

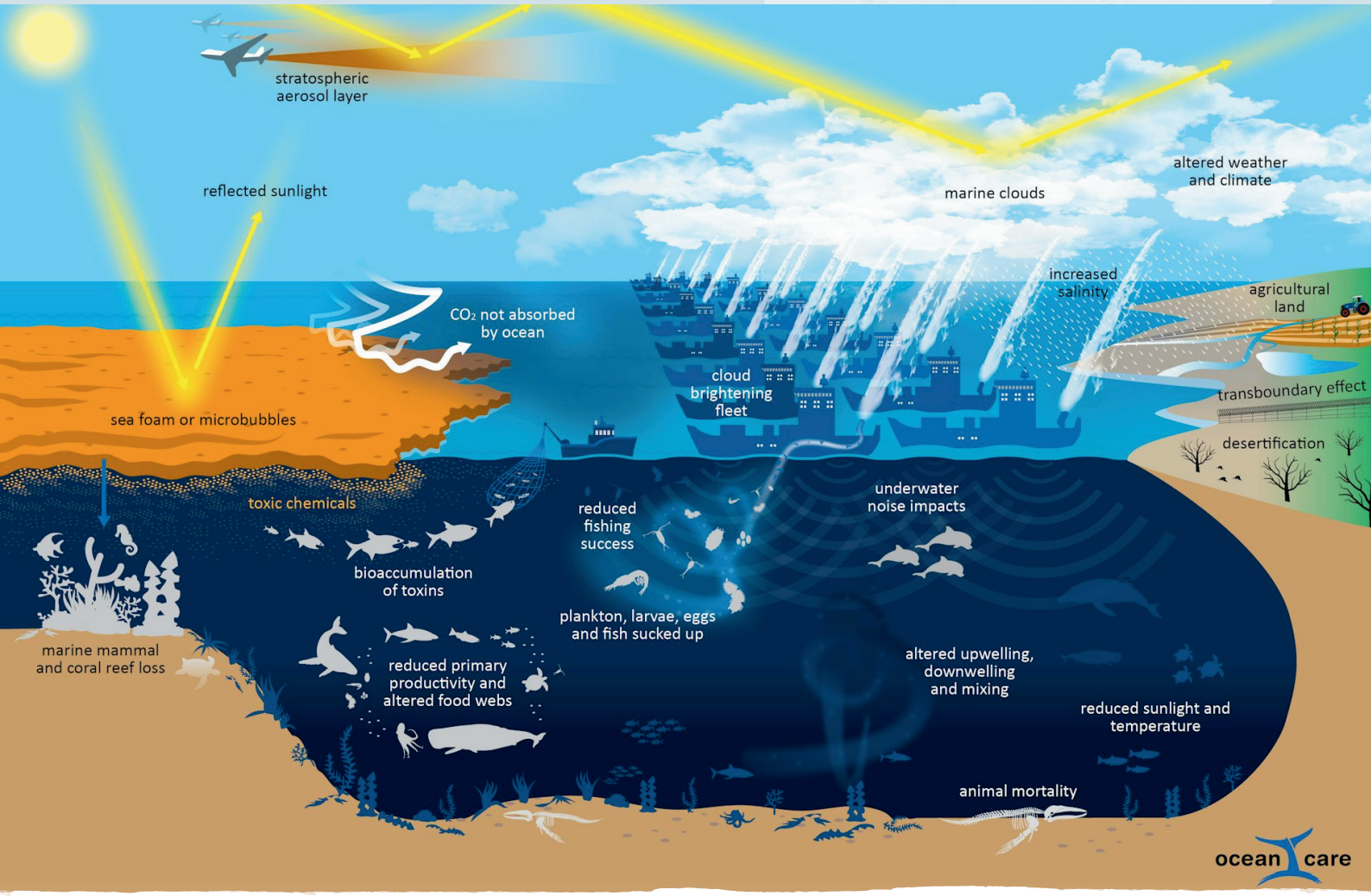
A BRIEFING ON MARINE GEOENGINEERING

HOME ALLIANCE

NOVEMBER 2026 (UPDATED EDITION)

WHAT IS MARINE GEOENGINEERING?

