CEUB
EDUCAÇÃO SUPERIOR
ISSN 2237-1036

REVISTA DE DIREITO INTERNACIONAL
BRAZILIAN JOURNAL OF INTERNATIONAL LAW

Treaty regime of ocean fertilization: gaps and solutions

Regime do Tratado de Fertilização Oceânica: lacunas e soluções

Zahra Mahmoodi Kordi

Masume Gholami Miansarayi

VOLUME 20 • N. 2 • 2023
DIGITAL TRANSFORMATION OF MERCOSUR: INFLUENCE AND COOPERATION WITH THE EUROPEAN UNION

Sumário

doi: 10.5102/rdi.v20i2.9079

Treaty regime of ocean fertilization: gaps and solutions*

Regime do Tratado de Fertilização Oceânica: lacunas e soluções

Zahra Mahmoodi Kordi**
Masume Gholami Miansarayi***

Abstract

The international community has been trying to regulate ocean fertilization technology as a new geoengineering technique to deal with climate change for about a decade. During this period, some strategies have been proposed by international jurist to govern this technology in the international law Regime. These solutions have been mainly driven from the available treaties such as Convention on the Law of the Sea, the Framework Convention on Climate Change, the Convention on Biological Diversity, and the London Convention Dumping Regime. There is no doubt that treaties are considered one of the primary and traditional sources of international law, as well as a means of creating rights and obligations for subjects of international law. Treaties are widely recognized as one of the most suitable forms for law-making and regulation in the framework of international law. Due to their efficient and expeditious approach to law-making, the significance of their role in shaping new rules of International Law continues to grow steadily. Despite the continuous and rapid advances in science and technology, contemporary international law faces new challenges in various fields, one of which is related to regulating new technologies such as ocean fertilization. The most important question in this issue is whether the capacity of existing treaties can be utilized for regulating ocean fertilization technology. The authors of the article hypothesize that although it is better to have scattered rules than none at all, treaties that have directly or indirectly addressed this technology have their weaknesses and gaps due to issues such as ignoring the benefits of fertilization as one of the emerging technologies to deal with climate change, ambiguities existing in defining the critical concepts related to this technology, content inconsistency, and neglecting the position of private actors. Therefore, these treaties do not fully represent the current situation, and the result will be incomplete regulation. Hence, in the present study, it is shown that International community needs to regulate ocean fertilization technology with a dedicated document, but until then, soft law capacities can be utilized for its regulation. Soft law tools are beneficial, especially when solutions are unclear, and their voluntary nature encourages participation by governments and non-state actors. Accordingly, Data collection of this research is library method and the procedure is descriptive analytical.

* Recebido em 10/04/2023
Aprovado em 21/06/2023

** Doctor of Public International Law at Shahid Beheshti University, Iran. Assistant Professor at Mazandaran University, Iran.
Email: z.mahmoudi@umz.ac.ir

*** Master of International Law at Mazandaran University.
Email: masume_gholami@yahoo.com

Keywords: ocean fertilization; climate change; environment; treaty regime; shortcomings; solution.

Resumo

A comunidade internacional tem tentado regulamentar a tecnologia de fertilização dos oceanos como uma nova técnica de geoengenharia para lidar com as alterações climáticas há cerca de uma década. Durante este período, algumas estratégias foram propostas para governar tais atividades na falta de um regime jurídico. Estas soluções foram impulsionadas principalmente pelos tratados disponíveis, como a Convenção sobre o Direito do Mar, a Convenção-Quadro sobre Alterações Climáticas, a Convenção sobre a Diversidade Biológica e o Regime de Dumping de Londres. Embora a disponibilidade de tais soluções seja tão valiosa, elas não representam totalmente a situação actual. Tal problema advém da ignorância dos benefícios da fertilização como uma das tecnologias emergentes para lidar com as mudanças climáticas, das ambiguidades existentes na definição dos conceitos críticos relacionados a esta tecnologia, da inconsistência de conteúdo e da negligência da posição dos atores privados. Assim, no presente estudo, mostra-se que a comunidade internacional deveria tentar estabelecer um documento específico para a fertilização dos oceanos, de forma parcial ou geral, para superar tais inconvenientes. Mas, uma vez que tal processo é tão demorado, as capacidades da legislação não vinculativa podem ser utilizadas para regular as actividades de fertilização dos oceanos. A aplicação de soft law será muito útil, especialmente na situação actual em que os problemas da fertilização dos oceanos e as suas soluções ainda são desconhecidos. Sem dúvida, é altamente provável que a natureza voluntária da legislação não vinculativa conduza a um maior envolvimento dos governos. Além disso, a sua flexibilidade permite a participação de intervenientes não estatais. Nesse sentido, a coleta de dados desta pesquisa é pelo método bibliotecário e o procedimento é analítico descritivo.

palavras chave: fertilização dos oceanos, alterações climáticas, ambiente, regime do tratado, deficiências, soluções

1 Introduction

Climate change has remarkably increased over the last few years. Besides, the adopted traditional measures have not been able to deal with this phenomenon appropriately. Therefore, the attention of the international community has shifted to a new method called geoengineering (climate engineering). Geoengineering is a set of deliberate large-scale technological interventions proposed to balance climatic change.[1] Geoengineering methods are often low-cost, easy, and fast-impact methods. Among these methods, ocean fertilization, a marine geoengineering method[2], has been considered more by policymakers, scientists, and jurists.

The Ocean and climate change are closely related. Since 1970, oceans have absorbed more than 90 percent of the energy stored by global warming and about 30 percent of the emitted carbon dioxide.[3] Thus, not only do they play a vital role in preserving the planet's life, but also they are one of the largest carbon reservoirs in the world. The biological pump's process is one of the essential mechanisms of the oceans to change the concentration of carbon dioxide in the atmosphere. The biological pump transports organic and mineral carbon from the ocean's surface to the depths. It should be noted that the physiology of phytoplankton and the structure of the marine community affect the performance of this process. Phytoplankton needs sunlight, nutrients (macronutrients such as nitrogen and micronutrients like iron), carbon dioxide, and water to grow similar to land plants. The production of organic matter from mineral molecules by photosynthesis is called primary production. Most of this primary product is consumed by marine life or decomposed by bacteria and returned

[1] THE ROYAL Society Report: geoengineering the climate: science, governance and uncertainty. 2009. p. 1-81.

[2] Marine geoengineering methods carried out in the sea are called marine geoengineering. According to Clause 5 of Article 1 of the 2013 amendment of the London Protocol, marine geoengineering is a deliberate intervention in the marine environment to manipulate natural processes, including dealing with climate change of human origin or its effects, as well as processes that have the ability to lead to the harmful impacts, especially where these effects are widespread, prolonged or severe.

[3] BODANSKY, Daniel. The ocean and climate change law: exploring the relationships. *In:* BARNERS, R.; LONG, R. (ed.). *Frontiers in international law:* oceans and climate challenges: essays in honor of David Freestone. Brill Publisher, 2020. p. 1-30. and see: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. 2014. p. 1-30.

to the ocean's surface. Otherwise, they are moved to the depths and stored there.[4]

Research conducted over the past few decades has shown that although about 30% of the world's oceans contain a high amount of macronutrients, they have very low chlorophyll. In this condition, photosynthesis and primary production will noticeably reduce. Based on the conducted research, the lack of micronutrients such as iron is one of the factors involved in this condition. In 1980, John Martin discovered that fertilization of the ocean by iron could increase its carbon dioxide absorption.[5] This technology, which tries to utilize micronutrients to boost the biological pumps of the oceans and thus boost carbon absorption, is called ocean fertilization.

