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Ocean Alkalinization: The Rights and Obligations under International Law

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ABBREVIATIONS

CBD	Convention on Biological Diversity
CDR	Carbon dioxide removal
COP	Conference of the Parties
CO_2	Carbon dioxide
EIA	Environmental Impact Assessment
GESAMP	The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
ICJ	International Court of Justice
ITLOS	International Tribunal for the Law of the Sea
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change LC London Convention
LC	London Convention
LC-LP	London Convention and London Protocol
LOSC	United Nations Convention on the Law of the Sea
LP	Protocol to London Convention
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VCLT	Vienna Convention of Law and Treaties

CHAPTER I – INTRODUCTION

"Without geoengineering, it is becoming highly unlikely that
'dangerous' climate change can still be avoided"
Phillip Williamson[1]

1. Background

1.1 Climate Change

Anthropogenic climate change and the lack of success in limiting greenhouse gas emissions have sparked interest in geo-engineering technologies, which are targeted interventions in the environment to counteract climate change and its effects.[2] Geo-engineering technologies are intended to achieve a deliberate change in the Earth's energy balance to prevent a further increase in temperature.[3] The Paris Agreement[4] temperature target is to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels.[5] There are efforts to reduce emissions, but the current ambition of States is not sufficient to reduce greenhouse gas emissions to the extent that global warming is limited to 2 °C.[6] The Climate Action Tracker demonstrates current climate policies are likely to lead to warming of between 2.1°C and 3.9 °C.[7] The oceans have a special role in the context of mitigating climate change, as they cover 71% of the Earth's surface.[8] The oceans are the largest carbon sinks, absorbing more CO_2 than they emit, which significantly reduces the total carbon dioxide content of the atmosphere.[9] According to the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate

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1 Phillip Williamson and others, 'Ocean Fertilization for Geoengineering: A Review of Effectiveness, Environmental Impacts and Emerging Governance' (2012) 90 Process Safety and Environmental Protection 475, page 476.
2 ibid page 475.
3 J. Shepherd et al., 'The Royal Society Report on Geoengineering the Climate: Science, Governance and Uncertainty (2009), Report 10/09' (The Royal Society 2009) page 1.
4 Paris Agreement under the United Nations Framework Convention on Climate Change (adopted 12 December 2015, entered into force 4 November 2016), 55 ILM 743 (hereinafter Paris Agreement).
5 ibid Art. 2 (1) (a).
6 cf. Kerryn Brent, 'Marine Geoengineering Governance and the Importance of Compatibility with the Law of the Sea' in Jan McDonald, Jeffrey McGee and Richard Barnes, *Research Handbook on Climate Change, Oceans and Coasts* (Edward Elgar Publishing 2020) page 444; Mark G Lawrence and others, 'Evaluating Climate Geoengineering Proposals in the Context of the Paris Agreement Temperature Goals' (2018) 9 Nature Communications 3734, page 1; J. Shepherd et al. (n 3) page ix.
7 'The CAT Thermometer' <https://climateactiontracker.org/global/cat-thermometer/> accessed 1 July 2021.
8 'IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate' page 5 <https://www.ipcc.ch/srocc/chapter/summary-for-policymakers/> accessed 21 June 2021.
9 Michael Bothe, 'Measures to Fight Climate Change – A Role for the Law of the Sea?' in Holger Hestermeyer and others (eds), *Law of the Sea in Dialogue*, vol 221 (Springer Berlin Heidelberg 2011) page 32.

(IPCC Special Report on Ocean and Cryosphere), there is a high probability that "the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system"[10] and "will continue to warm throughout the 21st century".[11] Climate change negatively affects the natural function of the ocean as a carbon sink. The warming of the oceans reduces the solubility of carbon dioxide and reduces the amount of CO_2 that the oceans can absorb from the atmosphere.[12] In addition to the problem of climate change and the associated global warming, another problem should not be underestimated in this context, namely ocean acidification. Ocean acidification is the lowering of the pH value of the oceans caused by the increased absorption of CO_2 from the atmosphere into the oceans.[13] It is not a result of climate change, but is related to it, because both are caused by the increase in CO_2 emissions[14], which is the main cause of anthropogenic climate change.[15] The IPCC Special Report on the Ocean and Cryosphere notes the ocean is thought to have absorbed about 20-30% of the carbon dioxide emitted by humans.[16] It is necessary to reduce greenhouse gas emissions. For instance the recently published IPCC Report on Climate Change 2021 clarified that "global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades".[17] Emissions continue to increase and there are already clear negative impacts on the oceans from greenhouse gas emissions, such as the oceans water temperature rise, ocean acidification and the loss of oxygen in the oceans.[18] The urgency of mitigating climate change is also demonstrated by the recent IPCC Report, which states that "human-induced climate change is already affecting many

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[10] 'IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate' (n 8) page 9.

[11] ibid page 18.

[12] Long Cao, Ken Caldeira and Atul K Jain, 'Effects of Carbon Dioxide and Climate Change on Ocean Acidification and Carbonate Mineral Saturation' (2007) 34 Geophysical Research Letters page 2.

[13] Raphaël Billé and others, 'Taking Action Against Ocean Acidification: A Review of Management and Policy Options' (2013) 52 Environmental Management 761.

[14] James Harrison, *Saving the Oceans Through Law: The International Legal Framework for the Protection of the Marine Environment* (Oxford University Press) page 247.

[15] cf. 'IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change' page 9 <https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf>; Jean-Pierre Gattuso and Lina Hansson, *Ocean Acidification* (OUP Oxford 2011) page 272.

[16] 'IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate' (n 8) page 9.

[17] 'IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change' (n 15) page 17.

[18] Philip W Boyd and Chris Vivian, 'High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques' (2019) Journal Series GESAMP Reports and Studies No. 98 page 15.

weather and climate extremes in every region across the globe".[19] The current occurrences, such as the floods in Germany and wildfires in Turkey and Greece, demonstrate how serious the situation is and the Guardian is already talking about a "climate breakdown".[20]

1.2 The Need for Positive and Negative Emissions Reduction

In order to limit the negative effects just described, there must be a strong reduction in CO_2 emissions.[21] When it comes to the question of mitigating CO_2 emissions, a distinction can be made between primary emission reductions and negative emission technologies. The use of renewable energies (such as wind, solar or biomass), represents a primary reduction in emissions because it is associated with significantly lower CO_2 emissions than the use of fossil fuels.[22] In contrast, negative emission technologies, such as geo-engineering technologies[23], do not aim at reducing greenhouse emissions, but rather to remove carbon from the atmosphere through mechanical and chemical interventions in the global ecosystem.[24] There are several geo-engineering proposals for carbon dioxide removal measures, including both terrestrial and marine technologies.[25] Of the various marine geo-engineering technologies, ocean iron fertilization[26] is one of the most discussed methods, as it has already been implemented in scientific experiments.[27]Another less discussed alternative to ocean fertilization is artificial ocean alkalinization.[28] Both methods carry many risks, the harmful effects on the marine ecosystem have not yet been sufficiently studied and the potential effectiveness, which is "the

[19] 'IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change' (n 15) page 10.

[20] 'Global Water Crisis Will Intensify with Climate Breakdown, Says Report' (*the Guardian*, 17 August 2021) <http://www.theguardian.com/environment/2021/aug/17/global-water-crisis-will-intensify-with-climate-breakdown-says-report> accessed 19 August 2021.

[21] cf. 'IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change' (n 15) page 17.

[22] International Renewable Energy Agency, 'Renewable Energy: A Key Climate Solution' <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Nov/IRENA_A_key_climate_solution_2017.pdf?la=en&hash=A9561C1518629886361D12EFA11A051E004C5C98> accessed 17 June 2021.

[23] With reference to the measures to remove carbon dioxide.

[24] Laisa Branco Almeida, 'The Role of International Law of the Seas on the Global Governance of Marine Climate Geoengineering Techniques' (Social Science Research Network 2018) SSRN Scholarly Paper ID 3180953 page 3; Pete Smith, 'Soil Carbon Sequestration and Biochar as Negative Emission Technologies' (2016) 22 Global Change Biology 1315, page 1315.

[25] Brent (n 6) page 442.

[26] For the purpose of consistency, the term "fertilization" is spelled with a "z". The spelling is usually preferred in international documents where the term is used.

[27] Bernard Quéguiner, 'Iron Fertilization and the Structure of Planktonic Communities in High Nutrient Regions of the Southern Ocean' (2013) 90 Deep Sea Research Part II: Topical Studies in Oceanography 43, page 43.

[28] For the purpose of consistency, the term "alkalinization" is spelled with a "z". The spelling is usually preferred in international documents where the term is used.

degree to which something is successful in producing a desired result"[29], is still debated.[30] Nevertheless, in order to achieve the Paris Agreement target, the use of negative emission technologies is very likely to be necessary, as the IPCC Special Report on Global Warming of 1.5°C says: "All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO2 over the 21st century".[31] In addition, there are a growing number of scientific studies stating that the Paris Agreement target is unlikely to be achieved without negative emissions technologies.[32] Negative emissions must be achieved through the large-scale removal of existing CO_2 directly from the atmosphere.[33] In this context, negative emission technologies are not a substitute for a drastic reduction of greenhouse gas emissions, but an additional prerequisite for achieving the goal of the Paris Agreement.[34] It is clear that negative emission technologies alone will be sufficient to absorb enough CO_2 to meet the Paris Agreement target.[35] The Royal Society Report came to the same conclusion, saying that "no geoengineering method can provide an easy or readily acceptable alternative solution to the problem of climate change" but "could however potentially be useful in future to augment continuing efforts to mitigate climate change by reducing emissions".[36] It follows that there is a need for negative emissions technologies, such as ocean iron fertilization and ocean alkalinization, but that the focus on negative emissions technologies should not distract from the need to drastically reduce emissions. Furthermore, scientific uncertainty exists regarding the effectiveness of these technologies and impact on the marine environment.

2. Research Objective and Research Question

Marine geo-engineering measures could potentially help reduce emissions if the respective measure turns out to be effective, which would be positive in the interests of the climate change regime, since strong reduction of emissions is necessary to prevent dramatic consequences

[29] 'EFFECTIVENESS | Definition of EFFECTIVENESS by Oxford Dictionary on Lexico.Com Also Meaning of EFFECTIVENESS' (*Lexico Dictionaries | English*) <https://www.lexico.com/definition/effectiveness> accessed 28 June 2021.

[30] Boyd and Vivian (n 18) Chapter 5.1-5.3 and 5.13.

[31] 'IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C' page 17 <https://www.ipcc.ch/sr15/chapter/spm/> accessed 1 July 2021.

[32] cf. Boyd and Vivian (n 18) page 19; Kevin Anderson and Glen Peters, 'The Trouble with Negative Emissions' (2016) 354 Science 182, page 182; Branco Almeida (n 24) page 2.

[33] Brent (n 6) page 444.

[34] cf. Phil Williamson, 'Emissions Reduction: Scrutinize CO 2 Removal Methods' (2016) 530 Nature 153, page 153.

[35] cf. Jan C Minx and others, 'Negative Emissions—Part 1: Research Landscape and Synthesis' (2018) 13 Environmental Research Letters 063001, page 17.

[36] J. Shepherd et al. (n 3) page ix.

caused by climate change.[37] However, these technologies, such as ocean iron fertilization and ocean alkalinization, could lead to dramatic and unforeseeable consequences in the marine environment. Therefore, the question of compatibility with international law arises. The legal framework for geo-engineering activities as marine science research or large-scale negative emissions technology must be clarified to facilitate the implementation of research projects and potentially enable large-scale deployments. The potentially negative impacts on the marine environment raise issues in law of the sea for which the United Nation Convention on the Law of the Sea (LOSC)[38] is particularly relevant. The protection of the marine environment is one important objective of the LOSC and specifically regulated in Part XII of the Convention. Ocean iron fertilization and ocean alkalinization could be considered pollution of the marine environment. There are existing regulations to prevent substances from being introduced into the oceans in the context of marine pollution and more specifically dumping regulations in the LOSC. Questionable is how it is seen from the perspective of the climate change regime. Precisely the introduction of iron or alkalising minerals into the oceans could be necessary to achieve a reduction in CO_2 concentration in the atmosphere. Consequently, there might be a conflict of objectives between the law of the sea, with the protection of the marine environment, and the climate change regime, with the reduction of emissions to prevent the damages caused by climate change. Regarding ocean iron fertilization, the issue of compatibility with international law, specifically the law of the sea, has already been extensively discussed in the relevant legal literature[39] and it has led to marine geo-engineering, particularly related to ocean fertilization, already being addressed by the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972[40] (London Convention) and the Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1996[41] (London Protocol) and by the Convention of Biodiversity[42] (CBD). Non-binding

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37 Williamson (n 34) page 153; Kevin Elliott, 'Geoengineering and the Precautionary Principle' (2010) 24 International Journal of Applied Philosophy 237, page 237.