To effectively address the climate crisis, it is crucial to urgently reduce greenhouse gas emissions in a just and equitable manner.



However, in the context of the failure of high-emitting governments and corporations to take action to tackle the root causes of the crisis, there is a growing trend of integrating highly speculative marine geoengineering technologies into climate policy and forums. Marine geoengineering (mGE) involves efforts to alter the Earth's oceans in order to mitigate some of the impacts of climate change but does not tackle the root causes of climate change.

Most of these speculative proposals focus on removing carbon dioxide (CO_2) from the atmosphere and storing it in the ocean, a process often referred to as "marine Carbon Dioxide Removal" (mCDR) or "ocean-based Carbon Dioxide Removal." Other approaches attempt to manipulate ocean surfaces to increase the amount of sunlight reflected back into space in an attempt to cool the planet. For these technologies to have a significant impact on the climate, they would need to be deployed on an enormous scale, with serious adverse effects. Potential harmful impacts include ecosystem disruption, marine food chain disruption, loss of biodiversity, changes in ocean chemistry, concerns about governance, socio-economic losses, and violations of human rights including those of vulnerable populations and the inherent collective rights of Indigenous Peoples. Marine geoengineering methods, such as large-scale seaweed plantations, could also devastate coastal communities by disrupting local ecosystems, food systems, and livelihoods, raising ethical concerns about their long-term consequences for future generations.

Additionally, market-based mechanisms and carbon offsetting are significant drivers of many of these speculative technologies, perpetuating harm in already vulnerable populations and biodiversity.

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MARINE GEOENGINEERING TECHNOLOGIES

Ocean Fertilization (OF)

Ocean fertilization is a method in which iron or other nutrients such as nitrogen are added to parts of the ocean to stimulate plant growth. The idea is that by "fertilizing" ocean regions with lower biological productivity, minute plants called "phytoplankton" grow more readily. As these plants proliferate, they absorb carbon dioxide (CO2) from the atmosphere. When phytoplankton die, some sink to the ocean floor, although it is unclear what proportion of CO2 is locked away and for how long. In previous trials, ocean fertilization experiments stimulated phytoplankton blooms but also caused toxic outbreaks that released potent greenhouse gases like nitrous oxide and methane, which exacerbate global warming. Additionally, studies suggest most of the carbon phytoplankton initially absorbs is released back into the environment through the food chain, likely making long-term carbon sequestration ineffective.[1]

Ocean Alkalinity Enhancement (OAE)

The method involves attempting to increase the ocean's alkalinity to enable it to draw down more CO_2 from the atmosphere. There are two primary methods suggested for achieving this: adding ground alkaline rocks or alkaline liquids to the ocean or coastline (enhanced weathering) and using electrochemical techniques. Massive dumping of alkaline rock into the ocean would be necessary for any significant CO_2 removal; on a global scale, 5-26 gigatons would be needed each year to maintain ocean surface pH. This would lead to devastating environmental impacts from the large-scale mining, processing, and transportation of alkaline materials. While designed to increase CO_2 absorption by altering ocean chemistry, OAE could unintentionally affect marine ecosystems. If silicate materials are used at scale, they would likely release harmful trace elements like cadmium, nickel, and chromium, which could negatively impact deep-sea organisms. Increased pH from OAE would have harmful short-term impacts on marine life in surface waters, but particles sinking to deeper waters could alter microbial communities and affect the food supply for deep-sea life.[7] Electrochemical ocean alkalinity methods pose risks to marine ecosystems by releasing toxic by-products like chlorine gas and trace metals, which could lead to ecotoxicological effects on marine life. The processes are highly inefficient, processing large amounts of seawater for a small quantity of CO_2 removal, this would damage and kill marine life and also require large quantities of renewable energy that should instead prevent further CO_2 from being released into the atmosphere. [8]

Industrial Macroalgae Cultivation and Sinking (IMCS)