So ocean fertilization seeks to increase the absorption of carbon dioxide by the ocean and ultimately deal with global warming. Countering global warming, increasing of the fish resources, promote marine scientific research and the carbon trade have been cited as potential benefits of ocean fertilization, but in addition to these benefits, the possibility of environmental problems such as ocean acidification, toxic algal blooms[6] and anoxia[7] is not out of the question. Until now, 13 experiments have been performed on ocean fertilization[8]. But, despite all the advantages and disadvantages of this technology, it has not been implemented widely yet. This issue increases the importance of explaining and analyzing the position of this technology in the context of international environmental law sources. According to the available research, ocean fertilization is the only marine geoengineering method that can be regulated by the current treaty rules. However, it is debatable if the existing treaties will be able to provide a comprehensive regime is.

So the present study analyzes the treaty regimes applicable to ocean fertilization through a descriptive--analytical approach to answer the research question. These treaties can be classified into two categories The first category includes global conventions or framework-convention, which are broad and global in terms of geographical scale, scope, and performance. They have widespread application and specify general laws and principles for government activities in the world's oceans. The second category comprises various partial treaties developed in environmental areas and specific to environmental issues, such as the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes or Other Matter. The study identifies the strengths and weaknesses of each treaty and proposes solutions to address shortcomings and desirable models for treaty regulation to prove the authors' hypothesis.

The present paper is arranged as follows. In Section 2, the treaties whose provisions can be applied to the ocean fertilization are investigated. Section 3, illustrate the identified gaps in the current regime. In section 4, the solutions to eliminate these gaps are described. Finally, Section 5, concludes our findings.

2 The treaty regime governing the ocean fertilization

According to the investigations, the documents such as the Climate Change Framework Convention and the UN Convention on the Law of the Sea are placed in the ocean fertilization treaty regime owing to their thematic connections. These treaties contain general commitments regarding the protection of the environment, which can also be applied to ocean fertilization. On the other hand, the London Dumping Regime and the Convention on Biological Diversity are treaties playing more specific and explicit roles in regulating ocean fertilization. In the following, the methods of regulating ocean fertilization by the mentioned treaties have been reviewed.

2.1 Fertilizers as pollutant

The Convention on the Law of the Sea is described as the Constitution of the Seas owing to its thematic comprehensiveness and the rate of countries' partici-

[4] BASU, Samarpita; MACKEY, Katherine. Phytoplankton as key mediators of the biological carbon pump: their responses to a changing climate. *Sustainability*, v. 10, n. 3, p. 1-18, 2018.

[5] SVERDRUP, K. A.; DUXBURY, A. B.; DUXBURY. A. C. *Fundamentals of oceanography*. 5. ed. New York: McGraw-Hill College, 2004.

[6] In the process of fertilizing the oceans, toxic algal blooms may occur as a result of Eutrophication or an excess of nutrients (iron).

[7] Anoxia means a complete reduction in oxygen levels and a severe state of hypoxia.

[8] see YOON, Joo-Eun et al. Reviews and syntheses: ocean iron fertilization experiments: past, present, and future looking to a future Korean Iron Fertilization Experiment in the Southern Ocean (KIFES) project. *Biogeosciences*, v. 15, p. 5847-5889, 2018.

pation.[9] This treaty provides a legal framework for international cooperation in the field of the seas. It sets out the rights and obligations of members in the conduct of any maritime activity by which it governs all the matters relating to the sea from differentiation to environmental monitoring, scientific research, commercial activities, economic, technological, and dispute resolution. Thus, this convention also seems to be the starting point for identifying applicable laws and regulations for activities such as ocean fertilization. Nevertheless, due to the novelty of this technology and its absence at the convention's ratification stage, no rules have been set about it. However, based on the general definition of pollution described in Article 1 and the provision in Article 196, the Convention on the Law of the Sea can be applied to oceans fertilization in the operational phase. In addition, according to the content of the provisions of Section 13, it can be used for the experimental phase. It should be noted that this argument is based on the fact that iron and micronutrients used to fertilize are considered pollutants.

Pollution is the entry of any substance or energy that will definitely or possibly have harmful effects (1.1.4). Therefore, the fertilization process is a kind of marine contamination and is prohibited if it leads to definite or possible harmful effects on marine life and living resources. Based on Article 196, members must take the necessary measures to control and prevent pollution caused by the technology. Although the nature of such measures is not distinctly expressed in the article, the prevention and control of marine pollution caused by any technology, including fertilization, is the responsibility of member countries[10]. Moreover, while the oceans fertilization is at the test and research stage, the thirteenth section of the Convention, the rules governing scientific research, can be applied to this technology.

In Article 240, many criteria have been mentioned for conducting scientific research at sea, including being peaceful, using appropriate methods and tools, not obstructing the legitimate use of the sea, and observing all regulations, especially environmental regulations. Among these criteria, it is hard to ensure that the method of fertilization is appropriate and its application does not violate environmental regulations relating to the protection of the seas, including part 12 of the Convention[11]. Because, there is no scientific certainty about the environmental consequences of this technology. Based on the current knowledge, ocean fertilization is highly likely to lead to adverse environmental impacts such as ocean acidification, marine ecosystem restructuring, and marine biodiversity destruction.[12]

2.2 Ocean dumping of fertilizers

The London Convention aiming to prevent marine pollution by dumping waste and other matters at sea was approved in 1972. Later on, an additional Protocol aiming to eliminate the gaps in this Convention was approved in 1996. The London Convention and Protocol are among the few Conventions that have directly sought to regulate ocean fertilization. These documents are the most significant elements of the ocean fertilization treaty regime. Generally, the definition of the London Protocol on the dumping waste at sea, the list of permitted materials, the element of volume of waste discharged, the need for prevention in cases of uncertainty, and resolutions adopted by the members are the main criteria of these two treaties for regulating ocean fertilization, which shows a more precise structure than other related documents. Here, there are three issues that should be explained as follow:

i) According to the first paragraph of Section 4 of Article 1 of the Protocol, the deliberate disposal or storage of any "waste" or "other material" by ships, aircraft, platforms, or other manufactured structures at sea or in its seabed is prohibited. Indeed, iron micronu-

[9] NOORI, Mansoor Poor; HABIBI, Mohammad. *International law of the sea:* Convention on the Law of the Sea 1982. Tehran, 2006.

[10] It should be noted that some jurists, considering the broad definition of the convention of disposal, which includes any kind of intentional dumping of waste or other substances in the sea (Part A, Clause 5, Article 1), believe that fertilizers like iron and other micronutrients that are used in fertilization, thus governments are not only prohibited from disposing of them in the sea but also obliged to reduce the environmental pollution that results from their disposal, according to Article 210. There are however problems with this argument, since according to part (b) of the same provision, even if adding micronutrients is equivalent to disposal, Article 210 does not cover it because, firstly, the disposal of micronutrients is not solely for disposal but serves other purposes, and secondly, based on current knowledge, it is not contrary to the objectives of the Law of the Sea Convention.