38 United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 397 (hereinafter LOSC).

39 Kerstin Güssow and others, 'Ocean Iron Fertilization: Why Further Research Is Needed' (2010) 34 Marine Policy 911; Brent (n 6); Karen N Scott, 'Mind the Gap: Marine Geoengineering and the Law of the Sea', *High Seas Governance* (Brill Nijhoff 2018) <https://brill.com/view/book/edcoll/9789004373303/BP000003.xml> accessed 17 August 2021; James Harrison (n 14); Elise Johansen, 'Ocean Fertilization' in Elise Johansen, Ingvild Ulrikke Jakobsen and Signe Veierud Busch (eds), *The Law of the Sea and Climate Change: Solutions and Constraints* (Cambridge University Press 2020).

40 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (adopted 29 December 1972; entered into force 30 August 1975), 1046 UNTS 138 (hereinafter London Convention).

41 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (adopted 7 November 1996, entered into force 24 March 2006) 36 ILM 1 (hereinafter London Protocol).

42 Convention on Biological Diversity (adopted in Rio de Janeiro 5 June 1992, entered into force 29 December 1993), 1760 UNTS 79 (hereinafter CBD).

regulations were adopted, with an initial focus on ocean fertilization, and a legally binding mechanism to regulate marine geo-engineering activities was adopted to the London Protocol, which is not yet in force. These developments are considered in more detail below. In the context of ocean fertilization, the conflict between environmental protection and climate protection has been discussed in relation to the precautionary principle. The focus of the discussion on geo-engineering technologies has so far been predominantly on ocean iron fertilization, but ocean alkalinization may be a more promising alternative. This technology raises similar legal issues to ocean iron fertilization and the legal framework for the use needs to be clarified. It raises the question of the relationship between environmental protection and climate change mitigation, which this thesis elaborates on. The outcome could be different because, despite the similarity of the two technologies, ocean alkalinization could not only have positive effects on the reduction of CO_2 emissions in the atmosphere but could also counteract ocean acidification.[43] The question arises whether the regulations already developed by the dumping regime for ocean fertilization can be applied to ocean alkalinization. In addition, the precautionary principle, which provides guidance in case of scientific uncertainty[44], must be examined in the case of ocean alkalinization, since the application of the precautionary principle could play a role in resolving the conflict between protection of the marine environment and climate change mitigation. Against this background, the overall objective of this thesis is to analyse how ocean alkalinization is regulated in international law. From a legal perspective, there are some uncertainties related to ocean alkalinization activities, as there are no regulations specifically applicable to this technology. That does not mean that it is unregulated, as it falls under international law, such as climate law, environmental law and the law of the sea. In order to clarify the rights and obligations of States under international law, it is necessary to address the international legal framework for ocean alkalinization and how different regimes deal with the application of ocean alkalinization. In particular, it is necessary to clarify how ocean alkalinization can be used for scientific research or even large-scale operations. For this purpose, the thesis asks the following research question:

What are the rights and obligations for States under international law when conducting ocean alkalinization?

[43] Miriam Ferrer González and Tatiana Ilyina, 'Impacts of Artificial Ocean Alkalinization on the Carbon Cycle and Climate in Earth System Simulations' (2016) 43 Geophysical Research Letters 6493, page 6496; Boyd and Vivian (n 18) page 64.

[44] Jesse L Reynolds and Floor Fleurke, 'Climate Engineering Research: A Precautionary Response to Climate Change Special Issue on Climate Change Geoengineering (Part I)' (2013) 2013 Carbon & Climate Law Review 101, page 105.

The research question does not include ocean iron fertilization activities, but in order to answer the research question it is necessary to include this technology. The regulations already developed, and the handling of ocean iron fertilization technology will be considered in a comparative manner to ocean alkalinization. The issue of negative emissions technologies can be approached from two different perspectives. First, from the perspective of marine scientific research and second against the background of large-scale use. The focus of negative emission technologies has so far been on research. Due to the scale and rapidity of climate change, the use of technologies that affect the climate is required quickly and on a large-scale if it is to lead to significant changes.[45] Scientists demand large-scale implementation to achieve success in reducing emissions[46], whereas marine biologists are sceptical, fearing unpredictable negative impacts to the marine environment. This has for instance been highlighted by Lawrence, who stressed that "based on present knowledge, climate geoengineering techniques cannot be relied on to significantly contribute to meeting the Paris Agreement temperature goals".[47] This again demonstrates the conflict between protecting the marine environment and the need to reduce emissions to mitigate the effects of climate change.

3. Structure of the Thesis

This thesis is structured as follows: The remainder of this chapter explains the methodology in the next section. Chapter II describes in more detail the two geo-engineering technologies most relevant to this thesis, namely ocean iron fertilization and ocean alkalinization, their effectiveness and potential harmful consequences. Chapter III provides an analysis of what rights and obligations States have under international law in conducting ocean alkalinization. As a first step, this Chapter presents the use of ocean alkalinization in the context of the climate change regime, which aims to reduce the concentration of greenhouse gases in the atmosphere and need negative emission technologies to meet the objectives. This is followed by a discussion of the LOSC with a focus on protecting the marine environment. In doing so, it will be examined whether ocean alkalinization is pollution by dumping, with a comparative view of ocean fertilization. Subsequently, the dumping regime and the development in relation to ocean fertilization are presented, in order to investigate whether the rules for ocean iron fertilization are applicable to ocean alkalinization, so long as the legally binding regulations developed under the dumping regime for marine geo-engineering more broadly entered into force.

[45] Boyd and Vivian (n 18) page 15.
[46] Brent (n 6) page 444.
[47] Lawrence and others (n 6) page 1.

Ultimately, the conflict of objectives between the climate regime and the law of the sea will be examined in the context of the precautionary principle.

4. Legal Sources and Methodology

4.1 Legal Sources

The relevant legal issues will be discussed on the basis of various sources of international law, as listed in Art. 38 of the Statue of the International Court of Justice (ICJ).[48] While this article originally was created to clarify which sources the ICJ has to take into account when making decisions[49], it is now "generally regarded as a complete statement of the sources of international law". [50] Art. 38 (1) ICJ Statute refers to the primary sources: international conventions, international custom and the general principles of law.[51] Given the research question the focus of this thesis is on treaties and the main sources used are the LOSC as well as the dumping regime treaties (London Convention/ London Protocol), the United Nation Framework Convention on Climate Change[52] (UNFCCC), the Paris Agreement and the CBD. This thesis takes into account non-binding resolutions, which are not provided for in Art. 38 ICJ Statute. Furthermore, Art. 38 (1) (d) ICJ Statute refers to "judicial decisions and the teachings of the most highly qualified publicists of the various nations, as subsidiary means for the determination of rules of law", which are both used in the thesis. This means judicial decisions and legal literature are not direct sources of law but can be used as a subsidiary means of determining legal norms. There is no doctrine of binding precedent in international law.[53] Rather, the ICJ Statute provides in Art. 59 that a decision of the Court is not binding on anyone except the parties to the case and even then, only in relation to that particular case.[54] However, court decisions are cited by other court decisions and in this respect have relevance beyond the inter partes decision, but it is still not in the nature of binding precedents.[55] It follows that legal sources, relevant jurisprudence and legal literature dealing with this issue, are used to support

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[48] Statute of the International Court of Justice (adopted 26 June 1945, entered into force 24 October 1945), USTS 993 (hereinafter ICJ Statute).
[49] ibid Art. 38 (1).
[50] William A Schabas, *The UN International Criminal Tribunals: The Former Yugoslavia, Rwanda and Sierra Leone* (Cambridge University Press 2006) page 75.
[51] ICJ Statute Art. 38 (1) (a-c).
[52] United Nations Framework Convention on Climate Change (adopted 9 May 1992, entered into force 21 March 1994) 1771 UNTS 107 (hereinafter UNFCCC).
[53] Krzysztof J Pelc, 'The Politics of Precedent in International Law: A Social Network Application' (2014) 108 American Political Science Review 547, page 1.
[54] ICJ Statute Art. 59.
[55] Malcolm Evans, *International Law* (OUP Oxford 2010) page 110.

the legal analysis. In contrast, the scientific literature is only used for background information, e.g., to make clear the effectiveness of ocean alkalinization as well as possible negative environmental impacts are still questionable.

4.2 Methodology

The methodology used is an in-depth legal analysis, by way of interpreting the law in accordance with Articles 31-33 of the Vienna Convention of Laws and Treaties (VCLT).[56] The VCLT was adopted in 1969 to promote the development of international law and its codification.[57] It has become the main instrument for treaty interpretation and the ICJ has recognised that articles 31-32 VCLT are expressions of customary international law.[58] The general rule of interpretation under Art. 31 (1) VCLT states that "a treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose". To answer the research question, the focus is on the interpretation and analysis of legal sources. The thesis furthermore examines permissibility of ocean alkalization under international law, considering ocean iron fertilization and ocean alkalinization in a comparative manner. This thesis thus compares two geo-engineering measures from a legal perspective. Importantly, this does however not amount to comparative legal research, which is mainly about comparing national legal systems.[59]

5. Delimitation

The thesis analyses what the rights and obligations for States under international law are when conducting ocean alkalinization. The focus is on international law issues, particularly on conflicts of objectives between the climate change regime and the law of the sea, dumping regime and biodiversity regime, in which the application of the precautionary principle has a decisive role. It is limited to the legal perspective and does not deal with the political, scientific and economic aspects of geo-engineering. Furthermore, no national law or European Union law is addressed, only international law. This thesis addresses the legal issues raised by marine geo-engineering technologies and, in particular, ocean alkalinization.

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[56] Vienna Convention on the Law of Treaties (adopted 23 May 1969, entered into force 27 January 1980), 1155 UNTS 331 (hereinafter VCLT) 31.
[57] Anthony Aust, *Modern Treaty Law and Practice* (Cambridge University Press 2013) page 5-6.
[58] *Sovereignty over Pulau Ligitan and Pulau Sipadan (Indonesia/Malaysia), 23 Oktober 2001, ICJ* page 625.
[59] Mark Van Hoecke, 'Methodology of Comparative Legal Research' [2015] Law and Method page 3.

CHAPTER II – GEO-ENGINEERING

Before turning to the legal questions raised by ocean alkalinization activities, this Chapter first clarifies term geo-engineering. In doing so, it distinguishes between two main types of marine geo-engineering. Based on that, this Chapter introduces in more detail ocean fertilization and ocean alkalinization and highlights in this regard how ocean alkalinization could provide benefits over ocean fertilization, through potential containment of ocean acidification.

1. Geo-Engineering Technologies

For some time now, there has been increasing discussion in the literature and in the media about the possibility of containing climate change through geo-engineering. There is no generally accepted definition of geo-engineering, but in the Meeting Report from the IPCC Expert Meeting on Geoengineering it is defined as "a broad set of methods and technologies that aim to deliberately alter the climate system in order to alleviate the impacts of climate change".[60] There are several geo-engineering proposals to mitigate climate change, which can be divided into two main groups, the carbon dioxide removal measures and solar radiation management measures. Solar radiation management measures aim to increase the albedo of the earth (atmosphere, clouds or earth's surface) to reduce the incoming solar radiation.[61] This deliberate manipulation of solar radiation is intended to lower the average global temperature.[62] Carbon dioxide removal measures, on the other hand, are about removing CO_2 from the atmosphere and storing it in terrestrial or ocean sinks.[63] This goal is to be achieved by removing CO_2 from the carbon cycle as permanently as possible. The fundamental difference between the two methods is that solar radiation measures are not concerned with the reduction of existing emissions in the atmosphere and thus not with the resulting acidification of the oceans.[64] Marine geo-engineering technologies, in addition to ocean iron fertilization and ocean alkalinization, include, for example, ocean upwelling, ocean pumping, crop waste dumping, and carbon capture and storage.[65] Carbon capture and storage, which involves transporting carbon dioxide

[60] IPCC Expert Meeting on Geoengineering and others, 'IPCC Expert Meeting on Geoengineering: Lima, Peru, 20-22 June 2011 : Meeting Report' (2012) page 2 <https://archive.ipcc.ch/pdf/supporting-material/EM_GeoE_Meeting_Report_final.pdf>.
[61] J. Shepherd et al. (n 3) page 1.
[62] Lauren Hartzell-Nichols, 'Precaution and Solar Radiation Management' (2012) 15 Ethics, Policy & Environment 158, page 158.
[63] Brent (n 6) page 442.
[64] Boyd and Vivian (n 18) page 17.
[65] ibid Chapter 5; cf. Brent (n 6) page 446 ff.

emissions from fossil fuel use to safe geological storage sites instead of releasing them into the atmosphere[66], is not necessarily considered a geoengineering measure.