Seaweed, also known as macroalgae, absorbs CO_2 and converts it into a form of carbon that living organisms store via photosynthesis. Proponents of large-scale industrial seaweed cultivation for geoengineering claim that this process could sequester carbon dioxide in three main ways. One method involves seaweed breaking away from farms and sinking, taking the stored carbon with it. Another approach is to use harvested seaweed to create materials like biochar or bioplastics. Lastly, seaweed biomass can be gathered, pressed, and submerged into the deep ocean. However, the massive scale of cultivation required would significantly disrupt marine ecosystems and affect the livelihoods of coastal communities - some 10% of the ocean surface has been suggested. [2] Seaweeds release bioaerosols that can act as potent greenhouse gases and their growth will rob nutrients from phytoplankton that are a significant component of the biological carbon pump. [3] Additionally, the idea of artificial upwelling—pumping nutrient-rich deep water to the surface to stimulate seaweed growth —has been proposed despite concerns that it could disrupt natural ocean processes and ecosystems and bring up CO_2 stored in deeper waters. [4] The large-scale sinking of organic matter over vast areas can have significant environmental impacts, such as releasing dissolved organic materials and chemicals during their descent and at the seafloor. This process can lead to smothering and create low-oxygen conditions (anoxia), which may produce harmful hydrogen sulfide. A meta-analysis showed that under hypoxic conditions, the survival rate of benthic communities decreases by an average of 30%. [5] These conditions can result in the mass die-off of seafloor organisms at the disposal site, with potentially cascading impacts on marine ecosystems. [6]

Carbon Capture and Storage (CCS)

This method involves capturing CO_2 emissions from power plants or industrial facilities, typically by using a sorbent chemical to trap the CO_2 before it exits a smokestack. The captured CO_2 is subsequently converted into a liquefied or carbonated state and then introduced into geological formations, typically within nearly depleted oil wells or sub-seabed locations, as a means of long-term storage. However, concentrated liquefied CO_2 is highly toxic. [9] When CO_2 is stored in deep ocean waters or on the seafloor, there are concerns about potential direct exposure of deep-sea animals and ecosystems to the CO_2 or CO_2-hydrate, as well as the possibility of a plume of carbon dioxide spreading from the storage site and affecting surrounding waters. Further marine impacts may arise from noise pollution and physical disturbance caused by the construction of extensive pipelines for transporting and storing CO_2. Additionally, there is an increased risk of seismic activity due to raised sub-surface pressure. [10]

