⁸

Biofuel in itself is not a ‘clean’ or ‘just’ form of fuel. The expansion of agrofuels (biofuels from agriculture and forestry) across the world has resulted in the loss of forests and more intensive agriculture leading to the use of synthetic fertilisers and the expansion of monoculture plantations. Biofuels produced from palm and soy have led to massive deforestation and come with significant environmental and climate impacts including from direct and indirect GHG emissions. They also have a catastrophic impact on food security since increased demand for biofuel production drives demand for food and feed crops and ultimately leads to increased food prices, both in the short- and long-term.⁵⁹

Moreover, large-scale breakdown of algal biomass – such as through biorefineries that convert seaweed into valuable industrial bioproducts – is likely to rely on high-risk biotechnologies. This process would also demand the development of an extensive supply chain to collect, dry, process and transport the seaweed. Additionally, there is a strong possibility that biorefineries might be located offshore to minimize transport distances, which could introduce new threats to the marine ecosystem and further strain already stressed coastal areas.⁶⁰



SEAFIELDS AND THE 'GEOCLIQUE'

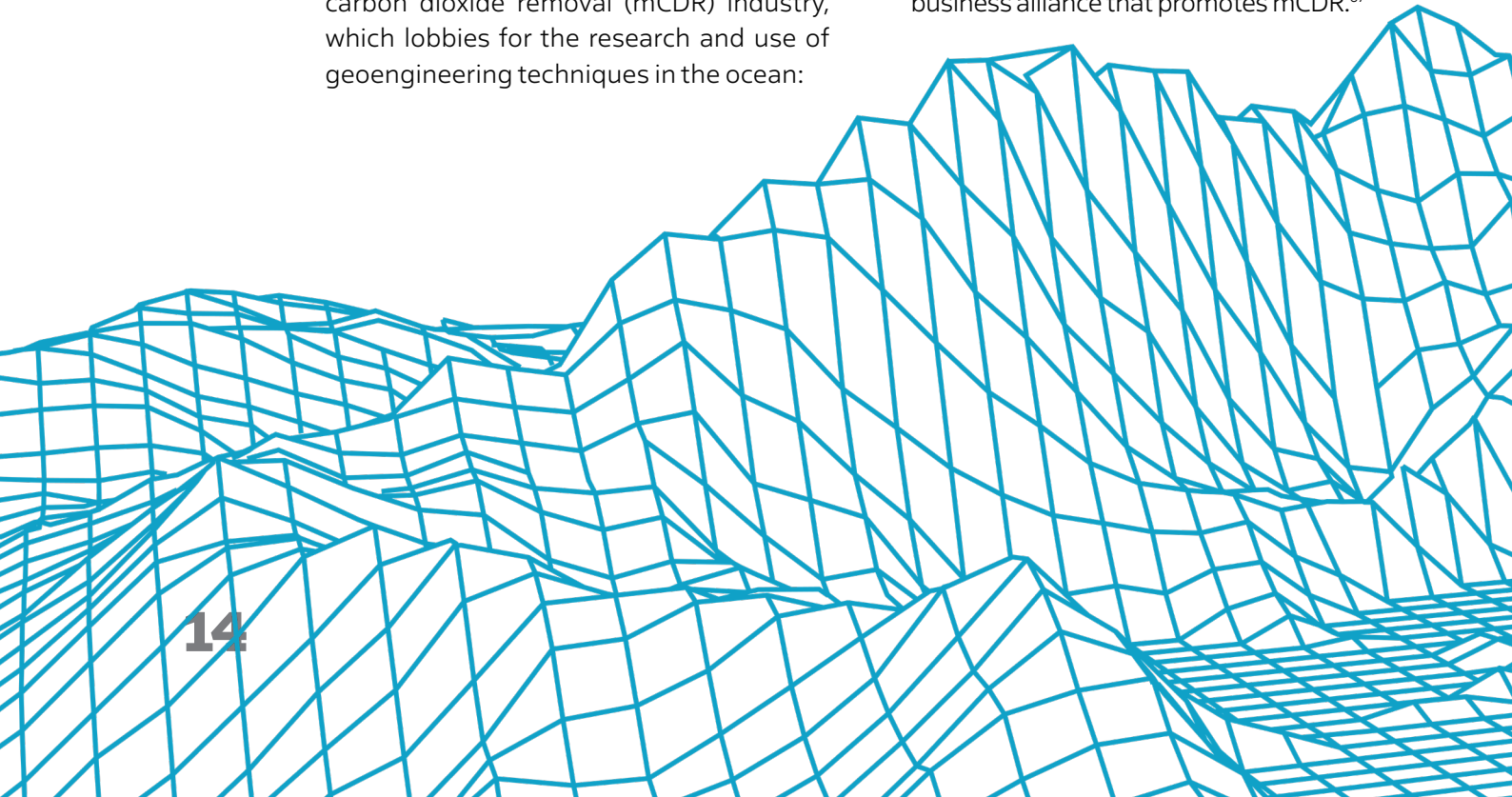


The geoengineering lobby, or 'geoclique' is a group of scientists, mostly based in western Europe and North America and usually supported by philanthropists, who propagate geoengineering proposals in response to climate change and other environmental issues.⁶¹ Seafields's scientific endeavours are part of this circle of philanthropy and funded research.

At the helm of Seafields is their chief scientist, Victor Smetacek, a scientist at the Alfred Wegener Institute Helmholtz (AWI) Centre for Polar and Marine Research in Bremerhaven, Germany.⁶² In 2009, Smetacek co-headed one of the largest ocean iron fertilization experiments in the world, LOHAFEX, in the Southern Ocean. LOHAFEX was cancelled after strong opposition by civil society groups and the German Environment Ministry⁶³ and reported a negligible impact on atmospheric CO₂ from the technologies it tested.

Seafields is also part of a wider marine carbon dioxide removal (mCDR) industry, which lobbies for the research and use of geoengineering techniques in the ocean:

- Seafields has an affiliation with Ocean Visions, a collaboration by several United States universities and institutions, who since 2021 have developed Ocean CO₂ removal (CDR) roadmaps to accelerate the development and testing of marine geoengineering approaches.⁶⁴ Ocean Visions provides financial and technical support to marine geoengineering companies, including Seafields.⁶⁵
- In 2022, Seafields participated in an Ocean Visions working group focused on Sinking Macroalgae for Carbon Dioxide Removal. The working group brought together other mCDR proponents including Running Tide (now defunct), Climate Foundation, the Alfred Wegener Institute's Helmholtz Center for Polar and Marine Research, Phytos and others.⁶⁶
- The company is a member of the World Ocean Council (WOC), an international business alliance that promotes mCDR.⁶⁷



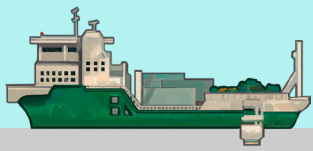
- Seafields is a member of the Carbon Business Council, which is an organization pushing market development for scaling carbon dioxide removal technologies, especially companies which are aiming for gigatonne-scale carbon removal.⁶⁸
- Seafields is part of the UN Global Compact's Global Seaweed Coalition, which promotes a so-called 'Seaweed Revolution' through its manifesto. The group advocates scaling up offshore seaweed farming and sinking practices as a strategy to counter climate change.⁶⁹
- The RETAKE project (CO₂ Removal by Alkalinity Enhancement: Potential, Benefits and Risks) which studies ocean alkalinity enhancement by adding alkaline rock flour to seawater.⁷²
- AWI is also involved in the Carbon Draw-down Initiative Carbdownd GmbH, which is researching enhanced weathering (a type of geoengineering).⁷³