1.1 Ocean Iron Fertilization

The technology for removing carbon dioxide on which most attention has been focused so far is ocean iron fertilization, where iron sulphates are introduced into the ocean to encourage the growth of Phyto-Plankton, which then uses photosynthesis to pull CO_2 from the atmosphere and transport it to the deep ocean where it sequesters the carbon.[67] The aim is to promote the growth of marine plants to provide increased uptake of CO_2 by the oceans from the atmosphere for a long enough period of time so that global climate benefits can be achieved.[68] The studies of the scientific experiments have demonstrated that Phyto-Plankton grows due to the addition of iron, the Phyto-Plankton biomass increases and the CO_2 in the surface water decreases.[69] Ocean iron fertilization as a negative emission technology is disputed because, as already mentioned, it has not yet been fully researched and its effectiveness and negative impacts are still uncertain. In 2012, Philipp Williamson already noted that "on the basis of small-scale field experiments carried out to date […] the maximum benefits of ocean fertilisation as a negative emissions technique are likely to be modest in relation to anthropogenic climate forcing".[70] Potential negative consequences include the development of toxic harmful algal blooms, the generation of an increase in emissions of other greenhouse gases and oxygen depletion in deep waters.[71] Furthermore, there is evidence of significant disruptions to marine biogeochemistry and ecology from large-scale ocean fertilization.[72] The possibility of increased concentrations of other greenhouse gases such as methane and nitrous oxide would be severe, because even releasing small amounts into the atmosphere could have a disproportionate effect that would cancel out the increased uptake of CO_2 that would occur from ocean iron fertilization.[73] Moreover, it has not yet been scientifically proven what the role of iron addition to the oceans is and to what extent ocean iron fertilization sequesters carbon in the deep sea.[74] Researchers claimed in the 1990s that for every tonne of iron, tens of thousands of tonnes of carbon are

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[66] Jon Gibbins and Hannah Chalmers, 'Carbon Capture and Storage' (2008) 36 Energy Policy 4317, page 4317.
[67] Brent (n 6) page 446; Johansen (n 39) page 185.
[68] Johansen (n 39) page 186.
[69] Kerstin Güssow and others (n 39) page 912.
[70] Williamson and others (n 1) page 475.
[71] Karen N Scott, 'Regulating Ocean Fertilization under International Law: The Risks Special Issue on Climate Change Geoengineering (Part I)' (2013) 2013 Carbon & Climate Law Review 108, page 110.
[72] Kerstin Güssow and others (n 39) page 912.
[73] Boyd and Vivian (n 18) page 44.
[74] Johansen (n 39) page 186.

sequestered by Phyto-Plankton blooms.[75] However, this was reduced over time when it was found that most of the absorbed CO_2 is released back into the atmosphere when the Phyto-Plankton decayed[76], thus raising the question of effectiveness. The current assumption is about 90 % of the CO_2 will be released back into the atmosphere within a year.[77] In addition to the direct consequences of adding iron to the oceans, it is currently believed that the potential increasing absorption of CO_2 due to iron fertilization also leads to an exacerbation of ocean acidification, which has a negative impact on marine life.[78]

1.2 Ocean Alkalinization

An interesting and somewhat underestimated form of ocean-based carbon dioxide removal methods is artificial ocean alkalinization. The oceans naturally absorb CO_2 from the atmosphere, but this process leads, as explained above, to the ocean becoming more and more acidic. Ocean acidification can have significant negative impacts on the marine ecosystem.[79] The pH of the oceans will continue to decrease for at least several decades as the oceans will continue to absorb CO_2. The application of geo-engineering technologies that target the alkalinity of the ocean are one potential way to fight ocean acidification.[80] Ocean alkalinization involves the introduction of alkalising minerals at the interface between the ocean and the atmosphere.[81] The increase in total alkalinity at the surface leads to a reduction in the acidity of the oceans, which increases the pH of seawater.[82] Thus, it is currently assumed that ocean alkalinization can lead to reversing the effects of ocean acidification and thus mitigating harmful impacts on marine biodiversity.[83] This represents a significant difference to ocean iron fertilization, which could possibly be a distinction in terms of legal assessment, as discussed below. In addition, experiments have demonstrated alkalinization has a positive effect on the climate because it increases oceanic carbon uptake and storage, which leads to a reduction in the CO_2 concentration in the atmosphere.[84] While ocean alkalinization holds some promise as a marine negative emissions technology, further research is needed because, as mentioned

[75] Williamson (n 34) page 154.
[76] ibid.
[77] Boyd and Vivian (n 18) page 42.
[78] Bothe (n 9) page 35 and 39.
[79] cf. Karen N Scott, 'Ocean Acidification: A Due Diligence Obligation under the LOSC' (2020) 35 The International Journal of Marine and Coastal Law 382, page 383; Boyd and Vivian (n 18) page 15.
[80] cf. Boyd and Vivian (n 18) page 19.
[81] González and Ilyina (n 43) page 6493.
[82] Gemma Cripps and others, 'Biological Impacts of Enhanced Alkalinity in Carcinus Maenas' (2013) 71 Marine Pollution Bulletin 190, page 191.
[83] Boyd and Vivian (n 18) page 64.
[84] González and Ilyina (n 43) page 6496.

above, there are uncertainties about the effectiveness and potential negative environmental impacts.[85] An unintended consequence of this method could be that the pH of the ocean is unnaturally increased, as the alkalinization completely compensates for the decreasing pH of the seawater, which can have negative effects on the marine biota.[86] In the case of alkalinization, similar to fertilization, it could lead to a fertilising effect of the ocean, so there would be similar risks to the marine environment.[87] Studies have also shown that the addition of alkalinity could disrupt the acid-base balance of marine organisms and release toxic heavy metals, which could affect the marine ecosystem.[88] While there is thus still a need for further research, it is important to note that ocean alkalinization could, in contrast to ocean fertilization, be beneficial because it is not primarily aimed at absorbing CO_2 from the atmosphere, but at counteracting ocean acidification. In comparison, ocean acidification could be caused by ocean fertilization, as this technology promotes increased uptake of CO_2. Against this background and given the need for negative emission technologies and the potential benefits, the thesis addresses below the legal issues that have been less discussed in relation to ocean alkalinization.

[85] Brent (n 6) page 448.
[86] Cripps and others (n 82) page 191; González and Ilyina (n 43) page 6501.
[87] Brent (n 6) page 448.
[88] González and Ilyina (n 43) page 6493.

CHAPTER III – THE LEGAL FRAMEWORK FOR OCEAN ALKALINIZATION

The purpose of this chapter is to analyse how ocean alkalinization is regulated in international law. From a legal perspective, there are some uncertainties related to ocean alkalinization activities, as there are no regulations specifically developed to address the use of this technology. That does not mean that it is unregulated, as it falls under international law, such as climate law, environmental law and the law of the sea. In order to clarify the rights and obligations of States under international law, it is necessary to address the international legal framework for ocean alkalinization and how different regimes deal with the application of ocean alkalinization. In particular, it is necessary to clarify how ocean alkalinization can be used for scientific research or even large-scale operations. In doing so, the use of ocean alkalization in the context of climate change regime as an emission-reducing technology will be demonstrated and the regulations of the LOSC for the protection of the marine environment will be considered. Based on that the developments with regard to ocean fertilization are presented and how they could apply to ocean alkalinization. The use of large-scale negative emission technologies is presented as a possible contribution to reducing CO_2 levels in the atmosphere.[89] There is a need to use, for example, ocean alkalinization technology, but the protection of the marine environment must not be disregarded. Geo-engineering technologies present governance challenges and it follows there is a need for international regulation to control and limit the risks of damage to the marine environment.

1. International Climate Change Law

Considering the current insufficient reduction of CO_2 emissions, ocean-based negative emission technologies can contribute to the objective of the climate change regime. While by no means providing an exhaustive overview of the UN climate regime, the following briefly discusses how the climate change regime addresses the use of ocean alkalinization.

1.1 United Nation Framework Convention on Climate Change

The UNFCCC is an international environmental agreement with the objective, according to Art. 2 UNFCCC, "to stabiliz[e] greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" and entered into force in 1994.[90] The Parties to the Convention have recognised action is needed to ensure the

[89] See Chapter I, Section 1.2.
[90] UNFCCC.

impacts of climate change are minimised and this will require "deep cuts in global greenhouse gas emissions".[91] The obligations of States under the UNFCCC include that they "shall […] take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks".[92] Sinks are therefore explicitly mentioned in the UNFCCC, although it cannot be ruled out that the oceans are considered to be such sinks, thus could include the use of ocean fertilization.[93] It is emphasized that measures to mitigate the effects of climate change should follow precautionary principle listed in the UNFCCC principles[94], which is discussed in detail below. The UNFCCC is a framework treaty and can be supplemented by further instruments. The Kyoto Protocol[95] was adopted in 1997 and strengthens the UNFCCC by requiring industrialized States to reduce greenhouse gas emissions, whereas the UNFCCC only requires them to adopt measures to reduce emissions and report regularly.[96] It is recognised that the Protocol's targets are insufficient to meet the overall UNFCCC goals and some States argue that action by developed States alone is not enough to combat climate change and all States need to take action.[97]

1.2 Paris Agreement

The Paris Agreement was adopted in 2015, after discussions following the Kyoto Protocol, which represented a new development for the international climate change regime.[98] The Paris Agreement is a legally binding international treaty aimed to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels.[99] To achieve this long-term temperature target, States are expected to take action to reduce emissions rapidly.[100] The Agreement clarifies the obligation and necessity to reduce emissions but does not discuss how CO_2 removal will be achieved. In Williamson's view, to achieve the emission reduction targets, either industry and agriculture must stop producing emissions, or greenhouse gases must be

[91] UNFCCC COP Decision 1/CP.16 (2011), Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010, FCCC/CP/2010/7/Add.1 para 4.
[92] UNFCCC Art. 4 (2) (a).
[93] cf. A Neil Craik and William CG Burns, 'Climate Engineering under the Paris Agreement' Climate Engineering 24, page 7; Johansen (n 39) page 190.
[94] UNFCCC Art. 3 (3).
[95] Kyoto Protocol to the United Nations Framework Convention on Climate Change (adopted 11 December 1997; entered into force 16 February 2005), 2303 UNTS 162 (hereinafter Kyoto Protocol).
[96] 'What Is the Kyoto Protocol? | UNFCCC' <https://unfccc.int/kyoto_protocol> accessed 21 July 2021.
[97] cf. James Harrison (n 14) page 251.
[98] Karin Bäckstrand and others, 'Non-State Actors in Global Climate Governance: From Copenhagen to Paris and Beyond' (2017) 26 Environmental Politics 561, page 569.
[99] Paris Agreement Art. 2 (1) (a).
[100] ibid Art. 4.

removed from the atmosphere in addition to reducing emissions.[101] The IPCC climate response scenarios have demonstrated that large-scale removal of CO_2 must take place to limit the increase in global surface temperature to 2 °C by 2100.[102] Following Harrison, States can fulfil their obligations under the climate regime without focusing on reducing CO_2 "if they can achieve their reductions by other means".[103] Each State is obliged to reduce its emissions, but States have broad discretion over which emissions are reduced to meet its emission reduction targets.[104] As Craik and Burns notes, this could allow States to adopt and include geo-engineering measures in their nationally determined contributions so that they meet their emission reduction targets.[105] All of this suggests that the use of negative emission technologies such as ocean alkalinization to reduce CO_2 emissions is advocated by the climate change regime even if the UNFCCC and its instruments do not explicitly discuss the use of geo-engineering technologies. However, this creates law of the sea problems, because even though the preamble of the Paris Agreement has a clear aim for all States to combat climate change through emission reductions, while ensuring "the integrity of all ecosystems, including oceans"[106], the climate change regime does not sufficiently address the marine environment and ocean acidification.[107] From the perspective of the UN climate change regime, the strong reduction of greenhouse gas emissions is necessary and the use of ocean alkalinization is therefore supported. As already noted by Johansen, "the UN Climate Regime is meant to cover matters related to climate change, which is highly terrestrial and atmospheric in scope, and with very limited application to the oceans".[108] However, the use of the ocean alkalinization technology must also be considered from an environmental perspective under the LOSC, as well as under the dumping and biodiversity regimes.

