Some perspectives on marine geoengineering from the (wider) NGO community

David Santillo, Greenpeace Research Laboratories (Greenpeace International)

Science Day 2023: Emerging technologies in marine geoengineering, 16 March 2023

'Manifesto' against geoengineering field experiments and deployment

SIGNATORIES
To date, 150 organizations from 45 countries have signed the HPGNE Manifesto.

International Organizations:
- Alliances for the Earth
- Amigos de la Tierra (Latin America)
- Asian Peoples Movement for Debt and Development (APMDD)
- The Baha’i Faith
- Climate Justice Alliance
- Corporate Accountability International
- Corporate Europe Observatory
- Development Alternatives with Women for a New Era (DAWN)
- Global Forest Coalition
- Indigenous Environmental Network
- International 5G Working Group
- Just Earth International
- La Via Campesina
- NAMI (The American Nurses Association)
- Third World Network
- Transnational Institute
- World Indigenous Women’s Alliance (TWSNET)

AN INTERNATIONAL CIVIL SOCIETY CAMPAIGN AGAINST GEOENGINEERING
Interactive map from ETC Group and Heinrich Böll Foundation shows growth of climate control efforts

This interactive geengineering map, prepared by ETC Group and the Heinrich Böll Foundation, is an attempt to shed light on the worldwide state of geengineering by showing the scope of research and experimentation. There is no complete record of weather and climate control projects on this map, necessarily partial.
Scaling Seaweed (Macroalgae) as a Carbon Dioxide Removal Technofix: The Theory.

THE HYPE:

“We have all these global problems and no solutions on land. Seaweed is the greatest untapped resource that we have,”
- Vincent Doumeizel, The Seaweed Manifesto

"By 2050, seaweed production could absorb 135m tons of CO2 a year and 30% of all nitrogen entering the oceans from land-based pollution."
- Safe Seaweed Coalition

"X-prize winning company Pull to Refresh believes kelp can store one trillion metric tons, enough to reverse climate change."
- Discover Magazine

THE PITCH:

Seaweed is “fast biomass”: Common claims kelp grows 2-3 feet per day.

Seaweeds scale-up: Proponents imagine “basin-scale” operations.

Seaweed Sequesters: Up to 10% of carbon fixed by natural seaweeds is sequestered (including in deep sea sediment) - claimed to be 173 million metric tonnes carbon annually.

CDR THEORY/BUSINESS PLAN:

a) Grow large quantity of macroalgae.
b) Move algal biomass grown at surface/coast to long cycle storage in the deep oceans.
c) $$$ Generate carbon credits $$$

“All we are is a supply chain. And the attribute that we sell is tons of carbon removed. We partner with nature to make that happen ... Instead of offloading ships at port, we’re offloading carbon at sea.”
- Running Tide.

A NEW INDUSTRY EXPLODES:

> Quarter billion Investment: $168 million dollars investment in seaweed ventures in 2021 plus $100 million from Bezos earth fund (to WWF)
> New players: 182 startups since 2015 - most in the last 3 years
> Market Prize: Hope to realize a new industry in the hundreds of billions of dollars size.

Scaling Seaweed (Macroalgae) as a Carbon Dioxide Removal Technofix: The Plans

1. Scale-up Coastal Seaweed Farming - primarily kelp.
   - Globally (theoretically) 4.8 billion hectares of coastal waters “potentially ecologically suitable for macroalgae” - 6 times the size of Australia.
   - Companies scaling up farming of kelps on lines - similar to the larger Chinese seaweed farms - to increase overall macroalgal biomass
   - Presented as ‘kelp forest restoration’
   Example: Kelp Blue plans to create the worlds largest seaweed farm off the coast of Namibia (70,000 ha), Cascadia aims for 6000 acres. Amazon.com working with NorthSea Farmers, WWF/Bezos with Ocean Rainforest

2. Moving Seaweed to Open Ocean - both kelp and sargassum.
   a) Create artificial open ocean floating kelp islands
   Example. Climate Foundation’s ‘marine permaculture’ platforms (Elon Musk /X-Prize).
   Seaweed Solutions ‘seaweed carrier’ platform. (funded by WWF/Bezos)
   b) Deliberately grow and farm Sargassum.
   Example – Seafields - Plan to grow 55,000 sq km of sargassum in Southern Atlantic. Using artificial upwelling pipes in gyres to fertilise their sargassum farm. Test in 2023.