[11] DU, Haomiao. *An international legal framework for geoengineering managing the risks of an emerging technology*. New York: Routledge, 2018.

[12] see WILLIAMSON, Phillip *et al*. Ocean fertilization for geoengineering: a review of effectiveness, environmental impacts and emerging governance. *Process Safety and Environmental Protection*, v. 90, n. 6, p. 479-482, 2012.

trients can be classified as "other substances". However, the second paragraph of Section 4 of this article immediately describes the cases that are not considered waste disposal. One of these exceptions is the placement of any material for purposes except disposal provided that do not conflict with the protocol's aims (i.e., protecting the marine environment, improving the sustainable use of its resources, and preventing pollution). Since adding iron to the water aims to separate the carbon dioxide and store it in the depths of the ocean, it locates within the scope of this exception. However, due to the scientific uncertainties, the negative effects of this technology on the marine environment and marine living resources are still unknown. Thus, the fertilization technology cannot be allowed with referring to such an exception. Moreover, the results of some studies demonstrate that the addition of iron to the sea can lead to many adverse consequences such as the spread of toxic algae, endangering the marine[13] ecosystem, and oxygen reduction. All of the consequences have a conflict with the goal of the London Protocol. In addition, the Protocol commits members to take preventive measures in the absence of explicit scientific evidence.[14]

ii) Regarding the first annex of the London Protocol, the disposal of any substance at sea (excluding the eight exceptions mentioned in the annex) is prohibited. Among these permitted exceptions, inert, inorganic geological material and organic material of natural origin might be used in the fertilization process[15]. Nevertheless, the need for a general permit for members of the London Convention and Protocol to carry out small-scale fertilization experiments and special permits when the volume of materials is extensive should be pointed out (Under the first annex of the protocol and the second annex of the London Convention). Therefore, a license is still required, even if the used materials are on the list of allowed materials for disposal.

iii) It is defective to explain the approach of the London Convention and Protocol without addressing the measures of member states aimed at controlling ocean fertilization. Member states commenced their actions in 2008 and issued a resolution defining ocean fertilization[16] and emphasizing that it is only allowed for small-scale scientific research. Afterward, in 2010, while announcing the inconsistency of ocean fertilization technology with the objectives of the convention and the Protocol, they set the initial evaluation framework for conducting scientific research related to fertilization by resolution LC-LP.2 (2010). An essential part of this framework emphasizes the need for environmental assessment for scientific research, such as considering an appropriate site for experiments, assessing possible environmental impacts, etc. The regulated framework obliges members to act with caution and refrain from continuing the project if environmental impacts are anticipated.

Eventually, in 2013, the members of the London Protocol illustrated their determination to make the Protocol the first mandatory marine geoengineering document by approving the amendment to the London protocol.[17] [18] If the amendment enters into force, the treaty regime governing the oceans fertilization will undergo fundamental changes, and the current ambiguities of the protocol will be removed. For instance, marine geoengineering will be formally defined (1. 5bis). Besides, the addition of materials to the sea by ships, aircraft, platforms, or other manufactured structures to carry out marine geoengineering activities shall be prohibited (6bis.1) unless the necessary permission is obtained. Furthermore, the prerequisites for obtaining a permit will be non-contradiction with the protocol's objectives and conducting environmental impact assessments.[19]

[13] ABATE, Randall S. Ocean iron fertilization: science, law, and uncertainty. *In:* BURNS, Wil C. G.; STRAUSS, Andrew L. (ed.). *Climate change geoengineering:* philosophical perspectives, legal issues, and governance frameworks. Cambridge: Cambridge University Press, 2013. p. 221-241.

[14] GERRARD, Michael; HESTER, Tracy. *Climate engineering and the law:* regulation and liability for solar radiation management and carbon dioxide removal. Cambridge: Cambridge University Press, 2018.

[15] Carbon dioxide separated by phytoplankton blooms in the process of fertilization of the oceans is buried as organic matter (remains of phytoplankton), which means that it can be considered the organic matter of natural origin, and more importantly, according to No. 5 of the List, iron is clearly considered as a mineral geological material, but there is no general consensus about whether it can be considered ineffective.

[16] In this resolution, it is stated that fertilization refers to the process of stimulating primary production in the oceans besides normal aquaculture and artificial reef building.

[17] AMENDMENT to The 1996 Protocol to The Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972 to Regulate Marine Geoengineering, 2013.

[18] There are only five countries that have adopted it as of 2019.

[19] GINZKY, Harald. Marine geo-engineering. *In:* SALOMON, M.; MARKUS, T. (ed.). *Handbook on marine environment protection.* New York: Springer International Publishing AG, 2018. p. 997-1011.

2.3 Threat to marine biodiversity

The Convention on Biological Diversity was adopted in 1992. The majority of the world's countries are members of this convention. One of the main goals of the Convention is the conservation of biodiversity, and the sustainable use of its components. Since marine ecosystems and aquatic are a kind of biodiversity, ocean fertilization can alter the marine biodiversity by changing the marine food chain and increasing the acidity of water. One of the important innovations of the Convention on Biological Diversity in regulating the technology of ocean fertilization is that it includes activities carried out in areas outside the jurisdiction of states (high seas)[20]. Moreover, criteria such as control and management of activities that have significant adverse impacts on biodiversity (8.3), assessment of environmental effects of projects that may have severe detrimental effects on biodiversity (14.1(a)), ratification of Bilateral, regional and multilateral agreements for the purpose of informing, exchanging information and consulting on the transboundary effects of activities threatening biodiversity (14.1.(c)) are among the criteria applicable by this Convention to the activities of members in the field of ocean fertilization.

Although the provisions of the Convention are so important, the efforts made by the Conference of the Parties[21] to regulate ocean fertilization should not be overlooked. The Conference of the Parties to the convention has adopted two specific decisions on ocean fertilization. Regarding the decisions made by the Conference of the parties in 2008, 2010, 2012, and 2016, it is clear that consistently want members and other states to refrain from activities related to ocean fertilization, as long as there is not enough scientific basis for the projects' justification. They made the decisions based on the precautionary approach and the substance of Article 14 of the Convention. Additionally, the mentioned scientific basis includes environmental risk assessment for biodiversity and related social, economic, and cultural impacts and a transparent and effective control and regulatory mechanism. However, according to the viewpoint of the members of the Convention on Biological Diversity, scientific research conducted on a small scale, in coastal waters, and in a controlled setting, intending to collect scientific data, and not for commercial purposes is an exception.[22]

It can be concluded that the Convention on Biological Diversity has taken a preventative approach in the face of large-scale ocean fertilization owing to the hazard that such activities may bring to marine biodiversity.

2.4 Stabilization of greenhouse gas concentration

The United Nations treaty regime on Climate Change includes the Framework Convention on Climate Change, the Paris Agreement, and the Kyoto Protocol. The Convention on Climate Change's purpose is to stabilize the concentration of greenhouse gases at a level that prevents dangerous interference by human activities with the climate (Using Article 2). The aim of the Paris Agreement is to reduce global temperatures by holding the increase of the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. One of the most important goals of ocean fertilization is to stabilize the concentration of greenhouse gases, reduce the carbon rate, and consequently decrease the earth's temperature.[23] [24] Hence, this technology's goal is compatible with the nature of the Framework Convention and Paris Agreement. Also, the Kyoto Protocol seems to have a positive view of ocean fertilization as one of the carbon dioxide removal technologies because the protocol has encouraged countries to use such technologies. But the problem is that the protocol considers safety to be a condition for the application of these technologies.[25] This crite-

[20] BRENT, Kerryn; BURNS, Wil; MCGEE, Jeffrey. *Governance of marine geoengineering:* special report. Centre for International Governance Innovation, 2019.