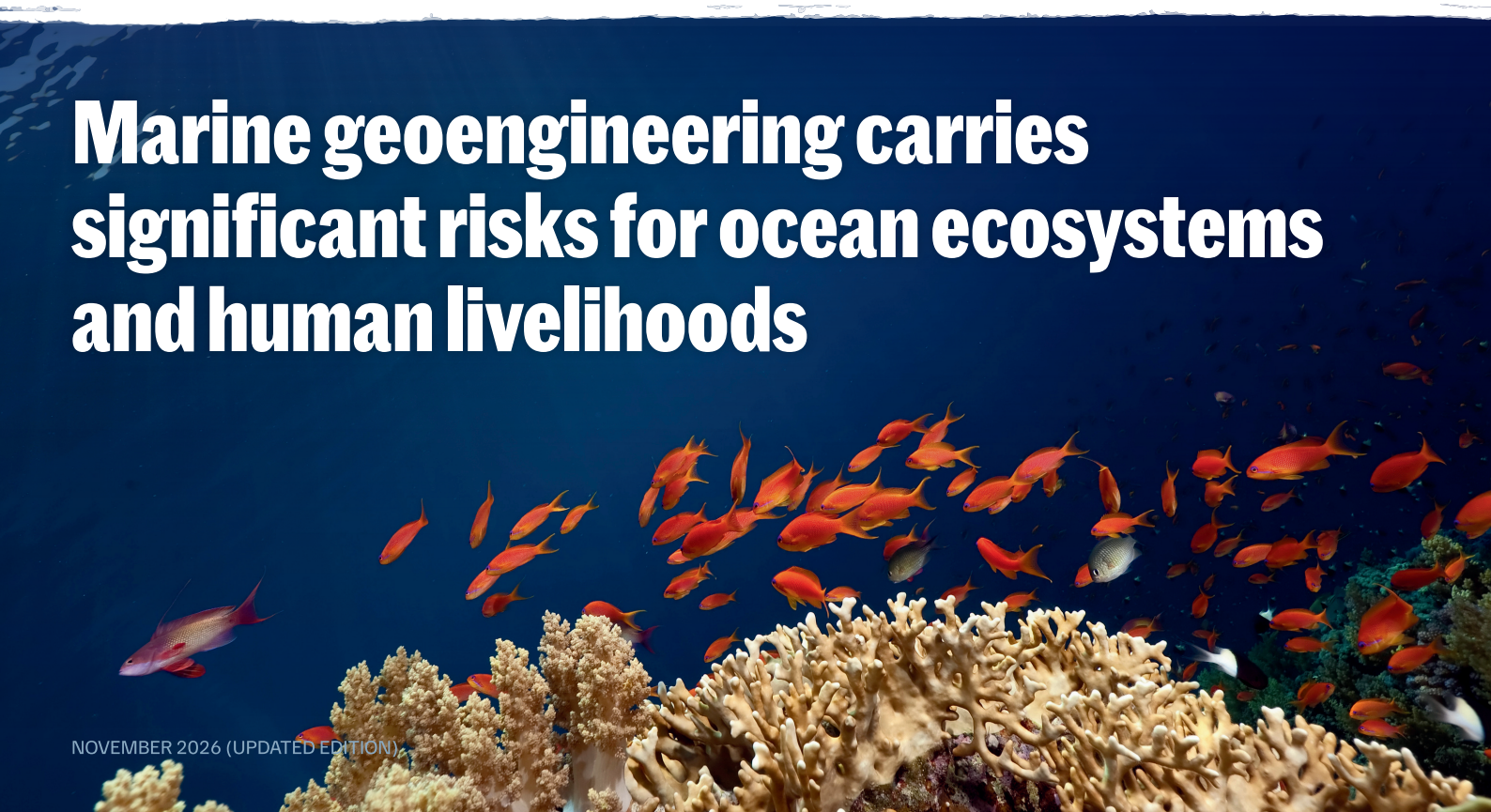
Marine Cloud Brightening (MCB)

This proposed solar geoengineering technique aims to increase the brightness of clouds in order to reflect more sunlight back into space. The idea is to enhance cloud reflectivity by injecting tiny particles—such as sea salt aerosols—into marine clouds, creating smaller and more concentrated droplets. While some models suggest that this technique could lower global temperatures, they also predict uneven and potentially harmful effects in different regions. For example, if deployed at a scale large enough to affect temperature, global rainfall is expected to decrease. One study suggests a potential 2.3% reduction in precipitation. This could have severe consequences, such as making South America warmer and drier, leading to devastating ecological impacts, particularly in the Amazon rainforest. In contrast, another study forecasts a 7.5% increase in runoff over land, especially in the tropics, due to uneven changes in precipitation patterns. [11] Additional salt loads returning to the ocean surface will slow air-sea gas exchange and, therefore CO_2 uptake by the oceans, reducing light and temperature levels that could affect ocean circulation and mixing. On land, increased salt deposition could corrode coastal infrastructure, pollute waterways, and harm agricultural productivity. Lastly, large-scale seawater pumping and filtration will ingest and kill significant numbers of marine organisms.

Ocean Reflectivity Enhancement

The technique involves using microbubbles and sea foam on ocean surfaces, including sea ice, as a proposed method of solar geoengineering. The aim is to increase the reflectivity of water surfaces (albedo) to reflect more sunlight and reduce heat absorption. This can theoretically be achieved by creating brighter water surfaces, such as whitecaps or foamy waves, which naturally reflect more sunlight. There are two proposed methods to extend the lifespan of these bubbles: using ships equipped with special nozzles to produce microbubbles or using chemicals called surfactants to stabilize the bubbles. Artificial foam can also be created using foaming agents like cellulose ethers. However, it's important to consider the potential negative effects of large-scale use of microbubbles. This method could disrupt marine ecosystems by reducing the sunlight that phytoplankton—the foundation of the marine food web—need for photosynthesis. It could also hinder gas exchange, leading to lower oxygen levels in the water, which would negatively affect marine biodiversity and productivity. Additionally, the surfactants used to stabilize bubbles would most likely be toxic to marine life. [12]

Marine geoengineering carries significant risks for ocean ecosystems and human livelihoods



NEGATIVE IMPACTS OF MARINE GEOENGINEERING



Large-scale interventions can lead to unintended and irreversible consequences in geoengineering carries significant risks for ocean natural ocean processes. The GESAMP high-level review of a wide range of proposed marine geoengineering techniques suggests that technologies such as ocean fertilization and ocean alkalinity enhancement would need to be deployed across roughly 10% of the world's oceans to be effective.[13] ecosystems and human livelihoods.

