Marine Geoengineering: Legal and Administrative Challenges

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Abstract

The Ocean, covering over 70% of the earth's surface is a crucial component of our planet's ecosystem, playing a vital role in climate regulation, biodiversity, and human livelihoods. The provisions of UNCLOS, which has frequently been hailed as the Constitution for the Oceans, may not sufficiently address contemporary technological advancements in Marine Geoengineering. This present study analyses the legal and governance challenges associated with MG. It critically examines the ecological and long-term implications of these technologies, assesses the sufficiency of existing legal frameworks and international legal instruments, and recommends the development of comprehensive and unified legislation to address governance gaps and regulatory challenges inherent in the marine geoengineering landscape.

Key Words

Marine Geoengineering, International Seabed Authority, UNCLOS, International Maritime Organisation, Regulatory Challenges

1. Introduction

Marine Geoengineering (MG) refers to technological interventions designed to modify oceanic and atmospheric processes to counteract climate change. These techniques, which include ocean fertilization, carbon capture and storage (CCS), ocean albedo enhancement, ocean alkalinity enhancement, and artificial upwelling, aim to enhance the ocean's natural capacity to absorb carbon dioxide (CO_2) or modify the Earth's radiative balance. While promising, these technologies are experimental and raise concerns about their ecological impacts and long-term efficacy, necessitating careful regulatory oversight and thorough understanding before large-scale implementation.

This paper is divided into 4 parts. It explores the complex legal landscape surrounding MG, focusing on the governance structures and regulatory bodies responsible for overseeing these emerging technologies. Part 1 examines some of the unique challenges of Marine Geoengineering such as scientific and technical uncertainties, governance issues, environmental and ecological risks, social and political challenges, and economic and regulatory considerations. Part 2 discusses the Legal framework for marine geoengineering. It further examines existing international legal instruments, such as the UNCLOS, CBD, London Convention and Protocol, as well as Customary International Law. Part 3 considers the Governance Gaps and Regulatory Challenges in the MG Framework while Part 4, analyses the Institutional Framework of Marine Geoengineering.

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Flowing from the above, my findings indicate that MG governance encounters significant challenges due to the absence of a dedicated international treaty, fragmented regulations, and rapidly evolving technologies. This situation calls for adaptive governance mechanisms and additional legal instruments to ensure comprehensive oversight.

2. Unique Challenges of Marine Geoengineering

MG presents a unique set of challenges distinguishing it from other environmental and technological interventions. These challenges arise from the inherent complexities of the marine environment, the global scale of potential impacts, the ethical and legal uncertainties, and the nascent stage of many geoengineering technologies. They include but are not limited to the following:

Scientific and Technical Uncertainties

MG technologies are still in their early stages of development. As a result, significant scientific uncertainty surrounds their effectiveness, environmental impacts, and long-term consequences to marine biodiversity and ecosystems.[1] The interconnectedness of ocean processes makes it difficult to predict the outcomes of geoengineering, with even small-scale interventions potentially causing widespread and unintended effects.

Governance Issues

MG raises significant ethical concerns, particularly regarding environmental justice, intergenerational equity, governance, and the moral hazard of relying on technological fixes for climate change.[2] These interventions could disproportionately impact vulnerable communities, especially in coastal and island regions, exacerbating global inequalities as the benefits may not be evenly distributed.[3] Developing countries, which contribute the least to greenhouse gas emissions, could suffer the most from the negative consequences of geoengineering led by more developed nations, raising issues of fairness and equity.[4]

Environmental and Ecological Risks

Geoengineering activities that alter ocean chemistry, such as ocean alkalinity enhancement, could have unpredictable effects on marine biodiversity and ecosystem services.[5] Furthermore, the long-term environmental impacts of geoengineering interventions are difficult to predict. Some geoengineering techniques, such as deep-sea carbon storage, involve the permanent alteration of marine habitats, which could have irreversible consequences for deep-sea ecosystems.[6] The potential for unintended consequences, such as the exacerbation of ocean

[1] Jeffrey McGee, Kerryn Brent, and Wil Burns, 'Geoengineering the oceans: an emerging frontier in international climate change governance' (2018) 10 **Australian Journal of Maritime & Ocean Affairs** 67.
[2] Joshua Wells, 'Geoengineering Governance: Addressing the Problems of Moral Corruption, Moral Hazard, and Intergenerational Inclusion' (PhD diss, University of Reading 2020).
[3] Albert Lin, 'Geoengineering: imperfect yet perhaps important options for addressing climate change' in David M Konisky (ed), *Handbook of US Environmental Policy* (Edward Elgar Publishing 2020) 373.
[4] Ibid
[5] Ibid
[6] Charles H Greene and others, 'Geoengineering, marine microalgae, and climate stabilization in the 21st century' (2017) 5 *Earth's Future* 278.

acidification or the disruption of nutrient cycles, further highlights the need for a precautionary approach in the deployment of MG technologies.[7]
(iv). MG also presents significant social and political challenges, particularly in terms of public perception, stakeholder engagement, and the legitimacy of decision-making processes.[8]

Economic Considerations

The economic aspects of MG are also challenging. The costs associated with research, development, deployment, and long-term monitoring of geoengineering technologies are substantial, and it remains unclear who would bear these costs.[9] Moreover, the potential economic benefits of geoengineering, such as the mitigation of climate change impacts, must be weighed against the risks and costs of potential environmental damage.[10]

Regulatory Considerations

The evolving nature of geoengineering technologies requires adaptive regulatory mechanisms capable of responding to new scientific knowledge and technological developments.[11] However, the absence of clear regulatory pathways and the potential for regulatory fragmentation across jurisdictions pose risks to the effective governance of MG.[12]

3. Legal Framework of Marine Geoengineering (MG)

The Legal framework for MG comprises of customary international law, the UNCLOS, the London Convention (LC) of 1972, LP 1996, the Convention on Biological Diversity.