Seafields' activities in the Caribbean are rooted in research led by universities in the Global North. Its scientific team and advisors are largely PhD graduates from Germany's Alfred Wegener Institute (AWI). AWI has been involved in other geoengineering research projects since 2018,⁷⁰ including:

- The OceanNETS project (Ocean-based Negative Emission Technologies) whose objective is to investigate the feasibility and impact of several ocean-based geoengineering approaches, aiming to remove CO₂ from the atmosphere.⁷¹

Seafields and AWI collaborated in the C-CAUSE project (Chemical Carbon Utilization through Sargassum Economy) in 2022. The project set out to promote sargassum farming in the open ocean as a 'proof of concept', claiming it could capture and verify carbon removal while converting the harvested seaweed into ethanol. One year later, another spin-off from AWI, Macrocarbon SL, focused on the cultivation and processing of sargassum for CO₂ capture and for consumer products such as ethanol.⁷⁴

In 2023, AWI along with Seafields and Running Tide Technologies Inc., began a multi-year experiment in the Fram Strait of the Arctic Ocean, at the AWI Hausgarten observatory 150km west of Spitsbergen.⁷⁵ The project aimed to measure how quickly land-based and algal biomass decomposes when dumped on the seafloor.

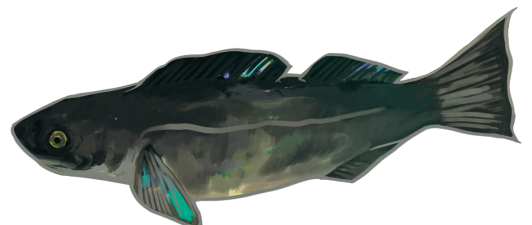
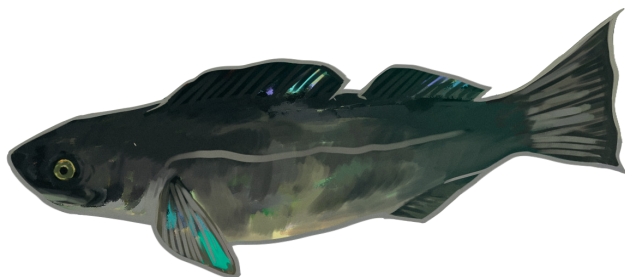


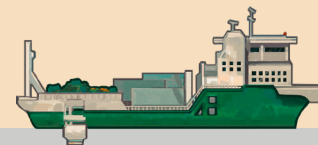
FUNDING AND INVESTORS



Seafields' main source of funding is crowdfunding, with additional support from research institutes in the form of grant funding. They also receive significant support for their tests and trials from national funding agencies in the UK as well as Germany. Available information shows that:

- Their total disclosed investments since 2020 totalled US\$693,000.⁷⁶
- In 2023, their crowdfunding campaign raised US\$63,000-65,000 through a UK-based crowdfunding platform called Crowdcube.⁷⁷
- Innovate UK, a part of the UKRI (UK Research and Innovation) national funding agency, gave a grant of £250,000 to Seafields in 2023. This grant went directly into artificial upwelling pipe trials that took place in the UK. The timing, scope, location and duration of the experiments have not yet been made available to the public.⁷⁸
- The British High Commission in the Caribbean co-funded the SeaSINC project in Barbados.⁷⁹
- Seafields' project in Isle de Quatre (part of the larger C-CAUSE project) is funded by the German Federal Agency, SPRIN-D (German Federal Agency for Disruptive Innovations), providing around €600,000.⁸⁰
- Ocean Visions have provided financial and technical support since 2022.
- Between 2021-2022 a sum of US\$1.17 million was provided to Seafields by founders, friends, family and angel investors. By March 2025, the company had raised US\$3.9 million through grants, equity and debt. Its latest funding round has already attracted over 140 investors, bringing in US\$226,000 so far.⁸¹
- Seafields has also joined the Tech Nation group, a start-up accelerator that provides direct support on fundraising, on acquiring multinational customers, and toward advocating on climate policy from 'mentor' companies such as Google, HSBC Innovation Banking and Oxford University.⁸²
- In 2024, Seafields won Startup of the Year at the inaugural SeedLegals Awards, gaining a £25,000 investment prize. This prize money was matched by an 'angel investor' bringing the total to £50,000.⁸³
- Other sponsors and partners include: CarbonWave, Coldplay and JustCarbon.





SOLUTIONS TO THE CLIMATE CRISIS



OR REAPING PROFITS FROM THE CARBON MARKET?

From its genesis Seafields intended to sell carbon credits to polluters, promising that it will be “producing the highest quality carbon removal credits...” Seafields, like other carbon credit start-ups, is hoping to profit from new ‘blue carbon’ projects in which the ocean is now seen as the new frontier for expansion of the carbon market.⁸⁴ It is betting on the exponential growth of the voluntary carbon market which in 2022 was predicted to grow to US\$10-40 billion by 2030.⁸⁵ Currently, however, the voluntary carbon market is going through transitions amid political upheavals, regulatory changes and demand for higher quality carbon credits.⁸⁶

A major flaw in this business model is the possibility that carbon credits do not work – that they do not mitigate the effects of pollution or address the root causes of climate change. This has already been observed in the case of land-based carbon credits, where it was found that carbon offsetting (a type of carbon market mechanism) in land-based carbon dioxide removal (CDR) methods does not reduce

emissions. Researchers and climate activists examining carbon offset schemes like the UN’s Clean Development Mechanism (CDM) have found, through multiple case studies, that these approaches have in fact led to higher global CO₂ emissions. They found that the expansion of CDM had channeled more funding into fossil fuel power projects.⁸⁷ Terrestrial ecosystems simply cannot ‘offset’ or ‘neutralize’ the emissions produced from extracting, processing and burning fossil fuels.⁸⁸

On top of serious scientific uncertainties and ethical considerations around blue carbon projects, there remain financial and legal hurdles which even supporters of the carbon market are quick to point out.⁸⁹ Despite this uncertainty, voluntary carbon programmes are being pushed.