The extensive deployment of these technologies raises serious concerns about long-term environmental sustainability and global equity.

1 Ecosystem Disruption

Interventions, such as ocean fertilization or artificial upwelling, can have a significant impact on marine ecosystems. For example, stimulating the growth of phytoplankton through ocean iron fertilization may increase short-term carbon uptake, but it could also result in harmful algal blooms that deplete oxygen levels in the water. [14] These oxygen-depleted zones can be fatal to marine life, causing the collapse of plankton communities, which are crucial to the marine food chain. This disruption could have far-reaching effects on fish, marine mammals, and other species that rely on these foundational organisms. [15]

2 Biodiversity Loss

Marine geoengineering would inevitably result in a loss of biodiversity. The introduction of artificial substances or alteration of ocean conditions inevitably leads to the favoring of certain species, ultimately causing a significant shift in species dominance. For example, enhancing one type of plankton through fertilization could hinder the growth of other types, resulting in a less diverse ecosystem. Large-scale algae monoculture cultivation would displace other species and could spread pathogens to natural algae and artisanal cultivation. [16] This loss of biodiversity could drive some species to extinction, especially those already vulnerable to environmental stressors, and could fundamentally change the balance of marine ecosystems. Similarly, another concern with storing CO_2 in deep ocean waters or on the seabed is that it could expose deep-sea creatures to harmful levels of CO_2, which can dissolve into the water and affect marine life. Storing CO_2 under the seabed also carries the risk of leaks, which could change the water's chemistry by altering pH and increasing metals or salinity, all of which can harm ocean ecosystems. [17]

3 Ocean Chemistry Alteration

The modification of ocean chemistry through marine geoengineering is a significant cause for concern. Methods such as Ocean Alkalinity Enhancement and Ocean Fertilization can unpredictably alter the chemical composition of seawater. While these techniques are intended to boost the ocean's ability to absorb carbon dioxide, they may lead to unintended consequences such as increased acidification or the creation of dead zones with dangerously low oxygen levels. Many marine species are highly sensitive to changes in pH, and even slight alterations can disrupt ecosystems and harm biodiversity. The long-term effects of these chemical changes are poorly understood, and there is a significant risk of triggering chain reactions that could be difficult or impossible to reverse. [18]

4 Social, Cultural, and Economic Impacts

Marine geoengineering could have significant social and economic impacts, especially on coastal communities that depend on healthy oceans for their livelihoods. Fisheries, which provide food and income for millions of people worldwide, could be disrupted by changes in fish populations or shifts in marine food webs. Likewise, for coastal and Indigenous communities that have worked for centuries on artisanal fisheries and small-scale algae cultivation. Coastal communities could face unintended consequences, such as increased storm surges or changes in coastal erosion patterns, which could be worsened by large-scale geoengineering projects. [19] Tourism, particularly in areas reliant on clean waters and thriving marine life, could suffer if geoengineering results in ecosystem degradation. Large-scale infrastructure built near Indigenous Peoples' territories has been shown to increase violence against and murder of Indigenous Peoples. [20] Indigenous Peoples' territories continue to be targeted by marine geoengineering researchers. [21] Further, marine geoengineering experiments and projects disrupt Indigenous Peoples' cultural practices. Researchers fail to implement free, prior, and informed consent (FPIC) or uphold the Rights of the Indigenous Peoples as enshrined in the UNDRIP. [22]



MARINE GEOENGINEERING IS NOT A SOLUTION TO CLIMATE CHANGE

Biodiversity Loss

Marine geoengineering is often presented as a technological solution, but it fails to address the root cause of climate change: greenhouse gas emissions from using and burning fossil fuels. Even if methods like ocean fertilization or artificial upwelling could theoretically temporarily capture small amounts of carbon, they do not stop the ongoing release of CO_2 into the atmosphere.