Customary International Law

State practices have established several customary legal principles, with the "no harm" principle being particularly significant.[13] This principle requires states to prevent, reduce, and manage pollution and substantial transboundary environmental harm resulting from activities within their territory or under their control.[14] This principle is widely accepted in non-binding declarations, backed by the UN General Assembly, the International Law Commission (ILC), international environmental agreements, and court rulings. The ICJ confirmed it in the Pulp Mills case, highlighting a state's responsibility to prevent significant harm to another state's environment, especially when shared resources and risky activities are involved.[15]

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[7] Sikina Jinnah, Simon Nicholson, and Jane Flegal, 'Toward legitimate governance of solar geoengineering research: a role for sub-state actors' in Toby Svoboda (ed), *The Ethics of "Geoengineering" the Global Climate* (Routledge 2020) 233.
[8] Sean Low and others, 'Public perceptions on solar geoengineering from focus groups in 22 countries' (2024) 5 *Communications Earth & Environment* 1.
[9] ibid.
[10] Elnaz Roshan, Mohammad M Khabbazan, and Hermann Held, 'Cost-risk trade-off of mitigation and solar geoengineering: Considering regional disparities under probabilistic climate sensitivity' (2019) 72 *Environmental and Resource Economics* 263.
[11] Olaf Corry, 'The international politics of geoengineering: The feasibility of Plan B for tackling climate change' (2017) 48 *Security Dialogue* 297.
[12] ibid.
[13] Sandrine Maljean-Dubois, 'The No-Harm Principle as the Foundation of International Climate Law' (2021) *Debating Climate Law* 35.
[14] Benoit Mayer, 'Climate change mitigation as an obligation under customary international law' (2023) 48 *Yale Journal of International Law* 105.
[15] *Case Concerning Pulp Mills on the River Uruguay, Argentina v Uruguay* (Judgment on the merits) [2010] ICJ Rep 14, ICGJ 425 (ICJ 20 April 2010).

However, the characterization of shared resources, including the legal status of the atmosphere and the classification of specific geoengineering activities as hazardous, remains debated in international law.[16] Despite these uncertainties, the "no harm" principle emphasizes preventing significant harm rather than classifying activities as hazardous.[17]

The United Nations Convention on Laws of the Sea (UNCLOS)

The UNCLOS established in 1982, incorporates various customary international law principles related to the maritime domain.[18] Part XII of UNCLOS, titled "Protection and Preservation of the Marine Environment," sets out key environmental obligations for maritime activities. States must regulate and monitor activities under their jurisdiction, as outlined in Article 94, which includes enforcing international safety, pollution prevention, and labour standards for vessels. Article 192 requires states to protect and conserve the marine environment, applying these duties to maritime activities within a state's territory, in international waters, or where cross-border impacts are involved. [19]

The effectiveness of MG regulations relies on how marine pollution is defined under UNCLOS. This includes the introduction of substances or energy into the ocean that harms marine life, poses risks to human health, disrupts marine activities, degrades water quality, and depletes marine resources.[20] It is concerned with activities that introduce substances likely to cause harm.[21] This broad definition covers impacts from MG activities like OIF and AOA, which involve introducing substances into the marine environment and are likely considered pollution due to their potential adverse effects.[22] However, other MG techniques like MCB or ocean upwelling, which involve moving water and nutrients within the ocean, may use pipes that are better classified as equipment rather than substances. These techniques might not qualify as marine pollution since they don't introduce harmful substances.[23] The classification of MG activities as pollution depends on whether they pose a risk of harmful effects.

During the research phase, such activities fall under the regulations outlined in Articles 258–262 of UNCLOS. Therefore, it's unclear if the marine pollution obligations apply to all MG proposals, depending on whether these activities meet the definition of marine pollution. UNCLOS sets specific procedural obligations for MG activities, requiring states to cooperate in protecting the marine environment, notify relevant parties of potential threats, and conduct EIAs for activities likely to cause significant pollution or environmental harm.[24]