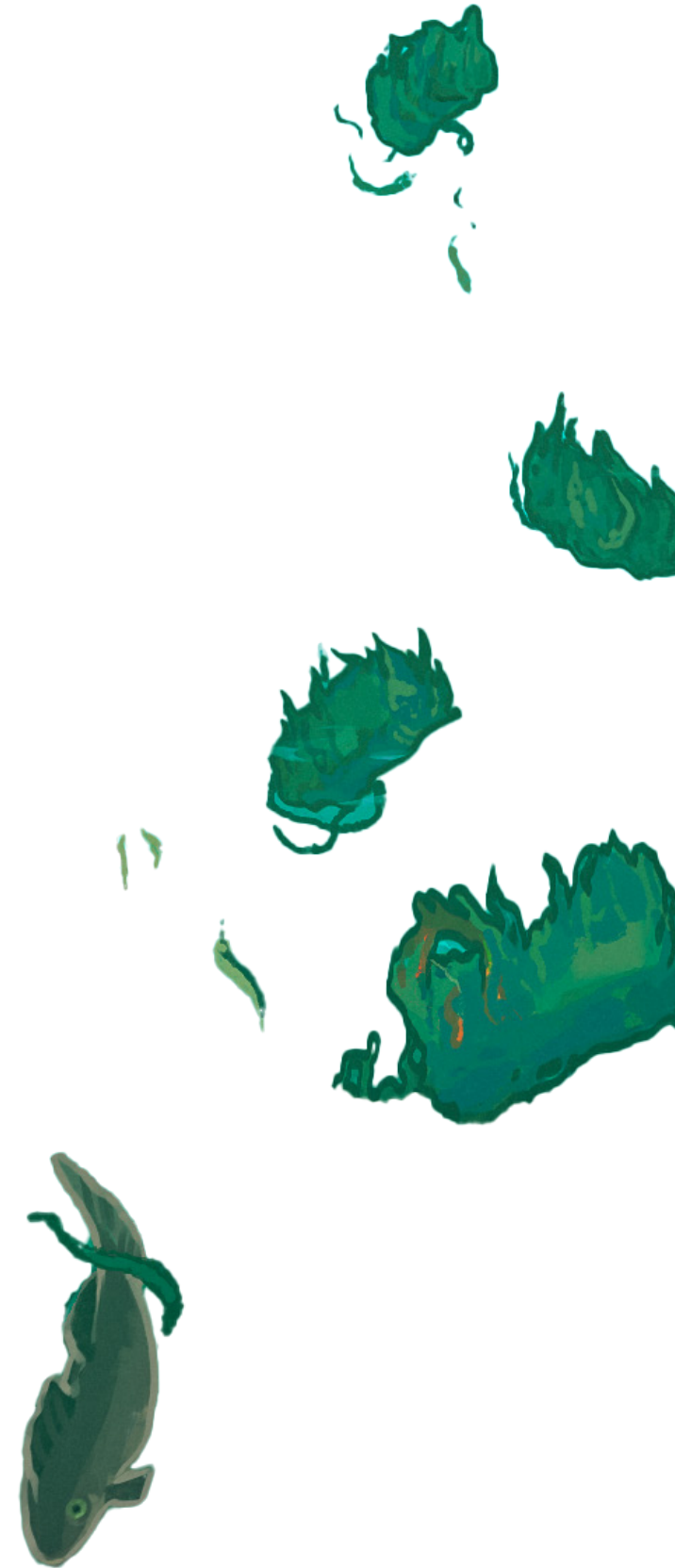
The reputation and integrity of carbon accounting technologies are also coming under question. Verra,⁹⁰ which is one of the world’s largest voluntary carbon trading agents has published the first ‘blue carbon’ offset methodology and is in the process of

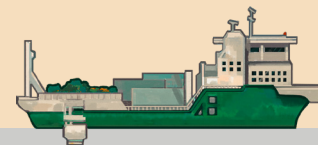


developing credit methodologies covering seaweed farming, restoration and sinking.⁹¹ Traders in carbon credits and consultants in carbon credit methodology are financially motivated to present carbon sequestration technologies as settled scientific fact even when they are unproven and under-researched. Indeed, in 2023 an investigation revealed that 90% of Verra's rainforest carbon offset credits do not represent real carbon credits, but are rather 'phantom' credits created from dubious methodologies and unrepresentative of actual carbon sequestration.⁹²

Currently, 'blue carbon' carbon credits constitute a trickle of credits in the voluntary carbon market. The high implementation costs and the technical barriers have proven unfavourable for industry proponents to scale widely in the ocean. In 2024, Running Tide announced the closure of its fairly advanced operations, citing lack of demand for carbon credits from the voluntary market.⁹³ When it comes to seaweed, the credits would incur exorbitant costs of US\$17,048 per tonne of CO₂ – compared to the US\$2-11 that has been set for forest sequestration.⁹⁴ In 2022, Seafields announced they were partnering with JustCarbon to sell carbon credits but their plans to sell carbon credits by early 2024 haven't materialised.⁹⁵

While these kinds of profit-driven technological fixes might be touted as climate 'solutions' by their developers and investors, the reality is that they are not proven to capture and permanently sequester carbon. They also fail to address the root causes of climate change, such as the burning of fossil fuels, which continue to contribute to the climate crisis.





REGULATORY FRAMEWORK



REGULATIONS COVERING SEAWEED FARMING FOR CDR ALREADY EXIST

The seaweed industry and its allies are using the platform of UNFCCC and more specifically the UNFCCC Climate Dialogues to push for seaweed-based CDR, even though many of these methods have not been shown to permanently remove carbon from the atmosphere. Under Article 4 of UNFCCC, the Paris Agreement has become the platform for discussions on carbon removals and the carbon market. The Paris Agreement does not legitimize the deployment of geoengineering technologies but its use of terms like ‘removals’ has left the door open for geoengineering proponents to develop a frame for carbon dioxide removal (CDR) technologies. In 2024, the Paris Agreement’s Article 6.4 established a framework for a new global carbon market with a Supervisory Body for Article 6.4 formed to study and make proposals on carbon removal techniques. A host of geoengineering technologies including marine geoengineering were suggested, mostly by companies. However, the acceptance of these technologies for use in relation to carbon markets would be in contravention of the reaffirmation of the CBD moratorium of 2024.⁹⁶

Furthermore, seaweed farming for marine carbon dioxide removal (mCDR) is not without governance, as seaweed proponents would like to portray. There are many international regulatory frameworks which can govern and regulate it.

UN Convention on Biological Diversity (CBD)

As companies lobby for large-scale seaweed cultivation to be pushed for CDR purposes, the CBD may become an important platform for overseeing the precautionary regulation of seaweed industrialization and the impact it has on biodiversity. Targets 4, 5 and 6 of the Kunming Montreal Global Biodiversity Framework (approved in 2022) emphasize genetic diversity, the sustainable use of wild species and the risks of invasive species.⁹⁷

Moreover, the CBD has been overseeing the impact of geoengineering since 2007. In 2010, the moratorium was established. Since then, the CBD has repeatedly reaffirmed this decision, including in 2016 and more recently in 2024, at COP16 in Colombia. At COP16, CBD also went further in terms of reinforcing this decision by urging parties and other governments to ensure implementation. The concern which led to this decision was that climate geoengineering activities, including marine and solar geoengineering activities, could result in serious irreversible impacts on biodiversity and the livelihoods of Indigenous People and local communities. Additionally, CBD took into account the growth of uncontrolled geoengineering field experiments which are proposed or under way and may cause harm to people and biodiversity (CBD COP 16 decision 16/22, paragraph 6).⁹⁸ While the CBD provides an exemption for small-scale research activities, these must be in a controlled setting and be subject to environmental assessment. Projects with a commercial aspect or selling carbon credits

are also inconsistent with decisions under the CBD.

On marine geoengineering, CBD discussed the impacts of geoengineering on marine and coastal biodiversity (Decision 16/17). The decision reaffirmed the earlier moratorium on geoengineering (Decision X/33), especially in the context of experiments such as the proposed use of marine cloud brightening to protect corals. By doing so, the CBD effectively warned against using such techniques on coral reefs. It also recognized the need for more research and understanding of marine geoengineering impacts to help implement the Global Biodiversity Framework.