[101] Williamson (n 34) page 153.
[102] cf. ibid; 'IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.' <http://ar5-syr.ipcc.ch/topic_summary.php> accessed 26 July 2021.
[103] James Harrison (n 14) page 253.
[104] ibid.
[105] Craik and Burns (n 93) page 6; Johansen (n 39) page 190.
[106] Paris Agreement Preamble.
[107] James Harrison (n 14) page 253; Grantly Galland, Ellycia Harrould-Kolieb and Dorothée Herr, 'The Ocean and Climate Change Policy' (2012) 12 Climate Policy 764, page 766; Donald R Rothwell and others, *The Oxford Handbook of the Law of the Sea* (University Press USA - OSO 2015) page 786.
[108] Elise Johansen, 'The Role of the Oceans in Regulating the Earth's Climate: Legal Perspectives' in Elise Johansen, Ingvild Ulrikke Jakobsen and Signe Veierud Busch (eds), *The Law of the Sea and Climate Change: Solutions and Constraints* (Cambridge University Press 2020) page 3.

2. Law of the Sea Convention

The LOSC is a comprehensive regime for regulations on the oceans and has been described as a "constitution for the oceans".[109] The preamble to the LOSC states it "desire to settle, in a spirit of mutual understanding and cooperation, all issues relating to the law of the sea".[110] The Convention is complemented by global and regional instruments and by customary international law or principles.[111] It provides regulations for the use of the oceans and their resources, and for the protection of the marine environment. The Convention was adopted in 1982 before climate change became an issue and therefore no existing regulations explicitly address climate change mitigation, and geo-engineering activities in particular were not part of the negotiations at that time.[112] As pointed out by Harrison, this does not mean that the LOSC has no bearing on the use of marine geo-engineering technologies.[113] In particular, he notes that "the jurisdictional framework established by UNCLOS must be taken into account by States when developing solutions to climate change and ocean acidification in other fora".[114] The view is shared by Scott, who said the "modern law of the sea provides the essential regulatory framework for marine geoengineering and the foundation upon which more detailed rules".[115] It follows that the LOSC has an important role in addressing marine geo-engineering technologies. The role of the law of the sea and the LOSC in the context of ocean iron fertilization has been already discussed, the following will consider this in context of ocean alkalinization. There are no specific regulations in the LOSC applicable to ocean alkalinization, but it contains provisions, discussed below, that are potentially relevant, as such obligations to protect and preserve the marine environment (Part XII) and rights and obligations concerning marine scientific research (Part XIII).

2.1 Marine Scientific Research

Ocean iron fertilization and ocean alkalinization have only been researched and not used as negative emissions technologies on a large scale. Marine scientific research is not defined in

[109] cf. Scott, 'Mind the Gap' (n 39) page 42; Tommy TB Koh, 'A Constitution for the Oceans (Statement by President Koh at the Final Session of the Conference at Montego Bay, 6 and 11 December 1982, Reprinted in United Nations, The Law of the Sea: United Nations Convention on the Law of the Sea 1983)' <https://www.un.org/depts/los/convention_agreements/texts/koh_english.pdf> accessed 17 August 2021.
[110] LOSC preamble.
[111] Scott, 'Mind the Gap' (n 39) page 42.
[112] ibid page 34.
[113] James Harrison (n 14) page 255.
[114] ibid.
[115] Scott, 'Mind the Gap' (n 39) page 42.

the LOSC, according to Rothwell and Stephens it means: "any form of scientific investigation, fundamental or applied, concerned with the marine environment".[116] According to 56 (1) (a) LOSC coastal States have sovereign rights to explore and exploit resources within their exclusive economic zone and the exclusive right to conduct marine scientific research in their waters.[117] In exercising these rights, for example when conducting ocean geo-engineering activities, coastal States must have due regard for the rights and duties of other States and must comply with LOSC obligations regarding marine scientific research and environmental protection.[118] Moreover, pursuant to Art. 87 LOSC all States have the right to exercise the freedoms of the high seas, which includes the freedom of scientific research[119] and according to Art. 88 LOSC "the high seas shall be reserved for peaceful purposes". Ocean alkalinization activities could constitute a freedom of the high seas if they are exercised under the conditions laid down in the LOSC and in other rules of international law[120] and for peaceful purposes.[121] Although there is the freedom of scientific research on the high seas, it is not unlimited as the States have to act with due regard for the interests of other States.[122] Furthermore, marine scientific activity has to be carried out in accordance with Part XII of LOSC.[123]

2.2 General Provisions on the Protection and Preservation of Marine Environment

2.2.1 General Rules

Part XII of the Convention is about the protection and preservation of the marine environment, which is an essential objective of the Convention and is recognised in the preamble.[124] The first article in this part says "States have the obligation to protect and preserve the marine environment".[125] It is generally accepted that Art. 192 LOSC is customary international law, which means that non-Parties to the LOSC are thereby obliged to comply with the relevant provisions, therefore all States must protect and preserve the marine environment.[126] According to Art. 193 LOSC States have the sovereign right to exploit their natural resources whereas they

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[116] Donald Rothwell and Tim Stephens, *The International Law of the Sea* (Second edition, Hart Publishing 2016) page 347.
[117] LOSC Art. 56 (1) (b) (ii), 245, 256.
[118] ibid Art. 56 (2), 192, 193 and 194.
[119] ibid Art. 87 (1) (f).
[120] ibid Art. 87 (1).
[121] ibid Art. 88; Scott, 'Mind the Gap' (n 39) page 43.
[122] LOSC Art. 87 (2).
[123] ibid Art. 240 (d).
[124] cf. ibid Preamble.
[125] ibid Art. 192.
[126] P Verlaan, 'Geo-Engineering, the Law of the Sea, and Climate Change' (2009) 3 Carbon & Climate Law Review 13, page 449.

have to protect and preserve the marine environment. According to Scott, this right arguably includes the ocean's ability to sequester carbon dioxide.[127] Moreover, Art. 194 (1) LOSC requires States to “take all measures necessary to prevent, reduce and control pollution of the marine environment from any source”. According to the 2019 GESAMP Report on High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques (GESAMP Report), pollution from greenhouse gases and marine geo-engineering activities are included in this obligation.[128] Art. 196 (1) LOSC deals more specifically with the obligations of States in the case of "pollution of the marine environment resulting from the use of technologies", which is more relevant for ocean alkalinization. Under this article, if an activity falls under the definition of pollution, “States shall take all measures necessary to prevent, reduce and control pollution”[129], which, according to Johansen means that the activity “cannot be executed at all, or must be carried out in a way that lowers the negative effects to the tolerated level”.[130]
Pollution of the marine environment is defined in Art. 1 (1) (4) LOSC as:

> the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.

This definition has four important components that need to be examined for the geo-engineering measure in question. It must be an (1) introduction of a (2) substance into the (3) marine environment and result in a (4) deleterious effect. Accordingly, a substance must be introduced into the marine environment, which can be any type of substance, regardless of whether it is harmful in itself, because it is the potential deleterious effect which makes an activity to pollution.[131] The deleterious effect that must occur is not further defined, only a few examples are mentioned in the definition.[132] The question of whether ocean iron fertilization qualifies as pollution according to Art. 1 (1) (4) LOSC has already been discussed. The addition of iron sulphate or other nutrients to the ocean could arguably fall under the definition because a

[127] Scott, ‘Mind the Gap’ (n 39) page 43.
[128] Boyd and Vivian (n 18) page 90.
[129] LOSC Art. 196 (1).
[130] Johansen (n 39) page 192.
[131] Verlaan (n 126) page 449; Randall Abate and Andrew Greenlee, ‘Sowing Seeds Uncertain: Ocean Iron Fertilization, Climate Change, and the International Environmental Law Framework’ (2010) 27 Pace Environmental Law Review 555, page 573.
[132] cf. LOSC Art. 1 (1)(4).

substance is introduced into the marine environment.[133] However, a problem of introduction arises, for example, with pipes used in the water column to bring nutrients from the deeper ocean to the surface, which is according to Scott not an "introduction" and therefore not pollution.[134] In addition, classifying ocean iron fertilization as a deleterious effect could be problematic, as mentioned by Abate and Greenlee, because it can be argued that the effects of fertilization are no different from those of the natural biological ocean pump.[135] However, as has now been researched, negative effects arise due to ocean iron fertilization, it is not yet certain how severe they are. Assuming the effect of fertilization could resemble a natural process is not a justification to introduce tons of iron into the oceans and not see it as pollution, since this is nothing natural for the ocean. In most cases, it can arguably be argued that ocean iron fertilization technology is covered by the definition of pollution, but it cannot be clearly said that all ocean fertilization activities always constitute pollution. Thus, it has to be decided on a case-by-case basis whether a particular activity should be considered as pollution under Art. 1 (1) (4) LOSC.

2.2.2 Ocean Alkalinization

It is now questionable whether ocean alkalinization is an activity that falls under the definition of pollution according to Art. 1 (1) (4) LOSC. Ocean alkalinization is the process where minerals are added to the oceans, which is similar to ocean iron fertilization and poses similar problems in subsuming whether it is pollution. Initially, it could be assumed this is pollution because a substance is introduced into the marine environment. Questionable is whether it will lead to a deleterious effect, especially because ocean alkalinization could increase the pH value of the oceans and lead to the reduction of ocean acidification.[136] No unified decision can be made for ocean alkalinization activities because it is not clear what the consequences of these activities are for the marine environment. It must also be decided on a case-by-case basis in the context of the ocean alkalinization activity whether it is pollution under Art. 1 (1) (4) LOSC. If the activity is ultimately a case of pollution under Art. 1 (1) (4) LOSC, then, as with ocean iron fertilization activities, States have to take measures to prevent, reduce and control the pollution of the marine environment.[137]

[133] cf. Karen N. Scott, 'Geoengineering and the Marine Environment', *Research Handbook on International Marine Environmental Law, R. Rayfuse* (Edward Elgar Publishing Limited 2015) page 465.
[134] ibid.
[135] Abate and Greenlee (n 131) page 573-574.
[136] See Chapter II, Section 1.2.
[137] LOSC Art. 196 (1).

2.3 Does Ocean Alkalinization qualify as Dumping?

Furthermore, it is to be examined whether ocean alkalinization can be defined as pollution by dumping. Dumping is a specific type of marine pollution and therefore an activity not under the definition of pollution in Art. 1 (1) (4) LOSC cannot be regulated under the dumping provision of the LOSC. In order to determine whether ocean alkalinization is pollution by dumping, the general rules are first presented in the context of ocean fertilization and then compared with ocean alkalinization.