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[16] Anthony E Chavez, 'Using legal principles to guide geoengineering deployment' (2016) 24 *NYU Environmental Law Journal* 59.
[17] Stephen M Gardiner, 'Ethics and geoengineering: An overview' in *Global Changes: Ethics, Politics and Environment in the Contemporary Technological World* (2020) 67.
[18] Nilmini Silva-Send, 'Deep Sea Mining in the Area Beyond National Jurisdiction–A Lost Opportunity or Yet Another Reason for the United States to Join UNCLOS?' (2024) San Diego Legal Studies Paper 24.
[19] Kerryn Brent, 'Marine Geoengineering Governance and the Importance of Compatibility with the Law of the Sea' in *Research Handbook on Climate Change, Oceans and Coasts* (Edward Elgar Publishing 2020) 442.
[20] Article 1(4) UNCLOS
[21] Anita Dian Eka Kusuma and Akbar Kurnia Putra, 'The Role of UNCLOS 1982 in Maintaining and Protecting the International Marine Environment' (2024) 6 *Lampung Journal of International Law* 23.
[22] Karen N Scott, 'Mind the Gap: Marine geoengineping and the Law of the Sea' in *High Seas Governance* (Brill Nijhoff 2018) 34.
[23] Simon Harding, 'Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity' (2016) Secretariat of the Convention on Biological Diversity 20.
[24] Article 197 UNCLOS, Article 198 UNCLOS

Convention on Biological Diversity (CBD)

The CBD imposes responsibilities on nations to preserve biological diversity, promote sustainability in utilization of its components, and ensure the fair and equitable sharing of genetic resources in Article 1. The CBD defines "biological diversity" to include ecosystems on land, in the sea, and in other aquatic environments.[25] Consequently, MG activities that could impact marine biodiversity and ecosystems fall under the purview of this agreement.

The CBD applies to MG research and activities within both territorial waters and areas beyond national jurisdiction.[26] Despite its broad relevance, the CBD imposes limited specific obligations regarding MG, primarily requiring states to prevent cross-border harm under Article 3 CBD and requires states to identify activities that could significantly adversely affect the conservation and sustainable use of biological diversity,[27] cooperate internationally,[28] and make national laws detailing EIA procedures. However, the CBD doesn't define the content or criteria for an EIA for MG activities, providing little guidance on what's appropriate. As a result, the obligations in the CBD are vaguely defined, and their effectiveness in governing MG is limited by the frequent use of qualifying language.[29]

The London Convention and London Protocol

The "Convention on the Prevention of Marine Pollution by Dumping of Wastes or Other Matter, 1972" (LC) and the London Protocol 1996 (LP) are international treaties that regulate ocean waste disposal, building on the UNCLOS principles in Article 210. The LC, adopted in 1972, focuses on preventing marine pollution from waste dumping.[30] The LP, adopted in 1996, aims to replace the LC with stricter measures, employing a precautionary approach to eliminate pollution from dumping.[31] Both agreements apply to territorial seas, EEZs, and the high seas, making them relevant to MG activities like OIF and AOA.[32] In 2013, a proposed LP amendment sought to regulate MG specifically, but it has not yet come into effect and is not legally binding.

Apart from this pending amendment, the LC and LP pertain to MG activities classified as "dumping." Dumping, as defined by both agreements, refers to the intentional disposal of waste or other substances into the sea from various structures at sea, including vessels, aircraft, and platforms.[33] It also covers deliberate disposal at sea of such structures themselves.[34] Activities that involve introducing substances into the ocean for purposes other than disposal are not considered dumping unless they conflict with the goals of the Convention/Protocol.[35] This definition covers a wide range of MG activities carried out from different structures near or within the ocean, provided that they involve the deliberate introduction of materials into the sea.

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[25] CBD, article 2
[26] ibid, article 4
[27] ibid, article 7
[28] ibid, article 5
[29] Kerryn Brent, 'Marine Geoengineering Governance and the Importance of Compatibility with the Law of the Sea' in *Research Handbook on Climate Change, Oceans and Coasts* (Edward Elgar Publishing 2020) 442.
[30] Article 11 LC
[31] Article 2 LP
[32] Article 3(3) LC and Article 1(7) LP
[33] Article 3(1)(a) LC and Article 1(4)(1)(1) LP
[34] ibid
[35] Article 1(4)(2) LP

The LC and LP face challenges in regulating certain MG activities, similar to the issues in defining pollution under UNCLOS, as adopted by Article 1(10) of the LP. Specifically, OIF and AOA are covered by these agreements because they involve deliberately adding substances like iron or calcium carbonate to the ocean.[36] Conversely, other MG methods, such as MCB, ocean upwelling/downwelling, and certain microbubble techniques, which do not entail the intentional addition of substances to the ocean, are likely outside the regulatory purview of these agreements.[37] Consequently, the LC and LP do not extend oversight or governance to these activities.

4. Governance Gaps and Regulatory Challenges in the MG Framework

MG poses significant governance challenges that are not fully addressed by existing legal frameworks. While some principles and instruments apply, substantial gaps remain due to the global, transboundary nature of marine environments and the novelty of these technologies.[38] The current legal framework is fragmented, with rules spread across various instruments primarily focused on pollution and environmental protection, rather than specifically regulating MG. [39]

Key frameworks like UNCLOS and the LP provide some foundational regulations but were not originally designed with MG in mind.[40] As a result, they have significant limitations in effectively governing these new technologies. For instance, UNCLOS offers broad principles for marine environmental protection but lacks specific regulations for geoengineering. [41] Similarly, while the LP has been amended to address ocean fertilization, it does not cover other MG techniques like ocean alkalinity enhancement or marine cloud brightening. This gap in coverage raises concerns about the adequacy of existing legal frameworks to ensure comprehensive governance and compliance across different jurisdictions.