The London Convention and London Protocol (LC/LP)

The London Convention/London Protocol, a global convention which regulates dumping and pollution at sea, has been looking at marine geoengineering since 2007.⁹⁹ In 2008 they passed a resolution prohibiting ocean fertilization deployment, and in 2010 a further resolution adopting a framework for “legitimate scientific research”.¹⁰⁰ Crucially, this framework excludes activities with a commercial nature. In 2013, a resolution was passed amending the London Protocol to enable the regulation of marine geoengineering activities.¹⁰¹

LC/LP has indicated its intention to regulate additional marine geoengineering technologies. In March 2023, the Scientific Groups reporting to the LC/LP decided to monitor four additional geoengineering technologies, including:

1. Enhancing ocean alkalinity.
2. The use of biomass for carbon sequestration such as via macroalgae cultivation and artificial upwelling.
3. Solar geoengineering techniques such as marine cloud brightening or the deployment of microbubbles, reflective particles and/or materials.

Parties stated that activities “other than legitimate scientific research should be deferred,” noting that each of the technologies

has “the potential for deleterious effects that are widespread, long-lasting or severe; and there is considerable uncertainty regarding their effects on the marine environment, human health, and on other uses of the ocean.”

OSPAR (Oslo-Paris Convention)

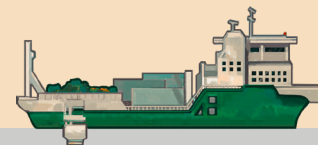
OSPAR is an international body which adheres to environmental principles, such as the precautionary principle. It brings together several nations to address concerns related to the marine space such as ocean acidification, disruption of ecosystems and leakage from sub-seabed storage sites. OSPAR seeks to balance technological innovation with the protection of marine biodiversity.

UNCLOS (United Nations Convention on the Law of the Sea)

UNCLOS provides key provisions that define the jurisdiction of a country over its oceanic territories, along with its responsibility to protect the marine environment. While it does not deal with marine geoengineering directly, it informs other international treaties. The recent Advisory Opinion from the International Tribunal on the Law of the Sea (ITLOS) clarified that if marine geoengineering polluted the marine environment, or had the effect of turning one form of pollution into another, it could be in violation of UNCLOS.¹⁰²

The UN High Seas Treaty

The UN High Seas Treaty, also known as the Agreement on Biodiversity Beyond National Jurisdiction or ‘BBNJ’, was adopted in 2023. It puts forward a framework for areas beyond national jurisdiction on the ocean, such as the high seas and international waters, and implementing the provisions of UNCLOS.¹⁰³ Under it, participating parties are obliged to conduct environmental impact assessments when a planned activity may have an effect on the marine environment, or when there is insufficient knowledge about the activity’s potential effects. In such cases, the party possessing jurisdiction or control over the activity is required to conduct the assessment.



CONCLUSIONS



SEAFIELDS PROJECT WILL NOT HELP THE CARIBBEAN OR COOL THE CLIMATE

In relation to addressing the environmental degradation of the Caribbean oceanic ecosystem, Seafields promised the transformation of “a coastal menace into an industrial wonder”. The company claims that its process will feed into new industries and benefit coastal communities by creating jobs and supporting livelihoods. While this may be presented as an opportunity for governments, investors and communities alike, case studies from regions where seaweed farming has been rapidly industrialized show evidence of it endangering existing social relations, creating dispossession and leading to the exclusion of some communities.¹⁰⁴

For example, as seaweed industrialization expanded, especially in East Asia and Southeast Asia, it led to the loss of traditional community rules which maintained the sustainable use of marine resources.¹⁰⁵

While seaweed industrialization might create ‘employment,’ as claimed by World Bank figures,¹⁰⁶ it also meant the bartering of one Sustainable Development Goal (SDG) for another. Moreover, these figures may be true for small-scale traditional seaweed farming, but it is unlikely that these benefits will scale up for large-scale industrial seaweed production.¹⁰⁷

Rapid seaweed industrialization has also led to the use of automated technologies, which have diminished the importance of human labour and made the existing labour market more competitive. In places

where family farming traditions and community management once flourished, new privatized farms took their place, exacerbating the displacement of populations and weakening social cohesion.¹⁰⁸

Creating market incentives for reducing excessive sargassum is a type of commodification of nature sometimes referred to as the ‘financialisation of nature.’ Financialisation of nature is the increasing role of financial motives, markets, actors and institutions into commodifying natural ecosystems as ‘services’ or ‘goods.’ Growing evidence suggests that these financial ‘solutions’ do not solve environmental degradation; rather, they might introduce new problems and create new social inequalities by putting the financial sector in control of common resources.¹⁰⁹

By trying to generate carbon credits from the ocean, Seafields along with others is aiming to create market incentives for ‘protecting’ or ‘healing’ ecosystems. This is a tactic which has already been observed in the case of REDD schemes in forests, and has been called out for being a mechanism for companies, carbon traders and states to control the forests of Indigenous Peoples and forest communities.¹¹⁰ Proponents of the carbon market and carbon credits present it as a protective mechanism, but it does not deal with the real drivers of deforestation. Despite billions in funding, REDD never delivered on its

promised results of reducing deforestation and forest degradation.¹¹¹

Companies like Seafields based in the Global North want to create carbon credits in the Global South, under the guise of protecting or providing some benefits to the local economy. However, the sale of carbon credits incentivises polluting companies to buy carbon credits, which are cheaper than reducing emissions outright. This allows companies, mostly in the Global North, to continue emitting above reduction limits, and therefore to circumvent environmental regulations in their own countries – while the countries in the Global South, where this geoengineering takes place, bear the brunt of the economic and environmental disruption that ensues.

On coasts and in relation to oceans, people are already threatened with the pursuit of ‘blue carbon’ and the financial push for investing in the ocean through the levers of the carbon market. They have already been resisting land grabbing and ‘water grabbing’ in the ocean by companies and international institutions (such as the World Bank) and putting forward governance frameworks that safeguard their rights.¹¹² The push for blue carbon and the deployment of marine geoengineering will not only introduce additional and potentially unknowable threats to the ocean, it will also further jeopardize the human rights of coastal people.

When it comes to industrial seaweed production, groups who have historically tended to coastal ‘ways of life’ through their traditional knowledge and practices have strongly resisted monoculture seaweed production, stating the threat it poses to their culture and economy.¹¹³ It is time these voices are recognised and their rights upheld in both global and national governance frameworks.

Recommendations for governments

- A moratorium should be established on the deployment of industrial seaweed farming and sinking.

- All discussions on seaweed farming for CDR purposes should be excluded from Article 6 discussions in the UN-FCCC, and the inclusion of seaweed farming in the carbon market should be prevented.
- Precautionary rules and frameworks must be developed together with Indigenous Peoples and traditional coastal communities to protect wild seaweeds, ecosystems and livelihoods associated with them.
- Environmental impact assessments must be carried out on any proposed industrial seaweed cultivation projects.
- Establish robust regulations for seaweed protection which are community-led and prioritize traditional, sustainable and customary uses and protection of seaweed. Frameworks of governance should also ensure any related project is developed through meaningful consultation and secures the Free, Prior and Informed Consent of affected Indigenous Peoples, as well as coastal communities.
- Seaweed activities should be kept small-scale, culturally appropriate and ecologically sound.
- The release and accidental spillage of both genetically modified and natural invasive seaweed must be controlled to protect native species of sargassum.