2.3.1 General Rules

Dumping is regulated in Art. 210 LOSC and states that "States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment by dumping".[138] According to Art. 210 (6) LOSC, these laws and regulations shall be "no less effective in preventing, reducing and controlling such pollution than the global rules and standards". This formulation is known as rules of reference, and it is debatable whether it refers only to the London Convention or to the London Convention and London Protocol, which will be discussed further below. The provision shall ensure that dumping is not carried out without the permission of the States.[139] Dumping is defined in Art. 1 (1) (5) (a) LOSC as "any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea". For ocean iron fertilization, it was argued that even if the addition of iron to the marine environment does not constitute "wastes", then it can be considered as "other matter".[140] Art. 1 (1) (5) (b) (ii) LOSC contains an exception according to which dumping does not include the "placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention". Ocean iron fertilization does not have the objective of disposing of substances, but rather to counteract climate change by increasing CO_2 uptake and storage.[141] In particular, the purpose is to research plankton growth by adding iron to achieve increased uptake of CO_2.[142] Thus, the purpose is different from the mere disposal of iron, and it can be argued that these activities are covered by the exception. However, the exception only applies to those activities that are not contrary to the aim of the LOSC.[143] The aim of the LOSC includes the protection of the marine environment, so that any activity that causes damage to

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[138] ibid Art. 210 (1).
[139] ibid Art 210 (3) LOSC.
[140] Kerstin Güssow and others (n 39) page 914.
[141] See Chapter II, Section 1.1.
[142] See Chapter II, Section 1.1.
[143] cf. LOSC Art. 1 (1) (5) (b) (ii).

the marine environment is contrary to the objectives of the Convention.[144] Scientific experiments on ocean iron fertilization only were carried out and there is still insufficient research to assess the extent of the environmental damage. It is thus a fortiori not possible to foresee environmental damage from a large-scale implementation. Negative consequences for the marine environment cannot be ruled out. It is not inconceivable that both marine scientific experiments and large-scale activities could be contrary to the objectives of the LOSC. It is questionable what the consequence would be if an ocean iron fertilization activity is defined as pollution by dumping. In this regard, Scott says: "Even if ocean fertilisation using iron or other nutrients were classified as 'dumping' for the purposes of Article 210 of UNCLOS, it is not conclusive that the activity is automatically prohibited under the regime", rather, the substantive regulations of the London dumping regime must be considered.[145] According to Johansen, any activity carried out in the oceans must "meet the obligations of precaution and due diligence".[146] Assuming that ocean iron fertilization could be defined as dumping, the legal assessment of whether the activity can be carried out must be based on the general obligations to protect and preserve the marine environment.[147] Art. 192 LOSC contains the general obligation to protect and conserve the marine environment, which have been more detailed in the South China Sea Arbitration (The Republic of Philippines v. The People's Republic of China).[148] Among other things, it states that Art. 192 LOSC "entails the positive obligation to take active measures to protect and preserve the marine environment" and "entails the negative obligation not to degrade the marine environment".[149] The general obligation arising from this provision is supplemented by the obligation to act with due diligence.[150] The due diligence obligation is an obligation of conduct not of result.[151] The International Tribunal for the Law of the Sea (ITLOS) in the Advisory Opinion to the Responsibilities and Obligations of State Sponsoring Persons and Entities states the due diligence obligation is "not an obligation to achieve [compliance] in each and every case" but "to deploy adequate means, to exercise best possible

[144] cf. ibid Preamble.
[145] Scott, 'Mind the Gap' (n 39) page 46-47.
[146] Johansen (n 39) page 193.
[147] LOSC Art. 192.
[148] *South China Sea Arbitration (The Republic of Philippines v The People's Republic of China) (Award) [2016] PCA Case No 2013-19.*
[149] ibid 941.
[150] Johansen (n 39) page 193; cf. *South China Sea Arbitration (The Republic of Philippines v. The People's Republic of China) (Award) [2016] PCA Case No. 2013-19* (n 148) para 944; *Pulp Mills on the River Uruguay (Argentina v Uruguay) (Judgement) [2010] ICJ Rep 14* [197].
[151] *Responsibilities and Obligations of State Sponsoring Persons and Entities with Respect to Activities in the Area (Advisory Opinion), 1 February 2011, ITLOS Rep 10* [110].

efforts, to do the utmost" to achieve compliance.[152] Furthermore, ITLOS clarifies which factors fall under the due diligence obligation and stated "the precautionary approach is also an integral part of the general obligation of due diligence".[153] The precautionary principle is not explicitly mentioned in the LOSC, but its relevance to the regulation of marine activities has led to its application being further developed through international jurisprudence and now forms part of the LOSC obligation.[154] Art. 192 LOSC is relevant to all maritime zones, therefore it does not matter where the geo-engineering activities are carried out.[155] It follows that if an activity is contrary to the aims of the LOSC and is therefore defined as pollution by dumping, which must be decided on a case-by-case basis, this activity must be considered under the general obligation to protect and prevent the marine environment to determine whether the activity is prohibited, preserving the due diligence obligation and, in particular, applying the precautionary principle.

2.3.2 Ocean Alkalinization

It is questionable whether ocean alkalinization can be defined as pollution by dumping within the meaning of Art. 1 (1) (5) (a) LOSC and whether States must therefore take action to prevent, reduce and control pollution of the marine environment by dumping under Art. 210 LOSC. Firstly, it should be noted that ocean alkalinization, like ocean iron fertilization, is covered by the dumping definition under Art. 1 (1) (5) (a) LOSC, since it is arguable an "other matter" which is deliberately disposed of. However, it is possible that ocean alkalinization falls within the exception of Art. 1 (1) (5) (b) (ii) LOSC. For this, it would have to be introduced for a purpose other than mere disposal thereof and must not be contrary to the aim of the LOSC. The purpose of this technology is to improve the pH value of the ocean to prevent ocean acidification and not primarily to improve CO_2 uptake, which is only a side effect.[156] Therefore, ocean alkalinization has another purpose than the mere disposal of the added minerals. In addition, the activity must not be inconsistent with the objective of the Convention, i.e., it must not result in harm to the marine environment.[157] In the case of ocean alkalinization, it is questionable whether the addition of minerals can have a positive effect on the marine environment by mitigating ocean acidification that results from increased carbon uptake. However, despite the potential positive effects to be considered that ocean alkalinization could have, there are still

[152] ibid.
[153] *ibid 131*.
[154] Johansen (n 39) page 194.
[155] *South China Sea Arbitration (The Republic of Philippines v. The People's Republic of China) (Award) [2016] PCA Case No. 2013-19* (n 148) para 940.
[156] See Chapter II, Section 1.2.
[157] See Chapter III, Section 2.3.1.

uncertainties regarding the effects on the marine environment which could potentially be harmful. It cannot be ruled out that ocean alkalinization activities could be contrary to the aim of the LOSC and not covered by the exception under Art. 1 (1) (5) (b) (ii) LOSC. It could be defined as pollution by dumping, but as discussed, the activity is not automatically prohibited, rather the general obligations to protect and prevent the marine environment with the due diligence obligation must be used for the legal assessment and the general rules of the London Convention and London Protocol have to be considered.[158] The fundamental concept of ocean alkalinization is different from ocean fertilization because this technology could mitigate another form of marine pollution. This assessment could result in a different outcome than the assessment for ocean fertilization activities. When assessing from a law of the sea perspective, it is important to consider that ocean alkalinization could mitigate oceans acidification. Acidification results from increased uptake of CO_2 from the atmosphere[159] and constitutes pollution of the marine environment.[160] The marine pollution from ocean alkalinization activities and the marine pollution from ocean acidification are in opposition. Ocean alkalinization technology results potential in pollution for the marine environment, but in turn could potentially mitigate another type of marine pollution. This leads back to the conflict of objectives described at the beginning, which is discussed in detail below. It should be noted, however, that the situation is different from ocean fertilization, as ocean fertilization does not result in the prevention of another type of pollution. It follows that if ocean alkalinization activities are to be considered pollution by dumping, the general obligation to protect and preserve the marine environment must be considered, which includes the due diligence obligation and the application of the precautionary principle, taking into account the possibility of minimizing ocean acidification in this technology.

3. Biodiversity Regime

The general regulations that are relevant for ocean alkalinization were discussed, therefore, attention is now drawn to the (non-binding) regulatory efforts under the biodiversity regime and in the following to those of the dumping regime. The CBD was adopted 1992 at the UN Conference on Environment and Development in Rio de Janeiro and is a framework Convention and relevant treaty regime for this topic.[161] It has three main objectives, which according to Art.

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[158] See Chapter III, Section 2.3.1.
[159] See Chapter I, Section 1.1.
[160] James Harrison (n 14) page 255.
[161] CBD.

1 CBD are “the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources”. It is precisely climate change and the interrelated problem of ocean acidification that led to biodiversity loss, which the CBD aims to prevent. Another challenge for biodiversity is the use of geo-engineering techniques and the potentially damaging consequences. The Conference of the Parties (COP) to the CBD adopted the Decision IX/16 on Biodiversity and Climate Change in 2008[162] which states that, in accordance with the precautionary principle, it should be ensured “that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities […] with the exception of small scale scientific research studies within coastal waters”.[163] This decision applies to ocean fertilization activities and makes it almost impossible to conduct it, as small-scale scientific studies in coastal waters are not suitable for such experiments, and therefore the decision could be seen as a de-facto-moratorium[164] on these activities, which include scientific experiments.[165] The Decision IX/16 is not legally binding, which means that implementation is not mandatory. The COP adopted subsequently the Decision X/33[166] in 2010, where they considered geo-engineering more generally and Decision XI/20[167] in 2012. The COP appeals for respecting biodiversity on the one hand, and on the other hand contributing to climate change mitigation.[168] The Parties clarified their statements and said that “no climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities” and reiterated the application of the precautionary principle.[169] In addition, they concluded that "there is no single geoengineering approach that currently meets the basic criteria for effectiveness, safety, and affordability, and that approaches may prove difficult to deploy or govern".[170] All this further underlines the

[162] COP to the CBD at its Ninth Meeting, 19–30 May 2008, Decision IX/16: Biodiversity and Climate Change, UNEP/CBD/COP/DEC/IX/16, 9 October 2008.
[163] ibid page 7.
[164] Boyd and Vivian (n 18) page 93; Harald Ginzky and Robyn Frost, ‘Marine Geo-Engineering: Legally Binding Regulation under the London Protocol’ (2014) 8 Carbon & Climate Law Review 82, page 93.
[165] cf. Kerstin Güssow and others (n 39) page 915.
[166] COP to the CBD at its Tenth Meeting, 18-29 October 2010, Decision X/33: Biodiversity and Climate Change, UNEP/CBD/COP/DEC/X/33, 29. October 2010.
[167] COP to the CBD at its Eleventh Meeting, 08-19 October 2012, Decision XI/20: Climate-Related Geoengineering, UNEP/CBD/COP/DEC/XI/20, 5. December 2012.
[168] COP to the CBD at its Tenth Meeting, 18-29 October 2010, Decision X/33: Biodiversity and Climate Change, UNEP/CBD/COP/DEC/X/33, 29. October 2010 (n 166) para 8.
[169] ibid 8 (w).
[170] COP to the CBD at its Eleventh Meeting, 08-19 October 2012, Decision XI/20: Climate-Related Geoengineering, UNEP/CBD/COP/DEC/XI/20, 5. December 2012 (n 167) para 6.

recommendation to apply the precautionary approach before geo-engineering measures are taken to mitigate climate change.

4. London Dumping Regime

The LOSC provides a basic legal framework for all States to protect the marine environment, but does not contain a detailed dumping regime, mostly regulating dumping in Art. 210 LOSC. When the LOSC was adopted, there was already a global treaty for dumping of wastes, namely the London Convention.[171] This section introduces the London Convention and London Protocol and discusses whether they represent the global rules and standards under Article 210 (6) LOSC. It then examines the regulations under the dumping regime and based on this the developments regarding ocean fertilization will be discussed. Based on that, it is considered how ocean alkalinization can be regulated under the dumping regime.

4.1 London Convention and London Protocol

The London Convention was adopted because of an increase in unregulated dumping in the oceans in the 1960s-1970s, which was limited by the development of waste management and the promotion of pollution prevention.[172] The adoption of the London Convention created an important step towards regulating the dumping of waste into the oceans and protecting the marine environment from human activities. According to Art. I LC the objective is to “promote the effective control of all sources of pollution of the marine environment” and “to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter”. The Parties to the London Convention have agreed to control dumping with regulatory programs and have undertaken to issue permits for dumping at sea and generally prohibit the dumping of certain hazardous substances.[173] The London Convention includes a "black list" containing substances prohibited to be dumped and a "grey list" of substances that may be considered for dumping under strict conditions.[174] In 1996, the London Protocol was adopted, which is a separate legal treaty that is a revision of the London Convention and intended to eventually replace the London Convention.[175] Until it replaces the Convention, the two instruments run in parallel and, according to Art. 23 LP, the Protocol is the operative instrument when a State is

[171] London Convention.
[172] Andrew Birchenough and Fredrik Haag, ‘The London Convention and London Protocol and Their Expanding Mandate’ (2020) 34 Ocean Yearbook Online 255, page 262.
[173] ibid page 256.
[174] ibid.
[175] ibid.

party to both instruments.[176] Birchenough and Haag noted that "the treaties have the objective to promote the effective control of all sources of marine pollution and therefore they have addressed, and continue to address, newly emerging issues threatening the marine environment".[177] Furthermore, they note that the new challenges to the oceans are then governed by the London Protocol, as “the Parties to the Convention agreed not to amend that treaty further”.[178] Amendments should be addressed under the London Protocol, as this is ultimately the treaty that will replace the London Convention in the future.[179] Unlike the London Convention, which only prohibited the dumping of certain substances, the London Protocol prohibits all dumping of wastes and other substances, with some exceptions listed in the so-called "reverse list" in Annex 1.[180] The aim is to provide a more stringent protection of the marine environment from pollution caused by dumping at sea.[181] The London Protocol strengthens the dumping regime by the general obligation in Art. 3 (1) LP to apply a "precautionary principle".