The lack of a specific legal framework for MG creates varying obligations for countries, complicating governance. States may need to follow different legal frameworks like the London Convention (LC), London Protocol (LP), or UNCLOS, depending on their commitments. For example, obligations for ocean fertilization (OIF) and AOA depend on whether a state is a party to the LP, LC, or just UNCLOS.

Countries that are not parties to the LC or LP but are signatories to UNCLOS must enact laws to prevent marine pollution from dumping, as outlined in Article 210 of UNCLOS.[42] This overlapping framework complicates the regulation of MG activities, as different sets of regulations may apply to the same activity. The vague and broad nature of international legal obligations, such as preventing harm to other states' territories and the marine environment,

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[36] Kerryn Brent, William Burns, and Jeffrey McGee, 'Governance of marine geoengineering' in *Governance of Marine Geoengineering* (Centre for International Governance Innovation 2019) 34.
[37] Stefan Partelow, Maria Hadjimichael, and Anna-Katharina Hornidge, 'Ocean governance for sustainability transformation' in *Ocean Governance: Knowledge Systems, Policy Foundations and Thematic Analyses* (Springer International Publishing 2023) 1.
[38] Karen N Scott, 'Transboundary environmental governance and emerging environmental threats: Geo-engineering in the marine environment' in *Transboundary Environmental Governance* (Routledge 2016) 246.
[39] Kerryn Brent, William Burns, and Jeffrey McGee, 'Governance of marine geoengineering' in *Governance of Marine Geoengineering* (Centre for International Governance Innovation 2019) 34.
[40] Harald Ginzky, 'Marine geo-engineering' in *Handbook on Marine Environment Protection: Science, Impacts and Sustainable Management* (2018) 997.
[41] Kerryn Brent, 'Marine Geoengineering Governance and the Importance of Compatibility with the Law of the Sea' in *Research Handbook on Climate Change, Oceans and Coasts* (Edward Elgar Publishing 2020) 442.
[42] Laisa Branco Almeida, 'The Role of International Law of the Seas on the Global Governance of Marine Climate Geoengineering Techniques' (2018) Available at SSRN 318.

presents challenges in applying these rules to specific MG projects. This complexity undermines trust and confidence in MG initiatives, making effective governance difficult for researchers and policymakers.

The overlapping international legal frameworks create complexities for researchers and policymakers by applying different regulations to the same MG activities, complicating governance.[43] International law obliges states to prevent or reduce harm to other states' territories and the marine environment, but the obligations differ depending on the impact of MG activities. These duties are often vague and broad, offering limited guidance for specific MG projects.

A significant governance gap is the absence of a dedicated international treaty that comprehensively addresses geoengineering, including MG.[44] Existing frameworks like UNCLOS and the LP provide some oversight but were not designed with geoengineering in mind and do not cover all aspects, such as marine cloud brightening or ocean alkalinity enhancement.[45] This lack of a specific treaty creates a regulatory vacuum, leaving significant MG activities unregulated and posing risks of environmental harm due to insufficient oversight. Additionally, without a binding international agreement, the global community's ability to enforce compliance and ensure responsible geoengineering practices is limited.

The evolving nature of MG technologies presents significant regulatory challenges, particularly the need for adaptive governance mechanisms that can respond to unforeseen risks and ethical dilemmas.[46] Since these technologies are still experimental, their full environmental and social impacts are not yet fully understood. This uncertainty calls for regulatory frameworks that are both robust and flexible, capable of adapting to new information and emerging risks.[47]
Traditional regulatory approaches, which rely on fixed rules and standards, may not be adequate for managing the dynamic nature of geoengineering technologies.[48] Instead, adaptive governance mechanisms are needed, including iterative risk assessments, adaptive management practices, and the ability to revise regulations based on new evidence. Strengthening the precautionary approach, as outlined in the London Protocol (LP), could involve continuous monitoring, provisional regulations, and rapid response mechanisms for unforeseen environmental impacts.

However, even the yet-to-be-adopted 2013 amendments to the existing framework have limitations, such as not covering the governance of all MG activities. This underscores the need for a more comprehensive and adaptive regulatory approach. In its definition, the 2013 LP amendment defines marine geoengineering as:

> "a deliberate intervention in the marine environment to manipulate natural processes, including to counteract anthropogenic climate change and/or its impacts, and that has the

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[43] Harald Ginzky and Robyn Frost, 'Marine geo-engineering: legally binding regulation under the London Protocol' (2014) 8 *Carbon & Climate Law Review* 82.
[44] Ralph Bodle, 'Geoengineering and international law: The search for common legal ground' (2018) 46 *Tulsa Law Review* 305.
[45] Philip Boyd and Chris Vivian, 'High level review of a wide range of proposed marine geoengineering techniques' (2019) *International Maritime Law* 56.
[46] Karen N Scott, 'From ocean dumping to marine geoengineering: The evolution of the London Regime' in *Research Handbook on International Marine Environmental Law* (Edward Elgar Publishing 2023) 240.
[47] Grant Wilson, 'Murky Waters: Ambiguous International Law for Ocean Fertilization and Other Geoengineering' (2014) 49 *Texas International Law Journal* 507.
[48] Alexander Proelss, 'Law of the sea and geoengineering' in *The Law of the Sea* (Routledge 2022) 93.