For more information see:

- ‘Seaweed Delusion: Industrial seaweed will not cool the climate or save nature’ <https://www.etcgroup.org/content/seaweed-delusion>
- Geoengineering Monitor - An up-to-date source of information on geoengineering and its risks and impacts on people and environment. <https://www.geoengineeringmonitor.org/>
- The related Geoengineering Map, an interactive world map on geoengineering, prepared by ETC Group and the Heinrich Boell Foundation. It sheds light on the alarming expansion of geoengineering research and experimentation. <https://map.geoengineeringmonitor.org/>

NOTES

- ETC Group (2023) *The Seaweed Delusion*. Available at: <https://www.etcgroup.org/content/seaweed-delusion>
- For example, National Geographic (2011) "Photos: Thick Green Algae Chokes Beach—Swimmers Dive In", 27 July. Available at: <https://www.nationalgeographic.com/travel/article/110725-algae-china-beaches-qingdao-swimming-science-environment-world>
- Fletcher, R. (2021) "Stopping the Rot in China's Seaweed Aquaculture Sector", *The Fish Site*, 04 June. Available at: <https://thefishsite.com/articles/stopping-the-rot-in-chinas-seaweed-aquaculture-sector>
- Examples from Southeast Asia show how livelihoods were transformed when seaweed farming boomed. See Steenbergen, DJ, Marlessy, C & Holle, E (2017) "Effects of rapid livelihood transitions: Examining local co-developed change following a seaweed farming boom", *Marine Policy*, vol. 82, August, pp. 216–23. Available at: <https://doi.org/10.1016/j.marpol.2017.03.026>
- Hu, Z.-M., Shan, T.-F., Zhang, J., Zhang, Q.-S., Critchley, A.T., Choi, H.-G., Yotsukura, N., Liu, F.-L. and Duan, D.-L. (2021) "Kelp aquaculture in China: a retrospective and future prospects", *Reviews in Aquaculture*, 13, pp.1324-1351. Available at: <https://doi.org/10.1111/raq.12524>
- Hands Off Mother Earth (HOME) (2024) *A briefing on marine geoengineering*, November. Available at: <https://handsoffmotherearth.org/wp-content/uploads/2024/11/EN-Briefing-on-Marine-Geoengineering-UNFCCC.pdf>
- ETC Group (2024) "A big win as UN Convention on Biological Diversity COP16 reaffirms geoengineering is a risk", 16 December. Available at: <https://www.etcgroup.org/content/big-win-un-convention-biological-diversity-cop16-reaffirms-geoengineering-risk>
- Seafields (2025) *Homepage*. Available at: <https://www.seafields.eco/>
- Gallagher, J. B., Shelamoff, V. and Layton, C. (2022) "Seaweed ecosystems may not mitigate CO2 emissions", *ICES Journal of Marine Science*, 79, pp.585–592. Available at: <https://academic.oup.com/icesjms/article/79/3/585/6525671>
- Ross, F., Tarbuck, P. and Macreadie, P. (2022) "Seaweed afforestation at large-scales exclusively for carbon sequestration: Critical assessment of risks, viability and the state of knowledge", *Frontiers in Marine Science*, 9, 1015612. Available at: <https://doi.org/10.3389/fmars.2022.1015612>
- Ricart, A. M., Krause-Jensen, D., Hancke, K., Price, N. N., Masqué, P. and Duarte, C. M. (2022) "Sinking seaweed in the deep ocean for carbon neutrality is ahead of science and beyond the ethics", *Environmental Research Letters*, 17(081003). Available at: <https://iopscience.iop.org/article/10.1088/1748-9326/ac82ff>
- DOSI (2021) *Deep Ocean Climate Intervention Impacts*. Available at: www.dosi-project.org/wp-content/uploads/Macroalgae-Crop-Deposition-Policy-Brief.pdf
- Satizabal, P., Quinquillà, A., Franco, M., and Pedersen, C. (2024). *Ocean, Water and Fisher Peoples' Tribunals: Cutting the nets of capital and weaving nets of Solidarity*. Transnational Institute (TNI). Available at: https://www.tni.org/files/2024-06/People%27s_Tribunals_EN_WEB.pdf
- Carbon credits are tradable units that represent one tonne of CO₂ reduced, avoided or removed from the atmosphere. Carbon markets are systems where these credits are bought and sold, either to meet legally binding climate targets or voluntarily offset emissions. Instead of driving real climate action, these systems create loopholes where companies rely on credits instead of focusing on real solutions that cut emissions.
- Greenfield, P. (2023) "Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows", *The Guardian*, 18 January. Available at: <https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe> (Accessed 4 March 2026).
- See for example the advocacy of: Hands Off Mother Earth (HOME) Alliance (2025) *Homepage*. Available at: <https://handsoffmotherearth.org/wp-content/uploads/2025/06/Eng-Home-mGE-Statement-June-25.pdf>
- ETC Group and Heinrich Böll Foundation (2020) *Geoengineering Map: Seafields Solutions*. Available at: <https://map.geoengineeringmonitor.org/other/seafields-solutions-ltd>
- Seafields (2025) *Roadmap*. Available at: <https://www.seafields.eco/roadmap-seafields>
- Can seaweed help store CO2 on the ocean floor?* (news archive) (2023). <https://noc.ac.uk/news/can-seaweed-help-store-co2-ocean-floor>
- St Vincent Times (2024.) Blue carbon start-up leads revolutionary sargassum solution. St Vincent Times, 6 June. Available at: <https://www.stvincenttimes.com/blue-carbon-start-up-leads-revolutionary-sargassum-solution/>
- Ocean Visions (2025) *mCDR Field Trial Database*. Available at: <https://oceanvisions.org/mcdr-field-trials/>
- Business Barbados (2024) "Startup demonstrates Sargassum Solution Initiative in Barbados" *Business Barbados*, 8 June. Available at: <https://www.businessbarbados.com/post/sargassum-solution-initiative-in-barbados>
- Gallagher, J. B., Shelamoff, V., Layton, C. (2022) "Seaweed ecosystems may not mitigate CO2 emissions", *ICES Journal of Marine Science*, 79, pp.585–592. Available at: <https://academic.oup.com/icesjms/article/79/3/585/6525671>
- DOSI (2021) *Deep Ocean Climate Intervention Impacts*. Available at: www.dosi-project.org/wp-content/uploads/Macroalgae-Crop-Deposition-Policy-Brief.pdf
- Rasher, D. B. and Hay, M. E. (2010) "Chemically rich seaweeds poison corals when not controlled by herbivores", *PNAS*, 107(21), pp.9683-9688. Available at: <https://doi.org/10.1073/pnas.0912095107>
- DOSI (2021) *Deep Ocean Climate Intervention Impacts*. Available at: www.dosi-project.org/wp-content/uploads/Macroalgae-Crop-Deposition-Policy-Brief.pdf
- Jia, Y., Quack, B., Kinley, R. D., Pisso, I. and Tegtmeier, S. (2022) "Potential environmental impact of bromoform from Asparagopsis farming in Australia", *Atmospheric Chemistry and Physics*, 22(11), pp. 7631-7646. Available at: <https://doi.org/10.5194/acp-22-7631-2022>
- Bach, L.T., Tamsitt, V., Gower, J., Hurd, C.L., Raven, J.A. and Boyd, P.W. (2021) "Testing the climate intervention potential of ocean afforestation using the Great Atlantic Sargassum Belt". *Nature Communications*, 12, 2556. Available at: <https://doi.org/10.1038/s41467-021-22837-2>.
- Boyd, P.W., Bach, L.T., Hurd, C.L., Paine, E., Raven, J.A., and Tamsitt, V. (2022) "Potential negative effects of ocean