The only real, long-term solution is to rapidly and justly phase out all extraction and production of fossil fuels, and equitably cut all greenhouse gas emissions at the source.

Risk of Moral Hazard

Marine geoengineering risks presenting a false sense of security. This is sometimes called "moral hazard," where relying on future technological solutions to tackle the climate crisis might shift resources away from proven emissions reduction methods. Governments and industries might delay or avoid tough decisions, such as transitioning away from fossil fuels because they think geoengineering will buy them more time. In reality, the more we rely on these risky technologies, the harder it will be to mitigate climate change in the future and prevent its worst impacts.

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Financial Drivers of Marine Geoengineering Expansion

The rapid development of marine geoengineering projects is being fueled in part by substantial venture capital investments and the lucrative potential of generating profit from carbon credits. With financial incentives tied to carbon markets, a surge of initiatives aimed at manipulating ocean processes to remove CO2 is emerging, often without sufficient consideration of the long-term environmental consequences. Carbon markets, in both the voluntary and regulated sectors, convert claimed CO_2 reductions or removals into tradable credits. These units are then sold onto a market and bought by polluters, allowing them to falsely claim that they have reduced or removed their emissions. Ultimately, carbon markets allow polluters to continue to pollute while making money in the carbon markets by buying and selling these units when the market values fluctuate. Carbon markets are a lose-lose process on both sides because marine geoengineering is claimed to be a solution to reducing or removing CO2, and extractive industries can continue to pollute, worsening climate change.

While these projects are marketed as climate solutions, they present severe risks by focusing on profit-driven technological interventions rather than addressing the underlying cause of climate change—greenhouse gas emissions from fossil fuels. This reliance on financial mechanisms encourages speculative projects that divert attention from sustainable solutions and further intensifies the moral hazard by delaying the much-needed transition to renewable energy sources.

The Precautionary Principle

The long-term consequences of marine geoengineering (mGE) remain poorly understood. Techniques such as ocean fertilization and adding alkaline substances to seawater carry potential risks, as they may lead to unintended side effects that could exacerbate climate change. For instance, while these methods are intended to enhance carbon storage in the ocean, they could instead disrupt marine ecosystems or alter ocean chemistry in unpredictable ways. Given the complexity of ocean systems, even minor interventions can have far-reaching negative impacts on marine life and human communities.

If deployed on a large scale, such technologies could have devastating effects that are difficult, if not impossible, to reverse.

Compromising the Ocean's Natural Carbon Storage Role

Beyond uncertain climate impacts, these marine geoengineering techniques could compromise the ocean's existing role as a natural carbon sink. By adding stress to marine ecosystems, mGE could reduce the ocean's natural capacity to sequester carbon. This would not only counteract the intended benefits of mGE but could also exacerbate the climate crisis by reducing the ocean's ability to regulate atmospheric CO_2 levels. The ocean's carbon cycle is intricately linked with global climate stability,[23] and additional interventions might destabilize this balance, bringing serious risks to both marine ecosystems and human communities.

Risk of Temperature Overshoot and Irreversible Tipping Points

While mGE may seem like a promising tool to mitigate climate impacts, reliance on these technologies brings significant risks. If global temperatures temporarily overshoot the 1.5°C threshold, it could trigger tipping points and feedback loops that accelerate climate change. [24] Once such processes start, they might be impossible to reverse, even with carbon dioxide removal methods like mCDR. Relying heavily on geoengineering could also reduce the urgency to cut emissions at their source, potentially locking us into a path that results in catastrophic climate impacts over the long term. [25]



GOVERNANCE AND REGULATION

The field of marine geoengineering (mGE) intersects with various international and regional frameworks, each offering different regulatory perspectives and challenges. As interest in mGE grows, there is a greater recognition of the necessity for strong governance to prevent potential ecological harm and to ensure that mGE does not undermine existing climate and biodiversity goals. This section delves into the roles of key conventions, protocols, and treaties in regulating mGE.