> potential to result in deleterious effects, especially where those effects may be widespread, long-lasting or severe"[49]

These activities are characterized by their potential to cause harmful effects, especially if these effects are extensive, prolonged, or severe.[50] To be added to Annex 4 and regulated by the amendment, an activity must meet a specific definition. This definition covers activities aimed at addressing climate change, boosting marine productivity, or combating ocean acidification, but excludes those that unintentionally alter natural processes, like laying submarine cables or building artificial reefs. The activities must pose a potential risk to the marine environment, aligning with the LP's goal of protecting marine ecosystems. Importantly, the threshold for showing harm is low, requiring only the possibility of harm, not proof of actual damage.[51]

The amendment, specifically Article 6b, limits its regulatory scope to MG activities involving "the placement of matter into the sea from vessels, aircraft, platforms or other man- made structures at sea for MG activities listed in annex 4" such as AOA) or blue carbon initiatives that introduce substances like calcium carbonate or nutrients into the ocean.[52] This means that activities that do not involve the introduction of materials, like seawater extraction for cloud seeding or energy introduction into the ocean, are excluded from its oversight. For example, techniques like microbubble applications that involve depositing materials into the ocean would be regulated, but methods generating microbubbles without introducing matter, or ocean upwelling/downwelling that only move water or nutrients, are not covered.[53] This indicates that the governance framework does not comprehensively address all MG activities. The 2013 LP amendment faces several challenges in regulating MG activities. Developed before the Paris Agreement, the amendment does not align with global climate change goals, particularly the need for large-scale negative emissions to limit temperature rise to 2 degrees Celsius.[54] While it emphasizes protecting the marine environment, it fails to integrate geoengineering into broader climate change mitigation strategies or address the risks that climate change poses to marine ecosystems. The amendment also fails to consider the risks that climate change poses to marine ecosystems or align with the United Nations Framework Convention on Climate Change (UNFCCC) goals, stated in Article 2 UNFCC, for reducing greenhouse gas emissions.[55]

Furthermore, it lacks mechanisms to balance the marine pollution risks of geoengineering against the risks of inaction on climate change. According to paragraph 28 of Annex 5 of the 2013 LP, permits for MG activities are required to minimize environmental impacts while maximizing benefits. This means the amendment focuses solely on the risks of MG activities, without a broader view of climate change or geoengineering governance, limiting its effectiveness. Its impact is also reduced by the slow adoption rate—by 2024, only 10 out of 87

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[49] Sherry P Broder, 'International Governance of Ocean Fertilization and other Marine Geoengineering Activities' in *Ocean Law and Policy* (Brill Nijhoff 2017) 305.
[50] Article 1(5) bis
[51] Anita Talberg, Peter Christoff, Sebastian Thomas, and David Karoly, 'Geoengineering governance-by-default: an earth system governance perspective' (2018) 18 *International Environmental Agreements: Politics, Law and Economics* 229.
[52] Alexander Proelss and Robert C Steenkamp, 'Geoengineering: Methods, Associated Risks and International Liability' in Peter Gailhofer, Dorte Krebs, Alexander Proelss, Klaus Schmalenbach, and Roda Verheyen (eds), *Corporate Liability for Transboundary Environmental Harm: An International and Transnational Perspective* (Springer, Cham 2023) 419.
[53] Ibid
[54] Sophie Gambardella, 'The stormy emergence of geoengineering in the international law of the sea' (2019) 13 *Carbon & Climate Law Review* 122.
[55] James Harrison, 'C. Ocean dumping' (2021) 32 *Yearbook of International Environmental Law* 72.

LC member nations had ratified the amendment[56] far short of the required 2/3 majority needed for it to become legally binding.[57] This slow acceptance reflects the difficulties in achieving international consensus on MG regulation. Additionally, the amendment's scope is restricted to LP parties, excluding major countries like the U.S., Russia, India, and Indonesia, which could hinder its ability to effectively oversee MG activities.[58] Overall, despite its potential adaptability, the 2013 LP amendment may be insufficient for the comprehensive governance of MG technologies, given its narrow focus and limited global acceptance.

5. Institutional Framework of Marine Geoengineering

The International Maritime Organization (IMO)

The IMO is crucial in managing MG, helping the Contracting Parties, especially through its regulatory role under the London Convention (LC) and London Protocol (LP). These international agreements were originally created to prevent marine pollution from waste dumping but have since been expanded to cover new MG activities, adapting to the changing challenges in ocean governance.[59] Article 3(7) of the LC empowers the Contracting Parties to designate an organisation to carry out the mandate of the LC which was done in the LP in Article 1(2) when they appointed the IMO as the organisation to carry out the mandates of the Convention and Protocol.