- afforestation on offshore ecosystems”, *Nat Ecology and Evolution*, 6, pp.675–683. Available at: <https://doi.org/10.1038/s41559-022-01722-1>
- 29 Bermejo, R., Buschmann, A., Capuzzo, E., Cottier-Cook, E., Fricke, A., Hernández, I., Hofmann, L. C., Pereira, R. and Van Den Burg, S. (2022) *State of knowledge regarding the potential of macroalgae cultivation in providing climate-related and other ecosystem services*. Report prepared by an Eclipse Working Group. Available at: https://eclipse.eu/wp-content/uploads/website_db/Request/Macro-Algae/EKLIPSE_DG-Mare-Report-PrintVersion_final.pdf
 - 30 Williams, S. L. and Smith, J. E. (2007) “A global review of the distribution, taxonomy, and impacts of introduced seaweeds”, *Annual Review of Ecology, Evolution and Systematics*, 38, pp.327-359. Available at: <https://doi.org/10.1146/annurev.ecolsys.38.091206.095543>
 - 31 Williams and Smith (2007) *Ibid.*, pp.348.
 - 32 Ward, G. M., Faisan, J. P., Cottier-Cook, E. J., Gachon, C. et al. (2020) “A review of reported seaweed diseases and pests in aquaculture in Asia”, *Journal of the World Aquaculture Society*, 51, pp.815–828. Available at: <https://doi.org/10.1111/jwas.12649>
 - 33 Jouffray, J.-B., Blasiak, R., Norström, A. V., Österblom, H., Nyström, M. (2020) “The Blue Acceleration: The Trajectory of Human Expansion into the Ocean”, *One Earth*, 2(1), pp.43-54. Available at: <https://doi.org/10.1016/j.oneear.2019.12.016>
 - 34 Satizabal, P., Quinquillà, A., Franco, M., and Pedersen, C. (2024) *Ocean, Water and Fisher Peoples’ Tribunals: Cutting the nets of capital and weaving nets of Solidarity*. Transnational Institute (TNI). Available at: https://www.tni.org/files/2024-06/People%27s_Tribunals_EN_WEB.pdf
 - 35 The Guardian (2025) “Caribbean beaches blighted by record masses of stinking seaweed”, *The Guardian*, 3 June. Available at: <https://www.theguardian.com/world/2025/jun/03/caribbean-sargassum-seaweed>
 - 36 Seafields (2025) FAQs. Available at: <https://www.seafields.eco/faqs>
 - 37 Rodríguez-Martínez R.E., Torres-Conde E.G., Rosellón-Druker J., Cabanillas-Terán N., Jáuregui-Haza U. (2025) “The Great Atlantic Sargassum Belt: Impacts on the Central and Western Caribbean-A review”, *Harmful Algae*, 144, 102838. Available at: <https://doi.org/10.1016/j.hal.2025.102838>
 - 38 Resiere, D. et al. (2018) “Sargassum seaweed on Caribbean islands: an international public health concern”, *The Lancet*, 392(10165), p.2691. Available at: [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(18\)32777-6/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)32777-6/fulltext)
 - 39 Schell, J.M., Goodwin, D.S. and Siuda, A.N.S. (2015) “Recent Sargassum inundation events in the Caribbean: Shipboard observations reveal dominance of a previously rare form”, *Oceanography*, 28(3), pp.8-10. Available at: <https://doi.org/10.5670/oceanog.2015.70>
 - 40 The Guardian (2023) “Clumps of 5,000-mile seaweed blob bring flesh-eating bacteria to Florida”, 3 June. Available at: <https://www.theguardian.com/environment/2023/jun/03/sargassum-seaweed-algae-florida-bacteria-vibrio>
 - 41 The Guardian (2024) “Toxic gas, livelihoods under threat and power outages: How sargassum seaweed causes chaos in Caribbean”, 11 April. Available at: <https://www.theguardian.com/environment/2024/apr/11/toxic-gas-livelihoods-under-threat-and-power-outages-how-sargassum-seaweed-causes-chaos-in-caribbean>
 - 42 Stommel, H. (1953) “A survey of ocean current theory”, *Deep Sea Research*, 4.
 - 43 ETC Group and Heinrich Böll Foundation (2020) *Geoengineering Map: Artificial Upwelling*. Available at: <https://map.geoengineeringmonitor.org> and <https://map.geoengineeringmonitor.org/other/zhejiang-university-artificial-upwelling/>
 - 44 GESAMP (2019) *High level review of a wide range of proposed marine geoengineering techniques*. Report Stud. GESAMP No. 98. Edited by P.W.Boyd and C.M.G.Vivian. London: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Available at: <http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques>
 - 45 Oeschlies, A. et al. (2010) Climate engineering by artificial ocean upwelling: Channelling the sorcerer’s apprentice”, *Geophysical Research Letters*, 37. Available at: <https://doi.org/10.1029/2009GL041961>
 - 46 Keller, D., Feng, E. & Oeschlies, A. (2014) “Potential climate engineering effectiveness and side effects during a high carbon dioxide-emission scenario”, *Nat Commun*, 5, 3304. Available at: <https://doi.org/10.1038/ncomms4304>
 - 47 GESAMP (2019) *High level review of a wide range of proposed marine geoengineering techniques*. Report Stud. GESAMP No. 98. Edited by P.W. Boyd and C.M.G.Vivian. London: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Available at: <http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques>
 - 48 ETC Group and Heinrich Böll Foundation (2020) *Geoengineering Map: Artificial Upwelling*. Available at: <https://map.geoengineeringmonitor.org> and <https://map.geoengineeringmonitor.org/other/zhejiang-university-artificial-upwelling/>
 - 49 Levin, L.A., Alfaro-Lucas, J.M., Colaço, A., et al. (2023) “Deep-sea impacts of climate interventions”, *Science*, 379 (6636), pp.978–981. Available at: <https://pubmed.ncbi.nlm.nih.gov/36893246/>
 - 50 GESAMP (2019) *High level review of a wide range of proposed marine geoengineering techniques*. Report Stud. GESAMP No. 98. Edited by P.W. Boyd and C.M.G.Vivian. London: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Available at: <http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques>
 - 51 GESAMP (2019) *Marine and social scientists are urging a precautionary approach over marine geoengineering solutions for climate change*, 12 March. Available at: <http://www.gesamp.org/news/precautionary-approach-over-marine-geoengineering-solutions-for-climate-change>
 - 52 Chalmin, A. (2019) “Artificial upwelling: Current efforts and anticipated impacts of intermingling the ocean”, *Geoengineering Monitor*, 24 October. Available at: <https://www.geoengineeringmonitor.org/artificial-upwelling-current-efforts-and-anticipated-impacts-of-intermingling-the-ocean>
 - 53 Ricart, A. M., Krause-Jensen, D., Hancke, K., Price, N. N., Masqué, P. and Duarte, C. M. (2022) “Sinking seaweed in the deep ocean for carbon neutrality is ahead of science and beyond the ethics”, *Environmental Research Letters*, 17(081003). Available at: <https://iopscience.iop.org/article/10.1088/1748-9326/ac82ff>
 - 54 National Oceanic and Atmospheric Administration (NOAA) (undated) “How Much of the Ocean Has Been Explored?”