[21] See LAJAUNIE, Claire; MAZZEGA, Pierre. Mining CBD. *Revista de Direito Internacional*, Brasília, v. 13, n. 2, p. 276-290, 2016.

[22] KEANE, Kevin. *Towards a new climate ethic:* international law, ethics and geoengineering in the Anthropocene. 2020. Thesis (Master's in Public International Law) – Elferink Utrecht University, 2020.

[23] JOHANSEN, Elise. Ocean fertilization. *In:* THE LAW of the sea and climate change. Cambridge: Cambridge University Press, 2020. p. 184-205.

[24] See NGUYEN, Yen Thi Hong; NGUYEN, Dung Phuong. The efforts to respond to climate change and implementation of the Sustainable Development Goals (SDGS) from the hardest-affected countries: Vietnam case analysis. *Revista de Direito Internacional*, Brasília, v. 19, n. 1, p. 164-191, 2022.

[25] DU, Haomiao. *An international legal framework for geoengineering managing the risks of an emerging technology*. New York: Routledge, 2018.

rion is not applied to ocean fertilization in the current situation.

Furthermore, the third paragraph of Article 3 of the United Nations Framework on Climate Change Convention (UNFCCC) calls on the parties to take precautionary measures to anticipate, prevent or minimize the causes of climate change and reduce its adverse effects. Even scientific uncertainty should not be a reason to delay such measures. Tedsen et al. believe that Article 3 is considered in the context of preventive measures, given that ocean fertilization reduces the significant cause of climate change, namely global warming.[26] In addition, Article 4.1. (b) refers to the need to eliminate greenhouse gas emission sources from human activities by using sinks to absorb these gases. Also, paragraph (d) explicitly mentions oceans as one of the pivotal reservoirs of absorption and reminds us of the importance of strengthening them.

Based on the mentioned goals and provisions, it can be declared that ocean fertilization is one of the new technologies to deal with climate change that even developing countries can utilize[27]. The only limitation of the technology is the criterion of safety emphasized by the Kyoto Protocol. Thus, this technology has grabbed the attention of the treaty regime on climate change.

3 Major gaps in the ocean fertilization treaty regime

As shown, the treaty regime applicable to ocean fertilization to regulate this technology faces many gaps and shortcomings that will be discussed in the following.

3.1 Fragmentation of treaty framework to ocean fertilization

Fragmentation is a prominent feature of the issue containing different regimes. The diversity of regulatory instruments in international environmental law has led to fragmentation in the regulation of issues in this branch of international law, including environmental technologies such as ocean fertilization.[28] As noted, each treaty looks at the technology according to its matter, scope, goals, and even codification timing, resulting in inconsistencies in implementation. This situation is even more complicated for states that are parties to more than one treaty. An example to illustrate this point is the inconsistency between the London Protocol approach and the Convention on Biological Diversity. Comparing these two documents, we find that the attitude of the Convention on Biological Diversity is more restrictive than the London Protocol. Besides, large-scale experiments under the Convention on Biological Diversity are not justified, and small-scale experiments are only allowed in coastal waters. In addition, the convention prohibits ocean fertilization for commercial purposes, an issue not specified in other treaties.[29]

The lack of coordination between the climate change treaty regime and other regulatory treaties is another important issue. The Framework on Climate Change Convention and the Paris Agreement have a positive view of ocean fertilization as a method of carbon dioxide removal (the most important of which is to stabilize greenhouse gas concentrations). Also, The Kyoto Protocol welcomes this technology, providing it is safe. In contrast, the Convention on the Law of the Sea, the London Dumping Regime, and the Convention on Biological Diversity seek to prohibit this technology by relying on objectives such as protecting the marine environment from pollutants and disposed materials and the sustainable use of marine biodiversity.

3.2 Disregarding the private sector

Since traditional international law is a state-centered law, they have the initiative in fulfilling international obligations over the non-state actors. International law regulates the behavior of private actors indirectly through the imposition of obligations on governments to accept responsibility for their behavior or the imposition of few direct regulations on specific issues (e.g., the

[26] TEDSEN, Elizabeth; HOMANN, Gesa. Implementing the precautionary principle for climate engineering. *Carbon & Climate Law Review*, v. 7, n. 2, p. 90-100, 2013.

[27] VEDANT, Dikshit. Ocean fertilization as a method to mitigate the climate change. *In:* GUPTA, A. (ed.). *Conservation, sustainability, and environmental justice in India*. London: Lexington Books, 2021.

[28] BIERMANN, Frank; PATTBERG, Philipp; VAN ASSELT, Harro; ZELLI, Fariborz. The fragmentation of global governance architectures: a framework for analysis. *Global Environmental Politics*, v. 9, n. 4, p. 14-40, 2009.

[29] RADCLIFFE, Saadi. Geoengineering: ocean iron fertilization and the law of the sea. *LIM research paper*, p. 1-61, 2014.

foreign investment system)[30]. But technology is one of the new ones affected by non-governmental actors (individuals and companies). As an emerging technology, there is no exception for ocean fertilization. However, there is no international legal standard that directly regulates the actions of private sectors concerning ocean fertilization.[31] Since the regulations are only for member states and there is no regulation to monitor and control the activities of the private sector under their jurisdiction, it can be declared that the treaty regime does not indirectly include non-governmental actors.

Consequently, private sectors can engage in ocean fertilization activities without being legally and internationally responsible due to the silence of these documents. It is even possible for private sectors to act under the supervision of non-member states or members of treaties. Naturally, in states that are potentially affected by climate change, the tendency to apply this technology is undeniable.[32] However, based on the provisions of the Convention on the Law of the Sea, particularly Article 153.2, in the field of technologies and operations to exploit seabed resources, four entities are competent to exploit. These entities include the Enterprise of International Seabed Authority, States Parties to the Convention, natural or legal persons (which possess the nationality of States Parties or are effectively controlled by them or their nationals), and international organizations.

Under this framework, States can obtain a mining license directly from the authority through membership in the Convention on the Law of the Sea. So, they are committed to implementing the Convention, ratifications, and regulations adopted by the International Seabed Authority. Since mining requires high technology and notable investment, governments usually prefer to act in the form of supporters of private individuals (natural and legal). In this regard, the Convention on the Law of the Sea has established a mechanism called sponsoring, covering the problem of individuals as passive subjects of international law and forming the relationship between the protecting state and the contractors under its protection. Therefore, private individuals with the support of the Sponsoring State can participate in this field while complying with the Convention and its regulations. It should be noted that private individuals should have either the nationality of States Parties to the Convention or be under their effective control. Overall, the support mechanism can be an effective model for regulating the activities of private sectors in the field of ocean fertilization in the future.

3.3 Neglecting the capability of ocean fertilization to deal with climate change

Ocean fertilization can be one of the effective ways to deal with the adverse consequences of climate change. The fertilization experiments performed so far demonstrate that although this technology cannot solely cope with climate change, its positive effects are undeniable. However, most regulatory and applicable treaties have viewed this technology negatively, relying on its potential adverse effects without considering its possible benefits.