Duties and Responsibilities of the IMO

The IMO assists contracting parties in fulfilling their obligations to prohibit geoengineering activities, including marine geoengineering (MG), that pose significant risks to the marine environment unless permitted.[60] The 2013 Amendments to the Protocol, via Resolution LP.4(8), specifically regulate ocean fertilization, banning it unless classified as legitimate scientific research.[61] The IMO has established guidelines for assessing and permitting MG activities, including criteria for legitimate scientific research and procedures for conducting Environmental Impact Assessments (EIAs) as required by Article 6bis of the Protocol.

The IMO also monitors compliance with the London Convention and Protocol through various committees, reviewing reports from member states and addressing non-compliance through diplomatic channels or dispute resolution mechanisms.[62] Additionally, the IMO regularly updates its regulations and guidelines in response to new scientific knowledge and technological advances.[63] An example is the adoption of the "Assessment Framework for Scientific Research Involving Ocean Fertilization" to address environmental concerns. This adaptability ensures that regulations remain effective in managing the challenges posed by new MG technologies.

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[56] International Maritime Organisation, '45th Consultative Meeting of Contracting Parties to the London Convention and the 18th Meeting of Contracting Parties to the London Protocol (LC 45/LP 18)' (2023) <https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/LC-45-LP-18.aspx> accessed 1 August 2024.

[57] The United Kingdom, the Netherlands, Finland, Norway, Iran, Estonia, Sweden, Belgium, Denmark, and the Republic of Korea.

[58] Lucy Elizabeth Strapp, 'Tempting fates: The relevance and applicability of existing international environmental law in the context of global geoengineering governance' (2022) 29 *Australian International Law Journal* 45.

[59] Chiara Armeni and Catherine Redgwell, 'International legal and regulatory issues of climate geoengineering governance: rethinking the approach' (2015) 21 *Climate Geoengineering Governance Working Paper Series* 6.

[60] Article 4 LP

[61] Article 19(2(2) LP

[62] **Article 16** LP

[63] Article 14(4)(a) LC, Article 19(3)(1)

The IMO promotes sustainable marine geoengineering (MG) practices by developing guidelines that emphasize a precautionary approach, urging caution in the absence of full scientific certainty to prevent environmental degradation.[64] These guidelines aim to minimize risks and encourage responsible innovation in MG. The IMO also serves as a platform for international cooperation, facilitating discussions and negotiations among member states to ensure the safe and sustainable use of marine environments.[65] This includes promoting collaboration with regional and international organizations, which is crucial for harmonizing regulations and addressing transboundary environmental impacts.[66]

Additionally, the IMO supports its member states, particularly developing countries, by building capacity to implement the London Protocol's provisions.[67] This support includes technical assistance, training, consultations, and resources to help states conduct environmental assessments, enforce regulations, and develop national policies that align with international standards.[68]

Challenges of the IMO

The International Maritime Organization (IMO) faces several challenges that limit its effectiveness in MG.

The current regulatory framework under the London Protocol has major gaps and uncertainties, especially when it comes to new geoengineering methods beyond ocean fertilization. Although the Protocol was amended in 2013 to regulate ocean fertilization, it doesn't fully cover newer, more complex techniques like marine cloud brightening or artificial upwelling, which carry significant environmental risks. One major issue is the broad and sometimes unclear definitions in the Protocol, particularly regarding what counts as "dumping," which might not cover all relevant activities in Article 1(4)(1) of the LP.[69] While Article **3 of the LP** establishes the general obligation to prevent pollution of the marine environment. However, these provisions were not initially designed with the complexity of geoengineering in mind.[70] For instance, while ocean fertilization is covered, other techniques may not be seen as "dumping" in the traditional sense, thus escaping regulation. This lack of specificity can lead to differing interpretations by states of what is permissible or prohibited, creating inconsistencies in regulation.

Additionally, the binary categorization of activities as either "legitimate scientific research" or "industrial" is increasingly problematic as geoengineering technologies evolve.[71] These emerging techniques often blur the lines between research and commercial application, complicating regulatory oversight and raising questions about how to appropriately govern

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[64] Article 3 LP

[65] Article 14(3) LC, Article 19(2)(1)

[66] Article 13 LP

[67] Article 9 LC, Article 13(1) LP

[68] Article 14(3) LP

[69] Marcel van Marion and Marcel van Marion, 'Methodology of Dumping' in *International Trade Policy and European Industry: The Case of the Electronics Business* (2014) *Journal of Business Law* 407.

[70] Charlotte Clarke and others, 'Cumulative effect assessment in the marine environment: A focus on the London protocol/London convention' (2022) 136 *Environmental Science & Policy* 428.

[71] David L Vander Zwaag, 'The international control of ocean dumping: navigating from permissive to precautionary shores' in *Research Handbook on International Marine Environmental Law* (Edward Elgar Publishing 2015) 132.

these activities.[72] The current rules under the London Protocol have significant gaps and uncertainties, especially for new geoengineering methods beyond ocean fertilization. While the Protocol was updated in 2013 to regulate ocean fertilization, it doesn't fully address more complex techniques like marine cloud brightening or artificial upwelling, which pose serious environmental risks. A key problem is the broad and sometimes unclear definitions in the Protocol, particularly regarding what qualifies as "dumping," which may not cover all the relevant activities mentioned in Article 1(4)(1) of the LP.