3. Sinking Seaweed in deep ocean.
   - both kelp and sargassum.
   a) Growing giant kelp in coastal waters then bringing to open ocean to sink in deep ocean
   b) Growing or capturing sargassum – (eg in Great Atlantic Sargassum Belt) and then sinking it.
   c) Sinking achieved using marine robots with nets , ballast or processing and baling the macroalgae.
   Examples: Running Tide , Pull to Refresh, Seaweed Generation, SOS Carbon, Phykos. Seafields also plans to sink their farmed sargassum

NB: Many Seaweed startups make climate claims via substituting fossil carbon (fuel, plastics, etc.) with algal biomass – not CDR
## Scaling Seaweed (Macroalgae) as a Carbon Dioxide Removal Technofix: The Reality.

**Reality Check:**

1. **Seaweed ecosystems are a net carbon source (not a sink).**
   
   JB Gallagher (2022): “We estimate [CO2 emissions] could be potentially as high as 150 tonnes emitted to the atmosphere per km² every year, in contrast to previous estimates that seaweed absorbs 50 tonnes per km².”
   
   *Calcification changes alkalinity (absorption) + carbon not from air.

2. **The ocean is not ‘empty’ - Competition with other coastal uses, shading sea grasses, take nutrients, sunlight etc.**
   
   P Boyd (2022): “The purposeful occupation for months of open ocean waters by macroalgae, which do not naturally occur there, will probably affect offshore ecosystems through a range of biological threats, including altered ocean chemistry and changed microbial physiology and ecology.”

3. **Seaweed for CDR Doesn’t really scale efficiently**
   
   W Burns (2022): “Even sequestering 0.1 gigaton of carbon dioxide annually would require an area equivalent to the land mass of Ireland or if sited in coastal regions, a 100-meter-wide continuous belt encompassing 63% of the global coastline.”

4. **Kelp doesn’t really grow 2-3 feet every day.** > bad calculations.

**Other considerations:**

- **Diversion of nutrients** through macroalgae instead of phytoplankton could have implications for the nutrient cycle and secondary productivity (Phillips 1990).

- **Impacts of sinking biomass on deep ocean** is poorly understood. Also we don’t know impact on upper or mid column of ocean.

- **Real risk from escape, invasive species, new pests** accompanying scale-up. World’s largest algal blooms in Yellow Sea –result from escaped commercial seaweed strains *N. yeoensis* from large scale seaweed farms.

- **Loss of wild genetic diversity/contamination** - introducing non-native strains could negatively impact natural macroalgae population.

++ **Problem of rapid commercial speculation.**

Many new seaweed startups are already offering carbon credits based on poor claims - purchased by Stripe, Shopify. Trialling of seaweed carbon credit methodologies by Verra, BlueCs etc. Climate Foundation issues ‘kelp coin’ digital crypto token.

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### Marine Geoengineering in International Fora

- **IPCC AR6:** (WGIII) Ocean Fertilisation, Enhanced Rock Weathering, Ocean Alkalinity Enhancement

- **UNFCCC Article 6.4:** Ocean Fertilisation, Enhanced Rock Weathering, Ocean Alkalinity Enhancement

- **Human Rights Council Advisory Committee:** Ocean Fertilisation, Enhanced Weathering, Marine Cloud Brightening, Surface Albedo Enhancement
mention how the technologies are being discussed?
Serayna Solanki, 13/03/2023
Article 6.4 Mechanism.

"Through this mechanism a company in one country can reduce emissions in that country and have those reductions credited so that it can sell them to another company in another country. That second company may use them for complying with its own emission reduction obligations or to help it meet net-zero."

Initially included a number of marine geoengineering techniques, including OF, in a relatively unqualified way

Now more nuanced, and with specific reference to decisions and ongoing work under LC-LP and CBD

Local reactions to marine geoengineering techniques

Alaska Native Organizations react to Arctic Ice Project: An Alaska Native delegation of leaders held a protest outside a fundraiser for the California-based Arctic Ice Project, delivering a collective letter articulating their call to cease research, specifically citing the lack of tribal consultation and absence of Free, Prior and Informed Consent (FPIC). The delegation also held a press conference in the area with local campaigners.

FishNet Alliance, Africa: FishNet Alliance, a network of artisanal fishermen across the African continent on Sunday kicked against the concept of Ocean Geocengineering as an option to address climate change at the ongoing COP 27 Climate Conference in Egypt.