One of the most important criticisms of these documents is the ban on small-scale ocean fertilization. Although the first intent was to respect this technology as valuable scientific research within the framework of the London Dumping Regime, the recent international actions show the prohibition of small-scale activities. Certainly, such measures reduce the motivation for further research. Branson argues that we cannot fully assess ocean fertilization's positive and adverse environmental impacts as long as the experiments do not go beyond research. According to Branson, the legal framework governing this technology prohibits scientific groups from conducting responsible experiments that can provide vital information to humans.[33] This problem is even more evident in the Convention on Biological Diversity than in the London Dumping Regime.

As expressed, the decisions made by the Conference of the Parties have also limited this technology. Such decisions have provoked the objection of many individuals interpreting the restrictions as legal bans. For example, the Intergovernmental Oceanographic Commission of the UNESCO, a member of the Convention

[30] WILSON, Grant. Murky waters: ambiguous international law for ocean fertilization and other geoengineering. *Texas International Law Journal*, p. 1-40, 2014.

[31] CLAUDIO, Cavieze; REVERMANN, Christoph. *Climate engineering, endbericht zum TA-Projekt geoengineering*. 2014.

[32] BRANSON, Michael C. A green herring: how current ocean fertilization regulation distracts from geoengineering research. *The Santa Clara Law Review*, v. 54, n. 1, p. 163-200, 2014.

[33] BRANSON, Michael C. A green herring: how current ocean fertilization regulation distracts from geoengineering research. *The Santa Clara Law Review*, v. 54, n. 1, p. 163-200, 2014.

on Biological Diversity, has criticized these decisions owing to imposing unnecessary restrictions on valid scientific activities.[34] In this regard, one of the criticisms is that the size criterion of ocean fertilization projects with iron is not an appropriate criterion for deciding on approval or disapproval of these activities.[35]

3.4 Ambiguity in some fundamental concepts

One of the most critical issues in treaties is addressing the concepts playing pivotal roles in determining the scope of members' obligations. Ambiguity in the scope of such concepts will create problems in the treaty's practical implementation, in addition to causing disagreement over its implementation. This problem is quite evident in the treaties governing ocean fertilization. Lack of clarity in fundamental concepts such as pollution and inert minerals, along with the lack of a formal definition of ocean fertilization, has obscured the regulation of this technology. It seems that the current definitions have an old approach and are inconsistent with the new developments.

The main ambiguity is whether the micronutrients entering the ocean during the fertilization can be considered polluting under the Convention on the Law of the Sea or can be considered as disposal according to the definition proposed by the London dumping regime. In order to address this vagueness, two items should be considered. Firstly, the definition of pollution[36] does not present clear evidence to consider micronutrients as a pollutant. Additionally, according to this definition, the creation of destructive effects is the only indicator that can be viewed as a pollutant. Due to the scientific uncertainty about the environmental impacts of ocean fertilization, there is no consensus on whether this technology is subject to the definition of pollution or not. The source of such disagreement is the ambiguity of the definition of pollution. Secondly, the same objection applies to the concept of inert minerals in the London dumping regime.

One of the main reasons advocates claim that ocean fertilization is legitimate is to cite the annexed list of the London Protocol (list of authorized substances). The London Protocol positively lists discarded substances in this list, with the sixth article devoted to inert minerals. The challenging issue is whether the iron used to fertilize the oceans can be considered an inert substance or not. Chemists have taken a hard line on this, arguing that "inert" means that matter has no chemical reaction. However, scientists working in ocean fertilization focus on the toxicity of the substance and consider its ineffectiveness as a relative concept. On the one hand, opponents of ocean fertilization claim that the entrance of iron into the sea is for phytoplankton blooms. If the bloom of phytoplankton leads to biological damage, iron micronutrients will no longer be viewed as an inert substance. Hence, its disposal will not be allowed. On the other hand, the advocates believe that iron is an inert substance and its disposal is permitted[37]. The lack of transparency in the meaning of the "inert substance" term and the inefficiency of the annex are the main sources of this disagreement, which highlight the necessity to prepare a specific document.

4 Suggested solutions

In order to overcome the current gaps in the ocean fertilization regime, many practical solutions are introduced in this section. It should be noted that the proposed solutions may have both benefits and drawbacks described in the following.

4.1 A new binding instrument

As many policymakers believe, countries require coordinated regulatory responses to the challenges posed by emerging technologies such as cybersecurity, artificial intelligence, nanotechnology, and geoengineering. International treaties are important tools to make such

[34] UNESCO. *Report on the IMO London Convention Scientific Group Meeting on Ocean Fertilization*. Ad Hoc Consultative Group on Ocean Fertilization, Intergovernmental Ocean Commission (IOC). UNESCO Doc. IOC/INF-1247, 2008.

[35] BRODER, Sherry P. International governance of ocean fertilization and other marine geoengineering activities. *In:* ESPÓSITO, Carlos; KRASKA, James; SCHEIBER, Harry N.; KWON, Moon-Sang (ed.). *Ocean law and policy:* twenty years of development under the UNCLOS regime. Nijhoff: Brill, 2017. p. 305-343.

[36] According to part 4 paragraph 1 of article 1, marine environmental pollution is: "The direct or indirect entry of substances or energy by humans into the marine environment, including estuaries, which leads to destructive effects such as damage to living resources and marine life and creates risks for Human health."

[37] SCOTT, Karen N. Regulating ocean fertilization under international law: the risks. *Carbon and Climate Law Review*, v. 7, n. 2, p. 108-116, 2013.

coordination. Since the measures taken by the governments may have transboundary and even global effects, the prevention of unilateral fertilization of the oceans is one of the main reasons for the need to adopt harmonized regulations. Another reason to be taken into consideration is the equitable sharing of responsibility for achieving an international goal, such as dealing with climate change. Without an international agreement, some countries are highly likely to act passively and rely only on the measures of others. Another significant reason for concluding an independent treaty is the issue of transnational and global impacts of fertilization technology. Thus, making a new treaty can be suggested as one of the best ways to address the challenges of the current legal regime, which can eliminate its shortcomings.

The new treaty must bridge the gap by involving non-state actors in the negotiation process and anticipating commitments from the governments and individuals by relying on the experience of the deep-seabed exploitation regime. At the same time, it provides an opportunity for decision-makers to assess the environmental advantages and disadvantages of ocean fertilization technology. The proposed treaty will be a valuable opportunity to overcome the current shattered views. Furthermore, it is a tool that can properly provide adequate information about the following items:

- the ocean fertilization definition
- large and small-scale fertilizations
- the condition for obtaining a license for the technology
- conducting fertilization in coastal waters and the high seas
- the status of the Flag of convenience
- the responsibility of the individuals and governments involved in the process
- the prevailing international and environmental principles

However, no one can deny that introducing a new treaty in international law is generally along with various hardships. Firstly, since political issues may affect the negotiations to conclude such a treaty, it is hard to attain an appropriate result. Secondly, according to the disagreements between the governments currently engaged in global warming mitigation methods, there will be a low chance of successful implementation of new approaches and related treaties. Thirdly, the positions of countries that benefit from the commercialization of ocean fertilization[38] should be determined. Such industrialized and powerful governments will not be willing to restrict themselves easily through an international treaty. The unsuccessful attempts of United Nation Environment Programme (UNEP) to issue a resolution based on geoengineering frankly illustrates the difficulty of concluding an international treaty. At the 2019 session of the UNEP Assembly, a draft resolution prepared by Switzerland was presented. The specific purpose of this draft was the need to assess the state of geoengineering technologies and their regulation using confirmed and potential governance. But the draft resolution was severely opposed by the paramount fossil fuel producing countries, including the United States, Saudi Arabia, and Brazil.[39]

4.2 A new protocol to the UNFCCC

Another way to fill in the gaps of the current legal regime is the accession of a new protocol to the Climate Change Convention. This convention that deals with climate change and guarantees global participation is one of the most appropriate instruments to regulate ocean fertilization. Moreover, acceding a protocol to a treaty is much more accessible than the conclusion of an independent treaty. The approving background of the Climate Change Convention on the regulation of relevant instruments such as the 1997 Kyoto Protocol and the 2015 Paris Agreement is an evidence for this treaty's capacity to create new instruments.