A key limitation of the IMO's regulatory framework is its reliance on member states for enforcement, leading to inconsistent global implementation. Article 6 of the London Protocol mandates that parties prevent and control pollution from dumping activities, but practical enforcement varies widely. Some countries, like Norway and Canada, have the capacity and commitment to enforce IMO regulations on ocean fertilization, while others may lack the necessary resources or prioritize economic development over environmental protection. This creates regulatory loopholes and risks uneven enforcement, potentially allowing harmful geoengineering activities to go unregulated in certain regions.

The IMO itself lacks direct enforcement powers, relying on member states to report violations and act, which is problematic given the transboundary impacts of geoengineering. This situation can lead to "forum shopping," where entities seek jurisdictions with weaker enforcement to carry out activities that would be more strictly regulated elsewhere. Additionally, countries with limited environmental governance may become safe havens for potentially harmful activities, posing significant risks to global marine ecosystems and undermining the uniform application of international regulations.

The IMO faces a challenging task in balancing the promotion of scientific innovation with the precautionary principle, especially regarding marine geoengineering (MG) technologies. The precautionary approach, as outlined in Principle 15 of the Rio Declaration io Declaration on Environment and Development,[73] mandates that the lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[74] However, this principle is difficult to apply to MG, where new and untested technologies pose unknown risks to marine ecosystems.

The IMO must balance promoting legitimate scientific research, vital for understanding marine environments and developing climate solutions, while ensuring these activities don't harm marine ecosystems. This tension is clear in MG, where the risks of technologies like ocean fertilization, artificial upwelling, or marine cloud brightening are still uncertain. The London Protocol addresses this by permitting only activities deemed legitimate scientific research, as outlined in the 2013 Amendment.[75] This amendment aligns with the precautionary approach but also demonstrates the IMO's recognition of the importance of research in this field. However, as noted in *Article 3 of the London Protocol*, there remains a broad scope for interpretation, which can lead to inconsistencies in how precaution is applied, particularly when new geoengineering techniques are considered.

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[72] Karen N Scott, 'From ocean dumping to marine geoengineering: The evolution of the London Regime' in *Research Handbook on International Marine Environmental Law* (Edward Elgar Publishing 2023) 240.
[73] *A/CONF.151/26 (Vol. I) Report of the United Nations Conference on Environment and Development* (1992).
[74] Tony George Puthucherril, 'Protecting the marine environment: Understanding the role of international environmental law and policy' (2015) *Journal of the Indian Law Institute* 48.
[75] Article 16bis LP 2013

The rapid pace of technological advancement in MG compounds the challenge. Techniques that were once theoretical are now being tested, often outpacing the regulatory frameworks designed to manage them. This creates a scenario where the IMO must constantly adapt its guidelines and regulations to keep pace with innovation, a task that is both resource-intensive and politically complex. Moreover, the absence of comprehensive environmental impact assessments for many emerging technologies makes it difficult for the IMO to apply the precautionary principle effectively.

The global nature and potential cross-border impacts of marine geoengineering (MG) highlight limitations in the IMO's traditional state-centered structure, which may not fully address the complexities of these activities.[76] MG, particularly on the high seas, can affect marine environments across multiple nations, necessitating a governance framework beyond the IMO's current scope.

To address these challenges, the IMO must adopt a more integrated and collaborative approach involving not just member states but also international organizations, scientific bodies, and non-state actors. This broader involvement is essential for understanding the long-term impacts of MG and for developing more effective and scientifically grounded regulations. The IMO has made some efforts to collaborate with bodies like the UNFCCC and CBD, but these collaborations need to be deepened.[77]

Moreover, the participation of NGOs, industry stakeholders, and the scientific community is critical for creating a governance framework that is both scientifically sound and socially acceptable.[78] NGOs, in particular, play a vital role in raising awareness of MG risks and advocating for stronger precautionary measures.[79] Article 14 of the London Protocol encourages such cooperation, but its effectiveness depends on the meaningful engagement of all stakeholders and the creation of mechanisms to facilitate this collaboration.

Regional Cooperation Mechanisms and Organisations in MG

Regional cooperation mechanisms play a pivotal role in the governance of MG activities. Article VIII of the LC encourages Contracting Parties to promote bilateral and multilateral agreements, including regional agreements, to prevent marine pollution by dumping, while Article 13 of the LP specifically encourages Contracting Parties to cooperate regionally to promote the effective implementation of the Protocol with respect to MG activities.

Article 123 of the United Nations Convention on the Law of the Sea (UNCLOS) further underscores the significance of regional cooperation among states bordering enclosed or semi-enclosed seas for managing marine resources, protecting the environment, and conducting scientific research.[80] States are encouraged to establish regional centres for marine technology research and information dissemination to foster cooperation in these areas.[81]

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[76] Harald Ginzky, 'Marine geo-engineering' in *Handbook on Marine Environment Protection: Science, Impacts and Sustainable Management* (2018) 997.

[77] Karen N Scott, 'Geoengineering and the marine environment' in *Research Handbook on International Marine Environmental Law* (Edward Elgar Publishing 2015) 451.