- NOAA *Ocean Exploration*. Accessed February 21, 2026. <https://oceanexplorer.noaa.gov/ocean-fact/explored/>
- 55 GESAMP (2019) *High level review of a wide range of proposed marine geoengineering techniques*. Report Stud. GESAMP No. 98. Edited by P.W. Boyd and C.M.G.Vivian. London: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Available at: http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques_p.58
- 56 DOSI (2021) *Deep Ocean Climate Intervention Impacts*. Available at: www.dosi-project.org/wp-content/uploads/Macroalgae-Crop-Deposition-Policy-Brief.pdf
- 57 DOSI (2021) *Deep Ocean Climate Intervention Impacts*. Available at: www.dosi-project.org/wp-content/uploads/Macroalgae-Crop-Deposition-Policy-Brief.pdf
- 58 Global Carbon Budget (2024) *Fossil Fuel CO2 Emissions Increase Again in 2024*, 13 November. Available at: <https://globalcarbonbudget.org/fossil-fuel-co2-emissions-increase-again-in-2024/#:~:text=Global%20carbon%20emissions%20from%20fossil,driving%20increasingly%20dangerous%20global%20warming.>
- 59 Transport & Environment (2025) "IMO Fuel Rules Risk Fuelling Deforestation." *Transport & Environment*, accessed February 21, 2026. <https://www.transportenvironment.org/articles/imo-fuelling-deforestation.> and Oxfam, (2024) *Biofuel Blunders: The EU's Rush into Biofuels Is Driving Deforestation and Food Insecurity*, Oxfam Briefing Paper. <https://oxfamlibrary.openrepository.com/bitstream/handle/10546/621622/bp-biofuel-blunders-110924-en.pdf>
- 60 ETC Group (2023) *The Seaweed Delusion*. Available at: <https://www.etcgroup.org/content/seaweed-delusion>
- 61 ETC Group, BioFuelWatch and Heinrich Boell Stiftung (2017) *The Big Bad Fix*. Available at: <https://www.etcgroup.org/content/big-bad-fix>
- 62 Seafields (2025) *Our Advisors*. Available at: <https://www.seafields.eco/advisors>
- 63 ETC Group (2009) *Lohafex update: Geo-Engineering Ship Plows on as Environment Ministry calls for a halt*. 8 January. Available at: <https://www.etcgroup.org/content/lohafex-update-geo-engineering-ship-plows-environment-ministry-calls-halt>
- 64 Ocean Visions (2025) "Marine Carbon Dioxide Removal", undated. Available at: <https://oceanvisions.org/ocean-based-carbon-dioxide-removal/>
- 65 Ocean Visions (2024) "Launchpad team: Seafields", 28 August. Available at: <https://oceanvisions.org/launchpad/seafields/>
- 66 Ocean Visions and Monterey Bay Aquarium Research Institute (2022). *Answering Critical Questions About Sinking Macroalgae for Carbon Dioxide Removal: A Research Framework to Investigate Sequestration Efficacy and Environmental Impacts*. Available at: oceanvisions.org/seaweedresearch
- 67 World Ocean Council (2025) *Corporate Ocean responsibility for a sustainable and Regenerative Blue Economy*. Available at: <https://worldoceancouncil.org/>
- 68 Carbon Business Council (2025) "Marine Carbon Dioxide Removal: Issue Brief", 4 June. Available at: <https://www.carbonbusinesscouncil.org/news/marinecarbonremoval>
- 69 Global Seaweed Coalition (2023) *The seaweed revolution - global seaweed coalition - Building, Developing & Supporting a safer seaweed industry*, 20 July. Available at: <https://www.safeseaweedcoalition.org/the-seaweed-revolution/#seaweed-manifesto>
- 70 AWI (2020) "Geoengineering map: AWI". Available at: [https://map.geoengineeringmonitor.org/other/-alfred-wegener-institute-\(awi\)](https://map.geoengineeringmonitor.org/other/-alfred-wegener-institute-(awi))
- 71 OceanNETs (2020) *Geoengineering map: OceanNETs*. Available at: <https://map.geoengineeringmonitor.org/other/oceannets>
- 72 RETAKE (2020) *Geoengineering map: RETAKE*. Available at: <https://map.geoengineeringmonitor.org/other/re-take-project>
- 73 Project Carbdown (2020) *Geoengineering map: Project Carbdown*. Available at: <https://map.geoengineering-monitor.org/ggr/project-carbdown>
- 74 C-CAUSE (2020) *Geoengineering map: C-CAUSE*. Available at: <https://map.geoengineeringmonitor.org/other/c-cause-project>
- 75 Fram Strait Observatory (2020) *Geoengineering map: Fram Strait*. Available at: <https://map.geoengineering-monitor.org/other/fram-strait-hausgarten-observatory>
- 76 Airtable (2025) *Phyconomy Seaweed: A database of actors involved in the seaweed economy*. Available at: <https://airtable.com/appcYjjVpOfpQXpsd/tblZFNBiW-gVocM5BA/viwpawOq6LL8eHnqL/reccqHvsE89zCSs-D0?blocks=hide>
- 77 Crowdcube (2023) *Seafields Solutions Limited raised investment, April*. Available at: <https://www.crowdcube.eu/companies/seafields-solutions-limited/pitches/b65YAZ?country=DE>
- 78 Marchant, C. (2023) *Fresh funding to test carbon storage in the Atlantic, Net Zero Investor*, 5 April. Available at: <https://www.netzeroinvestor.net/news-and-views/briefs/blue-ccs-firm-wins-funding-for-uk-ocean-trials>
- 79 UK in Caribbean (2023) *Instagram Page, Instagram*, 21 December. Available at: https://www.instagram.com/ukincaribbean/p/C1HNWZjtULx/?img_index=1
- 80 Marine Industry News (2024) *Seafields to develop stationary aquafarms together with macrocarbon*, 13 February. Available at: <https://marineindustrynews.co.uk/seafields-to-develop-stationary-aquafarms-together-with-macrocarbon/>
- 81 Ranevska, S. (2025) *Seafields is gathering funds to turn coastal seaweed crisis into a CDR solution. Carbon Herald*, 20 August. Available at: <https://carbonherald.com/seafields-is-gathering-funds-to-turn-coastal-seaweed-crisis-into-a-cdr-solution/>
- 82 Tech Nation (2025). *Unveiling the UK's 24 leading climate tech companies joining Tech Nation's climate cohort 2024*, 23 June. Available at: <https://technation.io/unveiling-the-uks-24-leading-climate-tech-companies-joining-tech-nations-climate-cohort-2024/>
- 83 Deasy, E. (2025) "Fighting climate change with floating farms: Seafields' Smart Solution", *SeedLegals*, 30 May. Available at: <https://seedlegals.com/resources/fighting-climate-change-with-floating-farms-seafields-smart-solution/>
- 84 Howse, C., & Atkinson, N. (2024). "How the VCM can turn the tide for blue carbon", *BeZeroCarbon*, 11 January. Available at: <https://bezercarbon.com/insights/how-the-vcm-can-turn-the-tide-for-blue-carbon>
- 85 Reuter (2023) "Voluntary Carbon Markets Set to Become at Least Five Times Bigger by 2030-Shell", *Reuters*, 19 January. Available at: <https://www.reuters.com/markets/carbon/voluntary-carbon-markets-set-become-least-five-times-bigger-by-2030-shell-2023-01-19/>
- 86 Orbify (2025) "The Voluntary Carbon Market in Transition: A Look at 2025 amid Upheaval", 11 April. Available at: <https://orbify.com/blog/the-voluntary-carbon-market-in-transition-a-look-at-2025-amid-upheaval>