4.2 Global Rules and Standards

Before going into more detail on the regulations and developments of the dumping regime with regard to ocean fertilization, the question of which treaty is subject to “the global rules and standards” from Art. 210 LOSC must first be clarified. The London Convention existed already before the LOSC was adopted. Within the dumping regime in the LOSC, Art. 210 (6) LOSC contains the so-called rules of reference.[182] The rule of reference in Art. 210 LOSC has the effect of incorporating the provisions of the London Convention into the general framework of the law of the sea.[183] These rules apply to all States, regardless of whether they are a party to the London Convention.[184] This means that not only the 87 Parties[185] to the London Convention (or 53 Parties[186] to the London Protocol) are bound by the regulations, but also the 168 Parties[187]

[176] London Protocol Art. 23 LP.
[177] Birchenough and Haag (n 172) page 266.
[178] ibid.
[179] Boyd and Vivian (n 18) page 91.
[180] London Protocol Art. 4 (1).
[181] Birchenough and Haag (n 172) page 256.
[182] See Chapter III, Section 2.3.1.
[183] Birchenough and Haag (n 172) page 258.
[184] ibid.
[185] ‘Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter’ <https://www.imo.org/en/OurWork/Environment/Pages/London-Convention-Protocol.aspx> accessed 17 July 2021.
[186] ibid.
[187] ‘United Nations Treaty Collection (Law of the Sea Convention)’ <https://treaties.un.org/Pages/ViewDetailsIII.aspx?src=TREATY&mtdsg_no=XXI-6&chapter=21&Temp=mtdsg3&clang=_en> accessed 10 August 2021.

of the LOSC. Questionable is whether the London Convention and London Protocol, or only the London Convention, constitute the global rules and standards referred to in Art. 210 LOSC. This distinction is essential because the London Protocol is not only the more stringent treaty on dumping and requires the application of the precautionary principle[188], but also because the Resolution LP.4(8)[189], which included amendments related to the regulation of geo-engineering activities to the London Protocol, discussed below, was adopted by the London Protocol.[190] According to the opinion of Scott, Art. 210 (1) LOSC is referring to the London Convention and not to the London Protocol[191], while Güssow et al. opines that the reference is generally understood as a reference to both the London Convention and London Protocol.[192] This view is shared by Johansen, who argues the London Convention as well as the London Protocol form the global rules and standards referred to in Art. 210 LOSC.[193] The London Protocol with 53 Contracting Parties has a smaller accessibility compared to the London Convention with 87 Contracting Parties. This could be an argument for using only the London Convention as the rules of reference. Birchenough and Haag affirm that in principle the London Convention falls under the rules of reference in Art. 210 LOSC, but due to the new development it has been suggested that the London Protocol should form the global rules and standards incorporated by Art. 210 LOSC because it includes the precautionary principle and continues to develop amendments to address new ocean challenges.[194] There are strong arguments for considering the London Protocol as global rules and standards, ultimately it is a matter of interpretation whether Art. 210 (6) LOSC refers to the London Convention and London Protocol, or only to the London Convention. The London Protocol is a stricter regulation intended to replace the London Convention and it is even agreed that emerging issues would be addressed directly in the London Protocol. In the author´s opinion it seems right that both the London Convention and the London Protocol regarding marine geo-engineering are covered by the global rules and standards referred to in Art. 210 (6) LOSC. One current emergent issue for the dumping regime is geo-engineering. With developments in new technologies to mitigate climate change and the associated potential damage to the marine environment, the Parties have addressed geo-engineering activities, in particular ocean fertilization.

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188 Scott, 'Mind the Gap' (n 39) page 46; cf. Birchenough and Haag (n 172) page 258.
189 Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force).
190 ibid.
191 Scott, 'Mind the Gap' (n 39) page 46.
192 cf. Kerstin Güssow and others (n 39) page 914.
193 Johansen (n 39) page 194.
194 Birchenough and Haag (n 172) page 258.

4.3 Ocean Fertilization under the Dumping Regime

The purpose of the following sections is to clarify how the London dumping regime regulates geo-engineering technologies. In this section the general regulations will be discussed and the developments in relation to ocean fertilization will be addressed. The London dumping regime will be discussed in relation to ocean fertilization to use the outcomes comparatively to discuss how ocean alkalinization is regulated under the dumping regime. Dumping is defined in Art. III (1) (a) (i) LC and Art. 1 (4) (1) (1) LP as "any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea", which is the same definition as in Art. 1 (5) (a) LOSC. There is also an exception in Art III (1) (b) (ii) LC and Art. 1 (4) (2) (2) LP, which is identical to the exception in Art. 1 (1) (5b) (ii) LOSC. This raises the same issue as the previous review, i.e., that ocean fertilization can be defined as dumping but could fall under the exception if the activity is not contrary to the aim of the treaties.[195] The purpose of these treaties is to prevent the pollution of the oceans by the dumping of wastes and other substances. According to Güssow et al., an activity is contrary to the objectives of the treaties if "the substances introduced have a potentially damaging effect on human health, living resources, and/or marine life".[196] It remains uncertain what impact ocean fertilization activities will have on the marine environment and it cannot be ruled out that some experiments will have harmful consequences and thus violate the objectives of the London Convention and the London Protocol. In the context of the London dumping regime, it is understood that if an activity can be considered as dumping, this does not directly mean that the activity is prohibited, rather the general rules of the London Convention and London Protocol have to be considered in order to find out whether an activity can become dumped by a special permit.[197] Due to the lack of clarity regarding geo-engineering activities, international bodies have addressed the relevant issues and developed new rules for geo-engineering. In a first step the Parties of the London Convention and Protocol developed non-binding resolutions specific to ocean fertilization activities and then Parties to the London Protocol adopt legally binding amendments for marine geoengineering activities.

[195] See Chapter III, Section 2.3.1.
[196] Kerstin Güssow and others (n 39) page 915.
[197] Scott, 'Mind the Gap' (n 39) page 47.

4.4 Further Developments

4.4.1 Resolution LC-LP.1 on the Regulation of Ocean Fertilization

The meeting of the Parties to the London Convention and the London Protocol adopted the Resolution LC-LP.1 on the Regulation of Ocean Fertilization[198] in 2008 due to the growing interest from the scientific community and private operators in ocean fertilization activities and because of concerns about commercial ocean fertilization activities.[199] It was uncertain whether ocean fertilization fell within the scope of the London Convention and Protocol. In response, even before the adoption of the resolution, the Parties agreed "that the scope of work of the London Convention and Protocol included ocean fertilization"[200] and reaffirmed this in the 2008 Resolution LC-LP.1.[201] Thereby the Parties resolved that "in order to provide for legitimate scientific research, such research should be regarded as placement of matter for a purpose other than the mere disposal thereof under Article III.1(b)(ii) of the London Convention and Article 1.4.2.2 of the London Protocol".[202] In addition, they have provided a definition of ocean fertilization after which it is "any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans".[203] It follows that activities which are not legitimate scientific research are considered incompatible with the objectives of both instruments and do not qualify for the exception to the definition of dumping according to Art. III (1) (b) (ii) LC and Article 1 (4) (2) (2) LP, and should not be allowed.[204] The reasoning is "that knowledge on the effectiveness and potential environmental impacts of ocean fertilization is currently insufficient to justify activities other than legitimate scientific research".[205] The Parties have clarified with this resolution that legitimate scientific research on ocean fertilization is not contrary to the aim of the treaties. In contrast, large-scale use is not covered by the exemption and is contrary to the objective of the treaties and can be defined as dumping and thus requires prior authorization under the London Convention and is prohibited under the London Protocol.[206]

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[198] Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization (adopted on 31 October 2008), IMO Doc LC 30/16.
[199] cf. Birchenough and Haag (n 172) page 269.
[200] 'Report of the 29th Meeting of LC and 2nd Meeting of LP (IMO LC/29/17)' page 4 <https://www.imo.org/en/OurWork/Environment/Pages/2007.aspx> accessed 28 July 2021.
[201] Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization (adopted on 31 October 2008), IMO Doc LC 30/16 (n 198) para 1.
[202] ibid 3.
[203] ibid 2.
[204] ibid 8.
[205] ibid page 1.
[206] cf. Scott, 'Mind the Gap' (n 39) page 47.

4.4.2 Resolution LC-LP.2 on the Assessment Framework for Scientific Research

Following the increasing focus on geo-engineering and, in particular, ocean fertilization experiments, the Parties to the London Convention and London Protocol adopted in 2010 the Resolution LC-LP.2 on the Assessment Framework for Scientific Research Involving Ocean Fertilization[207], a comprehensive risk assessment framework for scientific research related to ocean fertilization. This framework is drafted to evaluate proposed activities which fall within the scope of Resolution LC-LP.1.[208] The Contracting Parties decided in Resolution LC-LP.2 "scientific research proposals should be assessed on a case-by-case basis using the Assessment Framework"[209] and "Parties should use the Assessment Framework to determine […] whether a proposed ocean fertilization activity constitutes legitimate scientific research that is not contrary to the aim of the London Protocol or the London Convention".[210] The framework includes detailed guidance on the assessment of whether an ocean fertilization proposal constitutes legitimate scientific research and sets out how an Environmental Impact Assessment (EIA) is to be carried out.[211] States are required to implement risk management, which is a process "designed to minimize and manage risk and to conduct appropriate monitoring", based on the precautionary principle.[212] Accordingly, legitimate scientific research which complies with the assessment framework would not constitute dumping, which must be decided on a case-by-case basis.[213]

4.4.3 Resolution LP.4(8) on the Amendment to the London Protocol

In 2013, Resolution LP.4(8) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities was adopted.[214] This resolution is intended to further regulate ocean fertilization activities and to regulate other marine geo-engineering activities within the scope of the Protocol.[215] Once in

207 Resolution LC.LP.2 (2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (adopted on 14 October 2010), IMO Doc LC 32/15.
208 Boyd and Vivian (n 18) page 82.
209 Resolution LC.LP.2 (2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (adopted on 14 October 2010), IMO Doc LC 32/15 (n 207) para 2.
210 ibid 3.
211 Birchenough and Haag (n 172) page 269-270.
212 Annex 6 - Assessment Framework for Scientific Research Involvong Ocean Fertilization (Adopted on 14 October 2010) IMO LC 32/15 page 3.
213 Resolution LC.LP.2 (2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (adopted on 14 October 2010), IMO Doc LC 32/15 (n 207) para 2.
214 Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189).
215 Birchenough and Haag (n 172) page 270.

force, the amendment provides a legally binding mechanism to regulate ocean fertilization. Furthermore, it offers the possibility to include other marine geo-engineering activities which may have negative impacts on the marine environment, to be discussed further below in terms of ocean alkalinization. The resolution includes amendments to the London Protocol, including the addition of a new Article 6bis LP, which states:

> Contracting Parties shall not allow the placement of matter into the sea from vessels, aircraft, platforms or other man-made structures at sea for marine geoengineering activities listed in annex 4, unless the listing provides that the activity or the subcategory of an activity may be authorized under a permit.[216]

In addition, a new Annex 4 is intended to list marine geo-engineering activities which will then be regulated under Art. 6bis LP. Currently only ocean fertilization is listed, but the provision allows Parties to regulate other marine geo-engineering activities under the London Protocol when they are listed.[217] According to Annex 4: "An ocean fertilization activity may only be considered for a permit if it is assessed as constituting legitimate scientific research".[218] The general provision of Art. 4 LP states dumping is prohibited with the exceptions listed in Annex 1 is replaced by the more specific provision for geo-engineering activities in Art. 6bis LP.[219] Furthermore, the resolution contains a definition for marine geo-engineering in Art. 5bis LP, according to which marine geo-engineering means "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 potential to result in deleterious effects, especially where those effects may be widespread, long lasting or severe."[220] The Parties to the London Protocol have deliberately defined marine geoengineering broadly, therefore activities such as fisheries enhancement can potentially be controlled.[221] Ocean iron fertilization, with the principal intention to increase the production of Phyto-Plankton, qualifies pursuant to this definition as a marine geo-engineering technology.[222] It follows that under this resolution, only

[216] Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189) Art. 6bis LP.
[217] Annex 5 - Guidance for consideration of Marine Geoengineering Activities, IMO LC 36/16 (hereinafter Annex 5) para 9.
[218] Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189) page 4.
[219] ibid Art. 6bis (3) LP.
[220] ibid Art. 1 (5bis) LP.
[221] Boyd and Vivian (n 18) page 21.
[222] Birchenough and Haag (n 172) page 268.

ocean fertilization that is assessed as legitimate scientific research is allowed and all other activities are prohibited. The resolution also affirms that "ocean fertilization and other types of marine geoengineering should not be considered as a substitute for mitigation measures to reduce carbon dioxide emissions"[223], making it clear that it is only an additional aspect of combating climate change and does not replace greenhouse gas reductions.