[78] Harriet Harden Davies, 'The Regulation of Marine Scientific Research: Addressing Challenges, Advancing Knowledge' in *Routledge Handbook of Maritime Regulation and Enforcement* (Routledge 2015) 212.

[79] Ibid

[80] Article 197 UNCLOS

[81] Article 276 UNCLOS

Regional cooperation is vital for managing marine ecosystems that cross multiple jurisdictions. It ensures the harmonization of policies, the sharing of best practices, and the creation of unified environmental standards, particularly in DSM and MG, where actions in one area can affect neighboring regions.[82] A key example is the United Nations Environment Programme's (UNEP's) Regional Seas Programme, which helps countries sharing common seas to collaborate on environmental protection.[83] This program has led to Action Plans and Protocols in various regions such as the Mediterranean, Caribbean, and West and Central African regions, addressing specific environmental challenges.

In MG, regional cooperation is crucial to prevent unintended consequences that could harm entire marine ecosystems. Agreements like the Barcelona Convention[84] provide a legal framework for regulating activities, including MG, and establish guidelines, such as the Protocol on Integrated Coastal Zone Management (ICZM)[85], for the sustainable management of coastal and marine resources.

Regional organizations play a crucial role in governing deep-sea mining DSM and MG activities by providing the institutional framework for regional cooperation and ensuring the implementation of international and regional agreements at the national level. Here, organizations like the Association of Southeast Asian Nations (ASEAN) through its Agreement on the Conservation of Nature and Natural Resources facilitates regional cooperation on environmental issues, essential for managing geoengineering activities.[86]

6. Conclusion

MG technologies offer potential for climate change mitigation but come with significant risks and uncertainties. These technologies present distinct environmental, social, and legal challenges that require thorough assessment before deployment. Despite existing international environmental law providing some regulatory starting points, there are substantial governance gaps, especially due to the absence of specific provisions or treaties addressing these emerging technologies. The evolving nature of geoengineering complicates governance, necessitating adaptive regulatory frameworks that address risks, incorporate ethical considerations, and ensure public participation. Key legal principles like the "no harm" rule from customary international law obligate states to prevent transboundary environmental damage and conduct thorough Environmental Impact Assessments, including in international waters. UNCLOS incorporates customary international law to regulate maritime activities, including MG, with a focus on environmental protection. It mandates states to prevent and control marine pollution, including harmful substances from geoengineering, though some activities remain ambiguously regulated. UNCLOS requires cooperation, environmental assessments, and continuous monitoring, but its guidelines lack specificity, particularly for geoengineering

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82 Alexandrya Herman, 'Assessing the Ocean Governance Frameworks Underpinning Deep Sea Minerals Development in the Cook Islands' (2019) *Marine Law Journal* 122.

83 Maria Adelaide Ferreira and others, 'A role for UNEP's Regional Seas Programme under the post-2020 global biodiversity framework' (2022) 136 *Marine Policy* 104.

84 *Convention for the Protection of the Mediterranean Sea Against Pollution* 1976, available at <https://www.unep.org/unepmap/who-we-are/contracting-parties/barcelona-convention-and-amendment> accessed 11 September 2024.

85 *Protocol on Integrated Coastal Zone Management* 1992, <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:034:0019:0028:EN:PDF> accessed 11 September 2024.

86 Sarah Yen Ling Tan and Hanim Kamaruddin, 'Environmental challenges within ASEAN: Contemporary legal issues and future considerations' in *ASEAN Post-50: Emerging Issues and Challenges* (2019) 155.

impacts. The CBD emphasizes biodiversity protection but offers vague guidance on EIAs for geoengineering. The LC (LC) and LP (LP) regulate marine pollution, with the LP adopting a precautionary approach. However, their scope is limited, particularly for unregulated geoengineering methods. The governance of MG faces significant challenges due to the lack of a specific international treaty, fragmented regulations, and evolving technologies, necessitating adaptive governance mechanisms and further legal instruments to ensure comprehensive oversight.

International organizations such as the IMO play central roles in shaping the legal and regulatory landscape in MG. These bodies are tasked not only with facilitating the exploration and exploitation of marine resources but also with ensuring the protection of the marine environment from the potentially harmful effects of these activities. The IMO's role in regulating MG highlights the evolving nature of ocean governance in response to emerging technological challenges. The IMO contends with regulatory gaps and ambiguities, particularly in addressing emerging geoengineering techniques. The organization's reliance on member states for enforcement leads to inconsistent global implementation of its regulations, which can undermine the effectiveness of its governance framework. Moreover, the IMO faces the delicate task of balancing innovation in MG technologies with the precautionary principle, a challenge compounded by the rapid pace of technological advancements and the need for broader international collaboration.

Regional cooperation mechanisms and organizations complement these international efforts by fostering collaboration among neighboring states, harmonizing policies, and ensuring the implementation of international agreements at the national level. These regional frameworks are essential for managing the transboundary nature of marine ecosystems and for addressing the unique environmental challenges posed by MG activities. The governance of MG requires continuous adaptation and collaboration at both the international and regional levels. The effectiveness of this governance framework depends on the ability of international organizations such as the IMO to address existing challenges, close regulatory gaps, and enforce environmental protections while fostering scientific innovation.