> **Thus, a precautionary approach that promotes ecosystem-based solutions, like restoring marine habitats, is crucial to ensure sustainable and environmentally sound climate action**

Convention on Biological Diversity

The Convention on Biological Diversity (CBD) has taken significant steps in regulating marine carbon dioxide removal (mCDR) activities.

In 2008, CBD made a landmark decision, calling for a precautionary approach to ocean fertilization, urging countries to halt such activities until there is sufficient scientific evidence to assess their risks and establish global, transparent regulatory mechanisms. Exceptions were made only for small-scale scientific studies in coastal waters, provided they undergo thorough environmental assessments and are not for commercial purposes. In 2010, CBD extended its caution to all climate-related geoengineering activities, calling for a moratorium on large-scale deployment until global, multilateral and transparent governance mechanisms are in place, with no risk of transboundary harm and sufficient scientific backing to ensure these activities don't threaten biodiversity or social and cultural values. [26]

At COP16 in Cali (2024), Parties reaffirmed decisions IX/16 C, X/33 paragraph 8(w), XI/20 and XIII/14, and went further than in 2010 by urging Parties, and encouraging other governments, to ensure their implementation.[27]

LONDON CONVENTION AND PROTOCOL

The London Convention (LC) and London Protocol (LP) provide important international rules for regulating ocean dumping, building on UNCLOS' general obligations.

Adopted in 1972, the London Convention prohibits dumping of certain harmful substances, while the 1996 London Protocol, which is more restrictive, prohibits all dumping except for a few listed substances. The two Treaties meet jointly for their annual Governing Bodies meeting, and many decisions are adopted jointly.

For almost two decades, the London Convention and London Protocol (LC/LP) have sought to regulate marine geoengineering. In 2008, Parties to the LC/LP agreed that ocean fertilization activities other than legitimate scientific research should not be allowed, and they directed the Treaties' Scientific Groups to develop an Assessment Framework for evaluating research proposals on a case-by-case basis[28] That framework was adopted in 2010 through Resolution LC-LP.2, as the Assessment Framework for Ocean Fertilization.[29]
In 2013, Resolution LC.4(8) proposed to amend the LP to prohibit the placement of matter for marine geoengineering activities listed in Annex 4, unless the listing provides that the activity may be authorized under a permit. Annex 5 of the amendment also noted that any activities listed in Annex 4 should be assessed using a "specific assessment framework" tailored to each technique. The only activity currently listed in Annex 4 is ocean fertilization. Although the amendment has not yet entered into force, it is the first attempt to create legally binding rules for certain types of marine geoengineering under international law, marking a significant step toward future governance.

In 2022, 2023, 2024, and 2025, LC/LP Parties adopted statements at each year's Governing Bodies meeting.[30] Importantly, in these statements, Parties identified four priority marine geoengineering techniques for evaluation (OAE, biomass sinking, marine cloud brightening, microbubbles/reflective particles),[31] acknowledged the potential for these techniques to have "deleterious effects,"[32] and reiterated the urgency of the LC/LP's work.[33]

In October 2026, at LC 48/LP 21, the Parties adopted a resolution adopting a Revised Assessment Framework for ocean fertilization, an Assessment Framework for ocean alkalinity enhancement, and an Assessment Framework for ocean sinking of biomass.[34] Under these frameworks, proposals are assessed on a case-by-case basis on whether they constitute legitimate scientific research and are not against the aims of the LC/LP. Parties stressed that further research is needed before any activity beyond the research stage can be considered.[35]

United Nations Framework Convention on Climate Change

United Nations Framework Convention on Climate Change (UNFCCC)

Article 6 is the carbon markets Article of the Paris Agreement. Specifically, Article 6.4 replaces the Kyoto Protocol's Clean Development Mechanism and is positioned to become the largest global carbon offsets platform. This market-based mechanism would allow countries to trade credits from emission reduction and removal projects, where one nation's carbon offsets can be used by another to meet its Nationally Determined Contribution (NDC) in the Article 6.2 registry database.[36] While presented as a cost-effective approach to achieving climate goals, Article 6 risks prioritizing technological fixes over direct emissions reductions and phasing out fossil fuels at source. Article 6.4 established what is now called the Paris Agreement Crediting Mechanism (PACM). Its standards on methodologies and on activities involving removals were adopted by the Supervisory Body in October 2024 and approved by Parties at COP29 in Baku.[37] A standard on reversals of credited removals followed in October 2025.[38] No marine CDR methodology has yet been approved. However, the removals standard does not exclude ocean-based approaches, so marine geoengineering could still be credited as a form of greenhouse gas removal. That would legitimize mGE despite its risks to marine ecosystems, biodiversity and coastal communities, and divert resources from essential climate solutions, like phasing out fossil fuels, toward technofixes and false solutions.