Small Scale Fisher Workers, India: India’s National Platform for Small-Scale Fish Workers Rejects Ocean Geocengineering Calls Upon All States to Stop Resorting to False Solutions and Experimentations to Resolve Climate Crisis. See statement here
How can geoengineering research be regulated?

David Santillo (Gosport Laboratory, d.santillo@newton.co.uk) and Paul Johnston (Gosport Laboratory)

The term climate engineering (or geoengineering) refers to a broad range of concepts, some with a history of practical research, others largely theoretical. These concepts range from artificially enhanced natural weathering and large-scale ocean fertilisation to modifying the chemistry of the upper atmosphere or making oceans and seas more reflective. Assessments of their likely effectiveness in mitigating climate change and their potential for adverse effects have highlighted substantial uncertainties and concerns (1,2). In 2019, the Royal Society concluded that although "geoengineering of the Earth's climate is very likely to be technically possible, ... the technology to do so is hardly formed, and there are major uncertainties regarding its effectiveness, costs, and environmental impacts" (3). Seven years on, that assessment remains just as valid.

In response to the limited knowledge and understanding of what might happen in a geoengineering world, the Royal Society in 2019 called for a "framework to ensure a safer and smarter future" (3). This framework should include robust risk assessment and management plans to ensure that the development of any potential geoengineering projects is "safely designed from the start, with appropriate safeguards built in as a matter of course" (3). The Royal Society therefore proposed a "geoengineering code of practice" (3) as a means of ensuring that potential studies are conducted in a manner that meets ethical standards and that potential hazards are identified and managed in a timely manner. The code of practice includes a number of key principles, including the need for rigorous risk assessment, the involvement of stakeholders, and the provision of transparency.

Marine geoengineering: a dangerous distraction from real climate action

David Santillo, PhD

Proposals to "geoengineer" marine ecosystems, whether floating or claims to tackle climate change, boost fisheries or even "restore" ecosystems, have raised concerns among scientists for as long as they have been considered. The term "marine geoengineering" covers a diverse array of ideas, ranging from proposals to change ocean chemistry on a vast scale, through schemes to alter circulation patterns, to attempts to reflect more sunlight back from the ocean surface or the clouds above it. Whatever they all share is the notion that we can deliberately manipulate natural systems, already under pressure from human activities, with the intent to engineer "benefits" for society. In that endeavor, what is all too often lost in an appreciation that our oceans are complex and delicately balanced living systems, not simply vast stores of water in which we can predictably "tune" the physics, chemistry, or biology to our

Questions…?

(and perhaps even some answers)
Marine Geoengineering Projects/Initiatives

**Marine Carbon Dioxide Removal (CDR)**

**Ocean fertilization**
- **WhaleX**, Australia
- UK-based [Center for Climate Repair at Cambridge](https://www.ccr-uk.org) and partners in South Korea, India and Hawaii experimenting with artificial whale poo.\(^1\)\(^2\)
- OPR Alaska Inc. (former Planktos Inc.) to conduct OF experiments in Alaska, USA
- Canada-based [OceanX](https://oceanx.com) attempting to conduct experiments in Chile, Peru and Argentina
- US-based [Climos Inc.](https://www.climosinc.com) with a goal of conducting large-scale OF in the high seas in the northwest Pacific [...] or the sub-polar Southern Ocean
- R&D by US-based [Nualgi America Inc.](https://www.nualgi.com) proposing large-scale ocean fertilization with its self-manufactured fertilizers

**Artificial Upwelling**
- US-based [Ocean-Based Climate Solutions](https://ocean-based.com) testing of wave-powered artificial upwelling technology in Morro Bay, California and in the Atlantic Ocean south of the Canary Islands
- US DOE-sponsored [Blue Fields project](https://energy.gov) (cancelled)
- US-based TROFX (formerly known as Trophic) intends to build a larger offshore algae farm for biomass production using wave-driven artificial upwelling
- US-based [The Climate Foundation](https://theclimaterepaircompany.org) ocean experiments in Hawaii, Philippines, with plans in Storm Bay, Tasmania and Southern California in the eastern Pacific Ocean
- R&D by [Zhejiang University](https://en.zju.edu.cn) in China, testing at various lakes and bays in the country