4.4.4 Enforceability

Both the Resolution LC-LP.1 on the Regulation of Ocean Fertilization and the Resolution LC-LP.2 on the Assessment Framework for Scientific Research involving Ocean Fertilization are not legally binding. Resolution LC-LP.1 is about clarifying whether ocean fertilization should be classified as dumping in the sense of the London Convention and the London Protocol and Resolution LC-LP.2 helps assess whether an ocean fertilization proposal constitutes legitimate scientific research. Therefore, they can be used at least for interpretation in the assessment of ocean fertilization activities.[224] Legally binding amendments to the London Protocol were adopted with the Resolution LP.4(8) but has not yet entered into force. If an amendment results in the adoption of a new article of the Protocol, it requires positive ratification. The amendments will enter into force 60 days after two- thirds of the Contracting Parties have deposited an instrument of acceptance with the International Maritime Organization (IMO).[225] The London Protocol has 53 Contracting Parties at the time of writing and only six of them have accepted the amendments so far.[226] It is already eight years since the amendments were adopted and may be some time before it finally enters into force. In the meantime, as Resolution LP.4(8) states, "resolutions LC-LP.1(2008) and LC-LP.2(2010) continue to apply for all Contracting Parties, pending the entry into force of the amendments to the London Protocols".[227] It follows that before the amendments become applicable law, the non-binding resolutions and the amendments can be used as an advisory aid to interpret geo-engineering activities.[228]

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[223] Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189) page 2.
[224] Kerstin Güssow and others (n 39) page 914.
[225] London Protocol Art. 21 (3) LP.
[226] International Maritime Organization, 'Status of IMO Treaties' (2021) page 566 <https://wwwcdn.imo.org/localresources/en/About/Conventions/StatusOfConventions/Status%20-%202021.pdf> accessed 16 August 2021.
[227] Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189) para 2; cf. James Harrison (n 14) page 272.
[228] cf. Scott, 'Mind the Gap' (n 39) page 46.

4.5 Ocean Alkalinization under the Dumping Regime

Having discussed the regulatory in relation to ocean fertilization, it is now time to consider how ocean alkalinization is regulated under the London dumping regime and, in particular, (a) whether the resolutions are applicable to ocean alkalinization activities and (b) whether ocean alkalinization can potentially be listed under Annex 4, whereby the consideration refers to how ocean alkalinization could be regulated in the future.

4.5.1 Applicability of the Resolutions to Ocean Alkalinization

4.5.1.1 Is Ocean Alkalinization to be defined as Ocean Fertilization?

The adopted resolutions have been developed specifically for ocean fertilization and raises the question what regulations apply to ocean alkalinization. First, it must be examined whether ocean alkalinization is to be subsumed under the definition of ocean fertilization provided by the Resolution LC-LP.1.[229] If ocean alkalinization is covered by the definition, then the resolutions developed for ocean fertilization could be directly applicable to it and there would be no need to develop separate regulations for ocean alkalinization and list it in Annex 4. According to the definition, ocean alkalinization would be ocean fertilization if the principal intention is to stimulate primary productivity in the oceans. There are, as already been noted above, similarities between ocean iron fertilization and ocean alkalinization, in particular similar problems which led to the same conclusion, for example, in the pollution regime, namely that it must be decided on a case-by-case basis whether the activities can be defined as pollution.[230] The commonality of the two technologies is ocean alkalinization, like ocean iron fertilization, involves adding a substance to the ocean. The main purpose of iron fertilization is enhancing the growth of Phyto-Plankton, to increase CO_2 uptake from the atmosphere. The introduction of alkalising minerals at the ocean alkalinization technology causes the neutralisation of acid in the ocean.[231] In addition, this introduction could lead to a reduction in the CO_2 partial pressure of the surface water and thus increase CO_2 uptake by the ocean.[232] The principal intention is not to stimulate primary productivity in the oceans, but rather to increase the alkalinity of the water surface in order to increase the pH value of the oceans and counteract ocean acidification. Since ocean alkalinization has the positive effect of increasing the uptake

[229] Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization (adopted on 31 October 2008), IMO Doc LC 30/16 (n 198) para 2.
[230] See Chapter III, Section 2.2.1 and Section 2.2.2.
[231] See Chapter II, Section 1.2.
[232] Boyd and Vivian (n 18) page 64.

and storage of CO_2 and not the stimulation of primary productivity as its main intention, it cannot be assumed that this technology is to be subsumed as ocean fertilization. It follows that the resolutions developed for ocean fertilization are not directly applicable to ocean alkalinization, as this technology cannot be subsumed under the definition of ocean fertilization provided by the Resolution LC-LP.1.

4.5.1.2 Analogous Application of the Resolutions

This raises the question of whether the resolutions developed for ocean fertilization are analogously applicable to ocean alkalinization. According to the view of Harrison the resolutions apply to geo-engineering activities that are not listed in Annex 4.[233] Ocean alkalinization is a marine geo-engineering technology under Art. 5bis LP, as alkalinization is a deliberate intervention in the marine environment to manipulate natural processes in order to counteract the effects of climate change (ocean acidification). Since only ocean fertilization is listed in Annex 4, this would mean that the resolutions apply to ocean alkalinization, as a marine geoengineering technology not listed in Annex 4. The GESAMP Report takes a different view, arguing that other types of marine geo-engineering activities which do not involve ocean fertilization are not affected by the resolutions.[234] Scott agrees, saying that the resolutions "do not apply to other geoengineering technologies that do not constitute ocean fertilisation but nevertheless involve introducing matter into the ocean".[235] It follows that if this technology does not fall under the definition of ocean fertilization developed by the Parties in the Resolution LC-LP.1, it may not be within the scope of the resolutions. However, the resolutions may have relevance to ocean alkalinization activities, as the idea behind the resolutions was to develop more comprehensive regulation of geo-engineering activities. The regulatory efforts of the dumping regime were not limited to ocean fertilization, but instead aimed at addressing marine geo-engineering more broadly. While the first two resolutions (Resolution LC-LP.1 and Resolution LC-LP.2) were developed specifically for ocean fertilization, further efforts in Resolution LP.4(8) indicated that other geoengineering technologies should be covered. The question arises as to whether the non-application leads to an unjustified result. If the resolutions are not applicable analogously, then an ocean alkalinization activity could be covered by the London Convention/ London Protocol if it could be defined as dumping. This would return to the question already discussed above for ocean fertilization, whether ocean alkalinization

[233] James Harrison (n 14) page 272-273.
[234] Boyd and Vivian (n 18) page 95.
[235] Scott, 'Mind the Gap' (n 39) page 46.

activities constitute dumping under Art. III (1) (a) (i) LC/ Art. 1 (4) (1) (1) LP and, if so, whether the exception under Art. III (1) (b) (ii) LC/ Art. 1 (4) (2) LP applies.[236] It can arguably be assumed ocean alkalinization is dumping, and which again leads to the interpretive question of whether it falls under the exception. Ocean alkalinization activities, even scientific research experiments, could be contrary to the aim of the treaties and not be covered by the exemption and could be considered as dumping under the London Convention/ London Protocol. A review of the regulations on ocean fertilization demonstrates these activities are not in contradiction with the treaties if they are legitimate scientific research.[237] Despite possible harmful effects, ocean alkalinization technology may be more promising than ocean iron fertilization, and therefore further research should be urgently conducted on it. Similarities between the implementation of ocean alkalinization and ocean fertilization support applying the resolutions analogously to ocean alkalinization to at least allow scientific research. It follows that it is arguable to expand the resolutions and apply them to ocean alkalinization.

4.5.2 Potential Listing of Ocean Alkalinization under Annex 4

Ocean alkalinization activities do not fall under the definition of ocean fertilization[238] and therefore these activities are not covered by ocean fertilization being listed in Annex 4, which is currently the only technology listed.[239] After the above review, it became clear there is a need for a special regulation for ocean alkalinization. Therefore, the question arises whether ocean alkalinization technology could and should be listed as a further geo-engineering activity in Annex 4. If Parties to the London Protocol include additional marine geo-engineering activities in the new Annex 4, further specific assessment frameworks could be developed to specifically regulate the activity in question.[240] Ocean alkalinization needs to be listed in Annex 4 in order for it to be regulated under Art. 6bis LP.[241] Guidance for the consideration of marine geo-engineering activities is provided in Annex 5, and specifically identifies the information required for the review of a new marine geo-engineering activity.[242] It must describe, among

[236] See Chapter III, Section 4.3.
[237] See Chapter III, Section 4.4.
[238] See Chapter III, Section 4.5.1.1.
[239] See Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189) Annex 4.
[240] Boyd and Vivian (n 18) page 92.
[241] cf. Resolution LP.4(8) (2013) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and other Marine Geoengineering Activities (adopted 18 October 2013, amendments not yet in force) (n 189) Art. 6bis (1) LP.
[242] Annex 5 - Guidance for consideration of Marine Geoengineering Activities, IMO LC 36/16 (hereinafter Annex 5) (n 217) 5.

other things, the purpose of the activity, the potential impacts on human health, ecosystems, and other legitimate uses of the marine environment and their significance (is the impact potentially widespread, long-lasting, or severe), and the effectiveness of the action.[243] Ocean alkalinization is a marine geo-engineering technology under Art. 5bis LP[244], since the purpose of this technology is to limit ocean acidification, with the effect of increasing CO_2 uptake by the ocean. The potential negative or even harmful effects and their magnitude is still uncertain as well as the effectiveness of the activities.[245] Compared to ocean iron fertilization, ocean alkalinization appears to be similar in the type of activity (introduction of a substance into the ocean) and consequences for the marine environment. If it has equally potentially harmful effects on the marine environment, then it must be regulated under this regime, with ocean alkalinization possibly having even lesser negative effects. It should not be underestimated that negative effects have already been demonstrated, but it is unclear what form they would take if carried out on a large scale or what further damage could be caused to the marine environment. It is therefore important to research and legally regulate before the consequences are clear. To ensure this, a first step would be to add ocean alkalinization to the list in Annex 4, not only to provide more public attention, but also to facilitate it for further research, in order to use the possibility of a technology that not only counteracts ocean acidification, but also helps to minimise climate change. The GESAMP report also concluded, after extensive review, that ocean alkalinization "potentially could be considered for listing in the new Annex 4 of the London Protocol after more detailed assessment".[246] Listing is made to ensure that activities can only be implemented when it is determined that the negative effects are limited so that it is justified to implement it. It follows that it is arguable to include ocean alkalinization in the list of Annex 4. In the London dumping regime, ocean alkalinization activities could thus be arguably regulated by analogous use of the resolutions and with the possibility of listing this technology in Annex 4. However, ocean alkalinization illustrates the problem that the amendments have not yet entered into force. Therefore, the non-binding resolutions and the amendments for the case of ocean alkalinization technology can be used in an advisory capacity.[247]

[243] ibid page 4.
[244] See Chapter III, Section 4.5.1.2.
[245] See Chapter II, Section 1.2.
[246] Boyd and Vivian (n 18) page 14.
[247] See Chapter III, Section 4.4.4.

5. Precautionary Principle

The purpose of this section is to consider the conflict of the objectives between the climate change regime and the law of the sea and environmental law (LOSC, dumping regime and biodiversity regime) which States must consider when implementing ocean alkalinization activities and how this can be resolved with the application of the precautionary principle. From the perspective of climate change regimes, it is necessary to carry out geo-engineering activities in order to limit CO_2 emissions, whereas from the perspective of the law of the sea, environmental protection has a significant role. The precautionary principle must be taken into account, as it is not only the basis for the London Protocol and is required under the due diligence obligation under Art. 192 LOSC, but also listed in the principles of the climate change regime, therefore a balancing exercise must be made between the environmental damage caused by geo-engineering technologies and due to climate change.