- 87 Gilbertson, T., and Reyes, O., (2009) *Carbon trading: How it works and why it fails*. Uppsala: Dag Hammarskjöld Foundation.
- 88 Graham Hughes, G., By, & Hughes, G. G. (2022) *Understanding Carbon Science to Develop Effective Climate Policy*, North Coast Environmental Center, 26 July. Available at: <https://www.yournec.org/understanding-carbon-science-to-develop-effective-climate-policy/>
- 89 McKinsey & Company (2022) "Blue Carbon: The potential of Coastal and Oceanic Climate Action", 13 May. Available at: <https://www.mckinsey.com/capabilities/sustainability/our-insights/blue-carbon-the-potential-of-coastal-and-oceanic-climate-action>
- 90 Verra (2025) *Home*. Available at: <https://verra.org/>.
- 91 Verra has disclosed that it has received two draft proposals for seaweed methodologies from partners. The proposed methodologies can be viewed at: Verra (2026) 'Methodology framework for seaweed carbon projects.' Available at: <https://verra.org/methodologies/methodology-framework-for-seaweed-carbon-projects/#overview>
- 92 Greenfield, P. (2023) "Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows", *The Guardian*, 18 January. Available at: <https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe>
- 93 Velev, V. (2024) "Running tide shuts down citing lack of demand from the voluntary market" *Carbon Herald*, 16 June. Available at: <https://carbonherald.com/running-tide-shuts-down-citing-lack-of-demand-from-the-voluntary-market/>
- 94 Coleman, S., Dewhurst, T., Fredriksson, D. W., St. Gelais, A. et al. (2022). "Quantifying baseline costs and cataloging potential optimization strategies for kelp aquaculture carbon dioxide removal", *Frontiers in Marine Science*, 9:1460. Available at: <https://doi.org/10.3389/fmars.2022.966304>. Cost for forest carbon removals taken from Opanda, S. (2023) "Carbon Credit Pricing Chart: Updated 2023", *8billiontrees.com*, 11 July. Available at: <https://8billiontrees.com/carbon-offsets-credits/new-buyers-market-guide/carbon-credit-pricing/>
- 95 Doneva, D. (2022) Seafields and JustCarbon make a deal for one billion tons CO2 removal. *Carbon Herald*, 22 November. Available at: <https://carbonherald.com/seafields-and-justcarbon-make-a-deal-for-one-billion-tons-co2-removal/>
- 96 Schneider, L., and Ribeiro, S. (2024) UN climate talks could undermine precaution on geoengineering called for by the biodiversity convention, 7 November 7. Available at: <https://www.boell.de/en/2024/11/07/un-climate-talks-could-undermine-precaution-geoengineering-called-biodiversity>
- 97 United Nations Convention on Biological Diversity (2022) *KunMing-Montreal Global Biodiversity Framework*, December. Available at: <https://www.cbd.int/gbf>
- 98 ETC group (2024) "ETC reinforces geoengineering moratorium", 16 December. Available at: <https://www.etcgroup.org/content/cbd-reinforces-geoengineering-moratorium>
- 99 International Maritime Organization (n.d.) "Marine Geoengineering". Available at: <https://www.imo.org/en/OurWork/Environment/Pages/geoengineering-Default.aspx>
- 100 International Maritime Organization (2010) Resolution LC-LP.2 (2010). Available at: <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/OFAssessmentResolution.pdf>
- 101 International Maritime Organization (2013) *Resolution LP.4(8)*, adopted on 18 October 2013. Available at: [https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/LCLPDocuments/LP.4\(8\).pdf](https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/LCLPDocuments/LP.4(8).pdf)
- 102 Khatri, U. (2024) "How a Historic Opinion on Climate Change and Ocean Protection Sets the Bar for Climate Action," *Centre for International Environmental Law*, 27 June 27. Available at: <https://www.ciel.org/how-a-historic-opinion-on-climate-change-and-ocean-protection-sets-the-bar-for-climate-action/>
- 103 The United Nations Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction adopted a maritime biodiversity treaty in June 2023. The text of the Agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction can be found at United Nations (2023) *Agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*, June. Available at: <https://www.un.org/bbnj/>
- 104 Spillias, S., Kelly, R., Cottrell, R.S., O'Brien, K.R. (2023) "The empirical evidence for the social-ecological impacts of seaweed farming", *PLOS Sustainability and Transformation* 2(2): e0000042. Available at: <https://journals.plos.org/sustainabilitytransformation/article?id=10.1371/journal.pstr.0000042>
- 105 Kim J (2022) "Changing fishery environment and adaptation of fishermen: Focusing on seaweed farming areas", *Journal of Rural Society*, 2002;12(1):189–217.
- 106 World Bank Group (2016) *Seaweed aquaculture for food security, income generation and environmental health in tropical developing countries*. Available at: <https://www.researchgate.net/publication/306396642>
- 107 Spillias, S., Kelly, R., Cottrell, R.S., O'Brien, K.R. (2023) "The empirical evidence for the social-ecological impacts of seaweed farming", *PLOS Sustainability and Transformation* 2(2): e0000042. Available at: <https://journals.plos.org/sustainabilitytransformation/article?id=10.1371/journal.pstr.0000042>
- 108 Spillias, S., Kelly, R., Cottrell, R.S., O'Brien, K.R. (2023) "The empirical evidence for the social-ecological impacts of seaweed farming", *PLOS Sustainability and Transformation* 2(2): e0000042. Available at: <https://journals.plos.org/sustainabilitytransformation/article?id=10.1371/journal.pstr.0000042>
- 109 See for example: Thomson et al. (2018) *Financialisation: A primer*, Transnational Institute (TNI) p.26. Available at: <https://www.tni.org/en/publication/financialisation-a-primer>
- 110 Global Forest Coalition (2024) *The Great REDD+ Climate Illusion: A flawed equation for forests, people, and planet*. Available at: <https://globalforestcoalition.org/redd-climate-illusion/>
- 111 Global Forest Coalition (2024) *The Great REDD+ Climate Illusion: A flawed equation for forests, people, and planet*. Available at: <https://globalforestcoalition.org/redd-climate-illusion/>
- 112 Satizabal, P., Quinquilla, A., Franco, M., and Pedersen, C. (2024). *Ocean, water and fisher peoples' tribunals. cutting the nets of capital and weaving nets of Solidarity*. Transnational Institute (TNI). Available at: https://www.tni.org/files/2024-06/People%27s_Tribunals_EN_WEB.pdf
- 113 InterTribal Sinkyone Wilderness Council (2021) Letter addressed to California Representative Jared Huffman, 01 July.