**Enhanced Weathering**
- US-based [Project Vesta](https://projectvesa.org) to test and scale EW with olivine on beaches along US States
- GEOMAR Germany coordinated- OceanNETs project doing field trials in Spain, Norway
- German research “CO2 Removal by Alkalinity Enhancement: Potential, Benefits and Risks” ([RETAKE](https://www.retake-project.eu) project)
- R&D by Canada-based [Planetary Technology Inc.](https://www.planetarytech.com)
- UK-based [SeaCURE](https://www.seacureproject.eu) project aiming to make seawater temporarily more acidic so that the CO2 in the water ‘bubbles out’, captured, concentrated, compressed and then ‘stored’.
- [Enhanced Silicate Weathering R&D, modelling, and controlled trials by Antwerp University](https://www.ira.unica.it) in Wilrijk, Belgium
- [Solid Carbon](https://www.solidcarbon.org) aiming to do a demonstration project in the open ocean, in the Cascadia Basin off the coast of Vancouver Island
- US-based [Ebb Carbon](https://www.ebbcarbon.com) seeking to commercialise an electrochemical process for removing acid from seawater, with the goal of fixing more CO2 in the form of bicarbonate in the oceans and reducing ocean acidification
- [SEA MATE](https://www.seamate.org) research supported by US NOAA and led by universities to explore electrochemical process for removing acid from seawater, with the goal of fixing more CO2 in the form of bicarbonate in the oceans and reducing ocean acidification
- US-based [SeaChange](https://www.seachange.com) aiming to develop an electrochemical process to capture carbon from seawater. Pilot tests were done in California and Singapore.
- Belgium-based [Out of the blue](https://www.outoftheblue.org) aiming to commercialise a process to remove CO2 directly from seawater.
Marine Geoengineering Projects/Initiatives

Solar Radiation Management (SRM) in marine environments

Reflective substance for covering glaciers
- US-Based Arctic Ice Project testing at various lakes in the United States and Canada, mostly within indigenous territories
- US-Based Bright Ice Initiative to conduct field experiments in the Himalayan glaciers

Marine Cloud Brightening
- MCB trial in the Great Barrier Reef, Australia
- Larger-scale MCB in the Great Barrier Reef, Australia
- MCB trial beside Broadhurst reef, Australia
- Marine Cloud Brightening Project (MCBP) by the University of Washington, the Pacific Northwest National Laboratory (PNNL), a team of engineers from Silicon Valley, the Palo Alto Research Centre and further research partners
- MCB with sea water by Stephen Salter, based at Edinburgh University

Combination of approaches
- China’s Xiamen University ONCE project is investigating Ocean Alkalinity Enhancement (OAE) and artificial upwelling
- UK-based Seafields Solutions Ltd. to supply seaweeds with nutrients through artificial upwelling, with small-scale testing in Mexico and St. Vincent

CO2 storage in oceans
- German funded and led research AIMS3 project is investigating the storage of CO2 in the upper ocean crust
- Norway-based Ocean Geo Logic claims that its technology can capture almost 100% of CO2 from flue gas based solely on an electrical process, without the use of chemicals. In 2022, the company commissioned its first carbon capture pilot plant at the Norske Skog's Skogn, Norway.

Other marine geoengineering promoters & activities
- US-based Ocean Visions established by several US universities and educational institutions has developed roadmaps to accelerate the development and testing of ocean-based CDR approaches. They regularly organize workshops, events, participate in various international conferences fora, and collaborate with international organizations like the Ocean Visions – UN Decade Collaborative Center for Ocean-Climate Solutions.
- The Sabin Center and Ocean Visions will jointly host a series of stakeholder workshops where members of the scientific community, government agency representatives and other interested parties can provide their input to support the development of model legislation for ocean-based carbon dioxide removal.
- NOAA Earth’s Radiation Budget (ERB) Initiative is a US government research program on solar radiation management (SRM), with emphasis on Marine Cloud Brightening (MCB) and Stratospheric Aerosol Injections (SAI)
Marine Geoengineering Projects/Initiatives

- Running Tide Technologies Inc.
- Brilliant Planet
- Pull to Refresh
- Kelp Blue
- Fearless Fund
- Seaweed Carbon Solutions
- Carbon Kapture Ltd.
- Omega Green
- Global Algae Innovations
- Pond Technologies
- Chinese ENN Research and Development Co. Ltd.
- Seambiotic Ltd.
- Seaweed Generation Ltd.
maybe these examples can be used in the slides that Jim/ETC Group will provide
Niki Miranda-Martinez, 25/02/2023