Ocean fertilization technology is in line with the purpose of the Climate Change Convention (i.e., stabilization of greenhouse gas concentration), and its mechanisms (e.g., encouraging Parties to accelerate their efforts to fund and access to environmentally sound technologies) can be applied to ocean fertilization. Consequently, considering the current infrastructures, regulating ocean fertilization in the form of a protocol accession to the Climate Change Convention could be

[38] In addition to helping to deal with global warming, ocean fertilization also has commercial benefits, including increased fish stocks and carbon trading. So far, the commercialization of ocean fertilization has attracted the attention of many private actors and some industrialized countries such as the United States.

[39] PERSPECTIVES on the UNEA Resolution. 2019. Available at: https://geoengineering.environment.harvard.edu/blog/perspectives-unea-resolution. Access in: 18 oct. 2022.

an important step in reducing the political expenses of concluding a new treaty. Simultaneously, it can eliminate the mentioned gaps like an independent treaty.

4.3 Create coordination between current documents

Another regulatory alternative is to align the content of applicable treaties. As mentioned, one of the gaps in the current treaty regime is the conflict between various treaties with different goals. It seems that by setting up joint working groups or concluding cooperation agreements between different institutions, it is possible to provide the condition for regulating ocean fertilization by current documents. The synergy process between the Basel, Stockholm, and Rotterdam conventions is a successful example. In this case, a joint working group was established between the three conventions to build the capacity of governments to manage hazardous chemicals and waste thanks to the initiative of the UNEP, which resulted in satisfactory cooperation[40]. This successful practice could be a model for regulating ocean fertilization. Institutions such as the UNEP, the International Maritime Organization, and the World Meteorological Organization can play an important role in establishing joint working groups to converge in this field. It is worth mentioning that establishing partnerships between different institutions will not necessarily lead to increased cooperation, as many factors like the competition between institutions can be an obstacle to this.[41]

4.4 Soft law

Although the treaty approaches proposed in the previous sections seem to be desirable options, in practice, they are not easy to implement due to their dependence on the will of governments. Experience has shown that concluding universal documents about emerging technologies is complex and time-consuming due to different economic, social, and political. For instance, in the early 21st, although the United Nations tried to draft an international convention banning human cloning, this attempt was not successful. Such efforts have failed mainly due to the lack of consensus on cloning's definition and the lack of agreement on the executive approach.

Currently, there is no treaty in international law to address the challenges posed by geoengineering technology in general and fertilization in particular. In addition, the prospect of adopting such regulations is unclear in the near future. Therefore, soft law can be a temporary solution to achieve international harmonization. The broader tools of soft law than hard law and the differences in its constituent entities (e.g., the governments, international organizations, and private actors) can lead to greater flexibility, greater compliance, a wider range of rules and, an increasing participation rate. The high flexibility of soft law compared to binding rules will create fewer barriers to the future development of ocean fertilization technology. Also, the informal nature of these legal rules makes them relatively easier to amend, which an important feature according to the conditions prevailing in emerging technologies that are constantly changing. In the following, the soft law which is presented so far to regulate geoengineering research in general and can be applied to ocean fertilization is investigated.

4.4.1 Asilomar Principles

The publication of the fourth assessment report of the intergovernmental panel on climate change and the growing demands of the international community to investigate geoengineering led to the holding of the Asilomar International Conference on Geoengineering Technology in 2010[42]. This conference led to setting five principles as follows:

(a) Promoting collective benefit: Promoting the collective benefit of humankind and the environment must be the primary goal of research conducted to develop and evaluate the potential of geoengineering technologies, including ocean fertilization. So, the result should be moderating or reversing the effects of climate change.

[40] KUOKKANEN, Tuomas; YULIA, Yam Ineva. Regulating geoengineering in international environmental law. *Carbon and Climate Law Review*, v. 7, n. 3, p. 161-167, 2013.

[41] KUOKKANEN, Tuomas; YULIA, Yam Ineva. Regulating geoengineering in international environmental law. *Carbon and Climate Law Review*, v. 7, n. 3, p. 161-167, 2013. p. 166.

[42] This conference is one of the actions that have been taken in order to deal with climate change, and more than 170 experts from 15 countries around the world were present.

(b) Responsibility and liability: The governments should take responsibility for managing and overseeing large-scale geoengineering research activities having the potential to make significant environmental changes and, if necessary, establish new mechanisms for handling them. These mechanisms should create a structure and regulations for the management of scientific research. Meanwhile, in the occurrence of destructive consequences, they should determine who is responsible for the consequences and how to compensate for them.

(c) Participation in research: Geoengineering research should be conducted openly and preferably with the participation of all countries and in a framework comprising widespread international support.

(d) Risk assessment: This principle emphasizes independent and continuous technical assessments of research progress. All geoengineering research activities, including ocean fertilization, which have the potential to affect the environment, are subject to risk assessment. Assessing potential and unintended consequences, impacts, and risks will help policymakers make better decisions.

(e) Public participation: In order to ensure that international and intergenerational geoengineering consequences are considered, public participation should be provided in the planning, monitoring, evaluating, and developing of decision-making mechanisms.[43]

4.4.2 GESAMP 41 Guidelines

In 2016, the United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) formed a working group to investigate the potential ecological and social impacts of marine geoengineering. The task of this group is to provide advice to the International Maritime Organization and the parties to the London Convention and Protocol. The working group released its first report in March 2019, including an initial review of twenty-seven marine geoengineering techniques. This report emphasized efficiency, practicality, side effects, current knowledge gaps, verification, and potential environmental, social, and economic impacts. In this report, the main recommendation is to establish a coordinated framework for the performance of marine geoengineering activities and the integration of independent expert evaluations. In addition, the report contains three suggestions for future measures as follows:

- The need for further analysis: Undoubtedly, to conduct future measures as well as possible, issues such as the potential environmental, social, and economic effects of various marine geoengineering techniques on the marine and atmospheric environment require more investigations.
- Providing an appropriate framework: Achieving an efficient and appropriate framework for scientific evaluation is a challenging task requiring a great deal of effort.
- The need for a more comprehensive assessment: It is essential that the assessment comprises social, political, economic, environmental, and moral dimensions.