THE LAW OF THE SEA

The United Nations Convention on the Law of the Sea (UNCLOS) provides a wide legal framework for regulating ocean-based activities.

Although it does not explicitly address marine geoengineering activities, UNCLOS may still influence their regulation. Key provisions, such as those defining countries' jurisdiction over ocean areas and responsibilities to protect the marine environment, could shape how nations govern mGE. For example, coastal states have sovereign rights over their territorial waters and exclusive economic zones, allowing them to regulate ocean-based activities, including mGE. However, ocean CDR could also be classified as marine pollution under UNCLOS, depending on its impacts on marine ecosystems. The convention also integrates international rules and standards from other treaties, meaning that future mGE activities will need to align with both UNCLOS and global climate agreements like the Paris Agreement.[39]

The OSPAR (Oslo-Paris) Convention is an international body dedicated to protecting the marine environment of the North-East Atlantic.

OSPAR brings together various nations to address issues like marine pollution, biodiversity conservation, and sustainable use of ocean resources. The Commission emphasizes a precautionary approach, ensuring that activities, such as carbon capture and storage (CCS), are rigorously assessed to prevent harm to marine ecosystems in the North-East Atlantic. OSPAR also highlights the need for clear regulations and monitoring frameworks for CCS, addressing concerns about unintended consequences, such as ocean acidification, disruption of ecosystems, and leakage from sub-seabed storage sites. By adhering to international environmental principles like the precautionary principle, OSPAR seeks to balance technological innovation with the protection of marine biodiversity.[40]

The High Seas Treaty, also known as the Agreement on Biodiversity Beyond National Jurisdiction or 'BBNJ', was adopted on 19 June 2023 and entered into force on 17 January 2026.

It is a framework established for the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction, such as the high seas. Though it does not specifically address marine geoengineering, it could be used to regulate these activities, based on the precautionary principle, through its tools for area-based management and environmental impact assessments. The treaty allows for the creation of protected marine areas where harmful activities like mGE could be restricted or monitored. Additionally, it requires countries to assess the environmental and other impacts of ocean-based activities, ensuring that mGE projects undergo thorough evaluations. The treaty emphasizes transparency, stakeholder consultation, and the use of scientific evidence, creating an opportunity for balanced assessments of mGE activities, considering both risks and potential climate benefits. The Agreement entered into force on 17 January 2026, and its first Conference of the Parties must convene before 17 January 2027.[41] However, its effectiveness will depend on how well countries implement its provisions, as the treaty comes into force.





We, as representatives from civil society, Indigenous Peoples, and grassroots organizations from around the world therefore call on governments and COP31 Presidencies to:



- Uphold the long-standing and repeatedly reaffirmed de facto moratorium on all climate geoengineering approaches, including marine carbon dioxide removals, under the Convention on Biological Diversity, noting the Rio Synergies agenda, and the ICJ Climate Change Advisory Opinion affirming that States must consider their obligations under other international environmental treaties when taking climate action and interpret their obligations under international law harmoniously.
- Avoid vague terminology such as Ocean Climate Solutions and Ocean Climate Technologies in COP31 decisions to shut down any loopholes for marine carbon dioxide removals/geoengineering proponents to exploit
- Exclude marine carbon dioxide removal credits and all CDR credits from Article 6 mechanisms and Nationally Determined Contributions accounting
- Urgently prioritize real solutions to the climate crisis, including a just and equitable phase-out of fossil fuels, a halt to offshore oil and gas activities, and grant-based ocean climate finance aligned with fair shares, rather than offsets.

RECOMMENDATIONS FOR UNFCCC COP31

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