Overall, the report argues that marine geoengineering approaches should be based on definitive science and then developed in a way that is useful and acceptable to society.[44]

4.4.3 Code of conduct governing the geoengineering research

For the first time, the Royal Society called for a code of conduct governing the geoengineering research. It includes a set of recommendations to the international scientific community that provide a governance framework for such research.[45] Finally, after several years of study, in October 2017, a code of conduct was developed for responsible geoengineering research, including ocean fertilization. The purpose of the rules is to monitor and guide geoengineering research. These

[43] ASOC. Asilomar Scientific Organizing Committee. *The Asilomar Conference Recommendations on Principles for Research into Climate Engineering Techniques*. Washington, DC: Climate Institute, 2010. Available at: http://www.climateresponsefund.org/images/Conference/finalfinalreport.pdf.

[44] BOYD, Philip; VIVIAN, Chris (ed.). GESAMP. Group of Experts on the Scientific Aspects of Marine Environmental Protection. *High level review of a wide range of proposed marine geoengineering techniques*. London: International Maritime Organization Albert Embankment, 2019. SE1-7SR.

[45] THE ROYAL Society Report: geoengineering the climate: science, governance and uncertainty. 2009. p. 1-81.

rules are considered a vital step in the emerging field of ocean fertilization. The role of the code of conduct in this area can be examined in several ways as follows:

• Provide specific principles and procedures to prevent and minimize adverse environmental effects of fertilization experiments.

Since initial small-scale fertilization experiments are not subject to international rules of prevention owing to the lack of significant risk of damage, codes of conduct are an excellent tool for monitoring such experiments. At the same time, this is in line with the growing trend of using the best environmental methods for conducting responsible scientific research. In this regard, Article 6 of the Code of Conduct, entitled Principles and Methods of Responsibility, stipulates that research should be conducted responsibly, in accordance with these rules as well as the provisions of international law. All appropriate measures should be taken to prevent and minimize the risks of outdoor experiments and maximize their benefits. Hence, a cautious and step-by-step approach should be considered. Experiments should be performed utilizing the best available scientific methods and tools. Meanwhile, disruption of further legitimate activities, including other research studies, should also be avoided.

• Promote international cooperation in the field of scientific research on ocean fertilization.

As discussed, ocean fertilization technology can affect the global environment if the governments put it into practice. However, most research has been conducted in the United States, Germany, and the United Kingdom. There is a need for broad, inclusive, and equitable participation in research to facilitate conscious decision-making for all countries. This technology requires international agreement, and codes of conduct can play a gradual influential role in informing and coordinating national and international measures and achieving global cooperation, resulting in a comprehensive understanding of the potential risks and benefits of geoengineering technologies, including ocean fertilization. In this regard, Article 5 of the Code of Conduct stipulates that all international actors (including governments, international organizations, and private actors) must cooperate to promote the responsible conduct of marine geoengineering research under international law. Promoting international justice is possible by increasing the capacity of developing countries and supporting decision-making in the form of joint programs to provide scientific and technical education.

• Paying attention to the principles of international environmental law in research.

Codes of conduct should be interpreted and implemented under the principles and rules of international environmental law. The principles include sustainable development (based on equity and common but different responsibilities), cooperation in good faith, dominance over natural resources, considering the principle of non-harmful use of land, prevention, precaution, informing, and consulting with countries that are potentially affected (Article 3 of the Code of Conduct).

• Prohibition of ocean fertilization on a large scale until scientific certainty is achieved.

Based on Article 4, no large-scale activity should be carried out unless there are sufficient scientific reasons to justify geoengineering activities according to the environmental impacts. Therefore, only responsible geoengineering research can be conducted under all applicable laws, regulations, and the guidance in this Code of Conduct.[46] [47]

5 Conclusion

Ocean fertilization technology is a geoengineering technique newly introduced to deal with climate changes. Since there is no consensus about the effectiveness of this novel technology against global warming and its adverse environmental consequences, it is necessary to establish a legal regime governing this technology. In this regard, some jurists believe that it is possible to form a legal regime to manage this technology by conventions related to international environmental law and the law of the sea. Nevertheless, such laws provide only a basic framework. Because, they are very interpretable due to their vagueness. In addition, they frequently involve a general phraseology. It should be noted that among the related treaties, there are only two documents including the Convention on Biological Diver-

[46] HUBERT, Anna-Maria. *A code of conduct for geoengineering research*. 2017. Available at: https://www.c2g2.net/code-conduct-promote-geoengineering-governance/. Access in: 15 sep. 2022.

[47] HUBERT, Anna-Maria. *Code of conduct for responsible geoengineering research:* an interim report of the Geoengineering Research Governance Project (GRGP). 2017.

sity and London Dumping Regime, in which there is a direct indication of ocean fertilization technology. On top of all that, the 2013 Amendment to the London Protocol, the most important effort of the international community to regulate ocean fertilization, has not been implemented yet.

It is undeniable that the current treaty regime suffers from many problems including fragmentation and conflict between regulatory treaties, inattention to the role of non-state actors, and neglecting the advantages of ocean fertilization in coping with climate changes. Thus, it is essential to overcome such problems by introducing practical strategies. In this regard, coordination of the current documents, concluding a new treaty, acceding a protocol to the Climate Change Framework Convention, and applying the capabilities of soft laws are some important strategies. Such strategies can be divided into three main categories including long-term, medium-term and short-term strategies.

Obviously, concluding a document focusing on ocean fertilization, whether as an independent treaty or in the form of a Protocol annexed to the Framework Convention on Climate Change, is highly likely to overcome many of these problems. However, despite all benefits, the experience of regulating other technologies and countering the resolution proposed by the Switzerland government to UNEP have confirmed that reaching consent and agreement between the governments is the main obstacle against this strategy. Generally, coordinating the will of countries' leaders on complex issues such as technology is a time-consuming and challenging process due to the conflict of interests. Hence, this strategy is a long-term strategy that can map the future's directions. Besides, coordination of current documents can be considered as a medium-term option by the international community. The successful experience in the coordination of documents relating to chemical and hazardous waste management has demonstrated that it is possible to overcome the current documents' points of differentiation by creating joint working groups. Moreover, further fragmentation of the legal regime can be prevented while providing appropriate conditions for simultaneous implementation of the current documents. However, this strategy also depends on the willpower of the governments. Accordingly, soft law instruments can partially fill the gap in the lack of harmonized regulations.

Based on the obtained results, soft laws have comprised many advantages. First of all, in spite of all criticisms, soft laws can be considered as a proper format for regulating ocean fertilization, especially in the current situation where we are at the beginning of its regulation. Secondly, the governments can accept and implement such laws more readily owing to their non-binding and voluntary nature. Another benefit is the pluralistic nature of these laws contrary to the treaty and custom, which means not only don't they depend merely on the will of the governments, but also they value the participation of private actors. Additionally, soft laws provide the basis for transnational negotiations and facilitate international coordination. Finally, it can also fill the gaps caused by the lack of international regulations to conduct scientific research on fertilization.

Currently, several soft laws such as the Asilomar principles, GESAMP guidelines, and the code of conduct governing geoengineering research have been developed to regulate and monitor the behavior of governmental and non-governmental actors conducting fertilization research. Consequently, observance of the international environmental law's principles such as prevention, risk assessment, cooperation, informing and participation has been considered in this field. Furthermore, essential legal issues like considering the public interest, compensation liability and prohibition of ocean fertilization until scientific certainty about the environmental effects of this technology have also been regarded. Although ocean fertilization technology is beneficial to cope with climate changes, the content of the current soft laws indicates that monitoring the research related to this technology until achieving scientific certainty is crucial due to its potential environmental damages.

References

ABATE, Randall S. Ocean iron fertilization: science, law, and uncertainty. *In:* BURNS, Wil C. G.; STRAUSS, Andrew L. (ed.). *Climate change geoengineering:* philosophical perspectives, legal issues, and governance frameworks. Cambridge: Cambridge University Press, 2013. p. 221-241.

AMENDMENT to the 1996 Protocol to The Convention on the Prevention of Marine Pollution by Dum-

ping of Wastes and other Matter, 1972 to Regulate Marine Geoengineering, 2013.

ASOC. Asilomar Scientific Organizing Committee. *The Asilomar Conference Recommendations on Principles for Research into Climate Engineering Techniques*. Washington, DC: Climate Institute, 2010. Available at: http://www.climateresponsefund.org/images/Conference/finalfinalreport.pdf.

BASU, Samarpita; MACKEY, Katherine. Phytoplankton as key mediators of the biological carbon pump: their responses to a changing climate. *Sustainability*, v. 10, n. 3, p. 1-18, 2018.

BIERMANN, Frank; PATTBERG, Philipp; VAN ASSELT, Harro; ZELLI, Fariborz. The fragmentation of global governance architectures: a framework for analysis. *Global Environmental Politics*, v. 9, n. 4, p. 14-40, 2009.

BODANSKY, Daniel. The ocean and climate change law: exploring the relationships. *In:* BARNERS, R.; LONG, R. (ed.). *Frontiers in international law:* oceans and climate challenges: essays in honor of David Freestone. Brill Publisher, 2020. p. 1-30.

BOYD, Philip; VIVIAN, Chris (ed.). GESAMP. Group of Experts on the Scientific Aspects of Marine Environmental Protection. *High level review of a wide range of proposed marine geoengineering techniques*. London: International Maritime Organization Albert Embankment, 2019. SE1-7SR.

BRANSON, Michael C. A green herring: how current ocean fertilization regulation distracts from geoengineering research. *The Santa Clara Law Review*, v. 54, n. 1, p. 163-200, 2014.

BRENT, Kerryn; BURNS, Wil; MCGEE, Jeffrey. *Governance of marine geoengineering:* special report. Centre for International Governance Innovation, 2019.

BRODER, Sherry P. International governance of ocean fertilization and other marine geoengineering activities. *In:* ESPÓSITO, Carlos; KRASKA, James; SCHEIBER, Harry N.; KWON, Moon-Sang (ed.). *Ocean law and policy:* twenty years of development under the UNCLOS regime. Nijhoff: Brill, 2017. p. 305-343.

CLAUDIO, Cavieze; REVERMANN, Christoph. *Climate engineering, endbericht zum TA-Projekt geoengineering*. 2014.

DU, Haomiao. *An international legal framework for geoengineering managing the risks of an emerging technology*. New York: Routledge, 2018.

GERRARD, Michael; HESTER, Tracy. *Climate engineering and the law:* regulation and liability for solar radiation management and carbon dioxide removal. Cambridge: Cambridge University Press, 2018.

GINZKY, Harald. Marine geo-engineering. *In:* SALOMON, M.; MARKUS, T. (ed.). *Handbook on marine environment protection*. New York: Springer International Publishing AG, 2018. p. 997-1011.

HUBERT, Anna-Maria. *A code of conduct for geoengineering research*. 2017. Available at: https://www.c2g2.net/code-conduct-promote-geoengineering-governance/. Access in: 15 sep. 2022.

HUBERT, Anna-Maria. *Code of conduct for responsible geoengineering research:* an interim report of the Geoengineering Research Governance Project (GRGP). 2017.

JOHANSEN, Elise. Ocean fertilization. *In:* THE LAW of the sea and climate change. Cambridge: Cambridge University Press, 2020. p. 184-205.

KEANE, Kevin. *Towards a new climate ethic:* international law, ethics and geoengineering in the Anthropocene. 2020. Thesis (Master's in Public International Law) – Elferink Utrecht University, 2020.

KUOKKANEN, Tuomas; YULIA, Yam Ineva. Regulating geoengineering in international environmental law. *Carbon and Climate Law Review*, v. 7, n. 3, p. 161-167, 2013.

LAJAUNIE, Claire; MAZZEGA, Pierre. Mining CBD. *Revista de Direito Internacional*, Brasília, v. 13, n. 2, p. 276-290, 2016.

NGUYEN, Yen Thi Hong; NGUYEN, Dung Phuong. The efforts to respond to climate change and implementation of the Sustainable Development Goals (SDGS) from the hardest-affected countries: Vietnam case analysis. *Revista de Direito Internacional*, Brasília, v. 19, n. 1, p. 164-191, 2022.

NOORI, Mansoor Poor; HABIBI, Mohammad. *International law of the sea:* Convention on the Law of the Sea 1982. Tehran, 2006.

PERSPECTIVES on the UNEA Resolution. 2019. Available at: https://geoengineering.environment.har-

vard.edu/blog/perspectives-unea-resolution. Access in: 18 oct. 2022.

RADCLIFFE, Saadi. Geoengineering: ocean iron fertilization and the law of the sea. *LIM research paper*, p. 1-61, 2014.

SCOTT, Karen N. Regulating ocean fertilization under international law: the risks. *Carbon and Climate Law Review*, v. 7, n. 2, p. 108-116, 2013.

SVERDRUP, K. A.; DUXBURY, A. B.; DUXBURY. A. C. *Fundamentals of oceanography*. 5. ed. New York: McGraw-Hill College, 2004.

TEDSEN, Elizabeth; HOMANN, Gesa. Implementing the precautionary principle for climate engineering. *Carbon & Climate Law Review*, v. 7, n. 2, p. 90-100, 2013.

THE ROYAL Society Report: geoengineering the climate: science, governance and uncertainty. 2009.

UNESCO. *Report on the IMO London Convention Scientific Group Meeting on Ocean Fertilization*. Ad Hoc Consultative Group on Ocean Fertilization, Intergovernmental Ocean Commission (IOC). UNESCO Doc. IOC/INF-1247, 2008.

VEDANT, Dikshit. Ocean fertilization as a method to mitigate the climate change. *In:* GUPTA, A. (ed.). *Conservation, sustainability, and environmental justice in India*. London: Lexington Books, 2021.

WILLIAMSON, Phillip *et al*. Ocean fertilization for geoengineering: a review of effectiveness, environmental impacts and emerging governance. *Process Safety and Environmental Protection*, v. 90, n. 6, p. 479-482, 2012.

WILSON, Grant. Murky waters: ambiguous international law for ocean fertilization and other geoengineering. *Texas International Law Journal*, p. 1-40, 2014.

WORKING Group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2014.

YOON, Joo-Eun *et al*. Reviews and syntheses: ocean iron fertilization experiments: past, present, and future looking to a future Korean Iron Fertilization Experiment in the Southern Ocean (KIFES) project. *Biogeosciences*, v. 15, p. 5847-5889, 2018.

Para publicar na Revista de Direito Internacional, acesse o endereço eletrônico www.rdi.uniceub.br ou www.brazilianjournal.org.
Observe as normas de publicação, para facilitar e agilizar o trabalho de edição.