5.1 Applicability of the Precautionary Principle

The precautionary principle[248] or precautionary approach provides guidance where there is scientific uncertainty and anticipation of possible environmental harm and is a key instrument in international environmental law.[249] It first emerged within a domestic legal context of the German "Vorsorgeprinzip".[250] The Rio Declaration, Principle 15, provides a definition[251] for the precautionary principle saying that:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[252]

[248] For the sake of consistency, the term "principle" is used throughout this thesis.
[249] Arie Trouwborst, 'The Precautionary Principle and the Ecosystem Approach in International Law: Differences, Similarities and Linkages' (2009) 18 Review of European Community & International Environmental Law 26, page 27.
[250] Dirk Hanschel, *Progress and the Precautionary Principle in Administrative Law — Country Report on Germany* (Eibe Riedel and Rüdiger Wolfrum eds, Springer 2006) page 180-181.
[251] Note: This is the most widely known formulation of the precautionary principle, cf. Kerstin Güssow and others (n 39) page 916.
[252] Rio Declaration on Environment and Development (adopted at Rio de Janeiro, 14 June 1992), 31 ILM 874 (hereinafter Rio Declaration) 1992 Principle 15.

The legal status of this principle is not clear and there are different views, the European Union is of the opinion that it is "a general customary rule of international law or at least a general principle of law"[253] whereas the United States of America speaks of an "approach" and denies the status as a principle.[254] Neither were the international courts explicit in addressing the issue of the status but ITLOS unanimously endorsed that it is part of the due diligence obligation.[255] ITLOS further noted that there is even "a trend towards making this approach part of customary international law".[256] In order to examine the applicability, the Rio Principle 15 must be interpreted. According to this, the precautionary principle is to be applied if certain criteria are met. The required criteria are that there must be (1) a threat of damage which is (2) serious or irreversible and (3) a lack of full scientific certainty.[257] The application of the precautionary principle would ensure that, prior to the use of the geo-engineering technology, it is necessary to ensure the potential adverse effects have been identified and, where appropriate, remedied so that they are below the threshold of harm.[258] It follows that the precautionary principle does not require that potentially hazardous activities be completely banned, but rather that preventive measures be taken.[259]

5.2 Precautionary Principle in Relation to Ocean Iron Fertilization

In the context of ocean iron fertilization, the application of precautionary principle has already been discussed. Based on this technology, there are still uncertainties regarding the potential huge negative impacts on the marine environment and the effectiveness of the activities. It could lead to damaging effects, especially for the ecosystem, ocean productivity and biogeochemical cycles, which are all serious damages.[260] Thus, there is a threat of serious or even irreversible damages from ocean iron fertilization activities, and a lack of full scientific certainty in this regard. Ocean iron fertilization has been researched mainly in terms of the effect for reducing global temperature rise and little has been researched in terms of their impact on the marine

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[253] *WTO Appellate Body Report on EC - Measures Concerning Meat and Meat Products (Hormones), WTO Doc WT/DS26/AB/R, WT/DS48/AB/R (16 January 1998)* [16].
[254] ibid 43.
[255] See Chapter III, Section 2.3.1.
[256] *Responsibilities and Obligations of State Sponsoring Persons and Entities with Respect to Activities in the Area (Advisory Opinion), 1 February 2011, ITLOS Rep. 10* (n 151) para 135.
[257] Note: Furthermore, the definition in the Rio Declaration states that if all the requirements are present, then uncertainty should not be used as a justification for postponing cost-effective measures to protect the environment. This explicitly mentions cost-effective measures, so it calls for an economic impact analysist. However, the thesis does not address economic aspects in more detail.
[258] cf. Johansen (n 39) page 194.
[259] Elliott (n 37) page 246.
[260] cf. ibid page 241.

environment.[261] Therefore, from a law of the sea perspective, the application of precautionary principle argues for further research into the impacts on the marine environment before ocean fertilization can be deployed on a large scale. This conclusion was also reached by Güssow et al. as they stated that when considering the law of the sea provisions, the precautionary principle seems to speak for the protection of the marine environment.[262] However, ocean iron fertilization could combat climate change by increasing CO_2 uptake and storage, thus the use of the technology may be necessary.[263] The anthropogenic CO_2 will continue to be released into the atmosphere, which will have catastrophic consequences for the environment. The climate change regime includes the precautionary principle which, according to Art. 3 (3) UNFCCC, states that:

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.

From the perspective of the climate change regime, the precautionary principle states if irreversible damage is imminent, the lack of full scientific certainty should not serve as a reason for postponement. Güssow et al. noted that from the perspective of the climate regime in terms of Art. 3 (3) UNFCCC and "in the context of global warming", the precautionary principle argues in favour of allowing ocean iron fertilization activities.[264] The precautionary principle as a guideline for responding to uncertainty can be helpful in dealing with the potential benefits and risks of geo-engineering. especially for balancing them with climate change benefits.[265] Therefore, the potentially harmful effects (damage to the marine environment) must be weighed against the beneficial effects (mitigate climate change) of geo-engineering activity and then considered in relation to the potential harms of climate change. Güssow et al. concluded that a balancing of the potential negative impacts of ocean iron fertilization with the impacts of climate change means that scientific research must continue to be allowed under the

[261] Boyd and Vivian (n 18) page 22.
[262] Kerstin Güssow and others (n 39) page 916.
[263] See Chapter I, Section 1.2.
[264] Kerstin Güssow and others (n 39) page 916.
[265] ibid.

precautionary principle.[266] This discussion was held before the detailed regulations of the dumping regime[267] were adopted and against the background that the CBD Decision IX/16 would have led to a de-facto-moratorium[268], even for marine scientific research. Nevertheless, it was carried out in consideration of the precautionary principle and thus has been solved in the same way as it would be the case taking into account the further developments of the dumping regime. Indeed, even after the adoption of the Resolution LC-LP.2 and the amendments to the London Protocol, ocean fertilization activities are allowed as scientific research applying the precautionary principle. The application of the precautionary principle was clarified in the context of ocean iron fertilization to the result that marine scientific research is permissible. In the following, it is to be clarified in comparison to ocean iron fertilization to what extent the same considerations are applicable to ocean alkalinization.

5.3 Precautionary Principle in Relation to Ocean Alkalinization

When it comes to ocean alkalinization it is questionable whether the precautionary principle is applicable and, if so, what the consequences are. Ocean alkalinization carries, as mentioned above, uncertainties about the potential negative impacts on the marine environment and the effectiveness of the measures. In particular, it is uncertain what effects the change in the ocean pH will have on the marine environment.[269] Thus, there is a risk of serious harm and a lack of complete scientific certainty, so the precautionary principle is applicable. The application of the precautionary principle in the sense of Art. 15 Rio Declaration argues in favour of the protection of the marine environment and against the use of ocean alkalinization. This means large-scale use would only be possible once the environmental consequences could be assessed, so ocean alkalinization could only be investigated in the context of scientific research, even though the use of geo-engineering technologies could be necessary precisely for climate change mitigation. Ocean alkalinization differs from ocean fertilization in that it is not solely for emission reduction but could also be used to limit ocean acidification.[270] It follows that while this technology raises problems in terms of potential negative effects, there is the possibility that it can have positive impacts in terms of reducing ocean acidification and minimizing climate change. This leads back to the conflict of the objectives between the climate change regime and the law of the sea and the balancing between the negative effects of ocean

[266] ibid.
[267] Note: It was adopted solely the Resolution LC-LP.1.
[268] See Chapter III, Section 3.
[269] See Chapter II, Section 1.2.
[270] ibid.

alkalinization and the effects caused by the CO_2 concentration in the atmosphere. Despite the supposedly positive effect of ocean alkalinization, there are still considerable uncertainties regarding the environmental impacts, therefore the precautionary principle applies, in the perspective of the law of the sea and in term of marine environmental protection, in the sense that ocean alkalinization should only be carried out when there is full scientific certainty. However, from the perspective of the climate regime, this technology could help combat ocean acidification while ensuring that more CO_2 is removed from the atmosphere. Ocean iron fertilization, in comparison, can potentially increase CO_2 uptake by the oceans, but the consequences for the marine environment are uncertain, and current knowledge suggests that it will increase ocean acidification.[271] Therefore, when considering this technology, it is probably more appropriate to say that until there is certainty about the consequences, ocean iron fertilization should be limited to marine scientific research. In contrast, ocean alkalinization has potentially two positive properties in that it could prevent ocean acidification and reduce atmospheric CO2 levels. This is a strong argument for allowing ocean alkalinization activities to a greater extent. The question raised is whether it is inevitable to use negative emissions technologies, such as ocean alkalinization in addition to decisive emission reduction, in order to mitigate climate change and avoid catastrophic consequences, which could themselves have drastic environmental consequences. It seems to be a consideration between the negative consequences of climate change or the negative consequences of ocean alkalinization, but it should not be forgotten that the consequences of ocean alkalinization are not yet foreseeable, especially not in the implementation on a large scale (neither the positive nor the negative consequences). It is not certain whether ocean alkalinization could effectively mitigate climate change and what the risks to the marine environment would be. It can be concluded for ocean alkalinization as that balancing the potential negative impacts on the marine environment against dangers which arise due to climate change result in applying the precautionary principle to conduct further scientific research to explore the potential of the activity and determine whether it can ultimately help minimize climate change. Nevertheless, it is arguable that in the balance of climate change damages, it may be more justifiable to allow ocean alkalinization activities to be implemented more strongly than ocean iron fertilization, as it currently appears that ocean alkalinization is more promising and the positive effects of lowering ocean acidification and enhancing CO_2 uptake would predominate. The question may arise whether

[271] See Chapter II, Section 1.2.

the regulations of the dumping regime, which rely on the precautionary principle, should be liberalized for ocean alkalinization.

5.4 Result of the Application of the Precautionary Principle

In order to meet their obligations under the law of the sea, States must apply the precautionary principle to protect the environment, given the uncertainty about the impact of ocean alkalinization. The result of the application of the precautionary principle is, for both ocean iron fertilization and ocean alkalinization, that scientific experiments can continue to be carried out. Even the knowledge of ocean fertilization, the most studied technology to date, remains insufficient to conduct large-scale deployment, as the global impacts on the marine environment are not yet sufficiently determined.[272] It is reasonable for ocean alkalinization to conduct small-scale experiments to further research whether it holds promise for combating climate change. According to current knowledge scientific experiments have small negative effects, which are also in a limited marine area compared to with large-scale implementation, which can lead to potentially widespread reactions in the sea with the potential for significant impacts on the marine environment.[273] Thus, more research is needed to see if it can be used on a large scale, while not severely damaging the environment during the research. Ideally, further experiments will show that ocean alkalization is effective and shows little to no environmental damage, allowing it to be used on a large scale, which would then lead to the minimization of climate change.

[272] cf. Boyd and Vivian (n 18) page 34.
[273] cf. ibid page 22; Kerstin Güssow and others (n 39) page 916.

CHAPTER IV – CONCLUSION

"Without geoengineering, it is becoming highly unlikely that
'dangerous' climate change can still be avoided"
Phillip Williamson[274]

Against the background of the need for geo-engineering technologies, the thesis has examined what the rights and obligations for States are under international law when conducting ocean alkalinization. From the research undertaken it, first and foremost, appears that States can currently conduct ocean alkalinization activities as research experiments in compliance with international law. The current regime for ocean alkalinization is based on the regulations of international law. Section 1 of Chapter III clarified that from a climate change regime perspective, there is a need to reduce CO_2 to meet the climate temperature goals of the Paris Agreement and that ocean alkalinization, as a marine geo-engineering technology, can contribute to the objectives of the climate change regime. This creates environmental problems which the climate change regime does not sufficiently address. The second Section of Chapter III addressed the rights and obligations of States when carrying out ocean alkalinization activities from the perspective of the LOSC. In this respect, it can be recalled that States have a general obligation to protect and preserve the marine environment according to Art. 192 LOSC, which is supplemented by the due diligence obligation, which requires the application of the precautionary principle. In addition, according to Art. 193 LOSC States have the right to explore their natural resources, taking into account environmental protection. Part XIII of UNCLOS deals with marine scientific research and Art. 238 LOSC gives States the right to conduct marine scientific research. Art. 240 LOSC states the general principles for the conduct of marine scientific research, whereas Art. 240 (d) specifically said "marine scientific research shall be conducted in compliance with all relevant regulations […] for the protection and preservation of marine environment. Furthermore, according to Art. 196 LOSC, States are obliged to take measures to prevent, reduce and control pollution from the use of technologies. Section 4 presented the London dumping regime, which has developed regulations for ocean fertilization as well as more broadly for geo-engineering. The resolutions that were adopted under the dumping regime specifically in terms of ocean fertilization, allow States to conduct marine scientific research. Moving forward, it would be possible and indeed advisable to list ocean alkalinisation in Annex 4 of the London Protocol to regulate ocean alkalinization

[274] Williamson and others (n 1) page 476.

activities specifically. Yet, given that this amendment has thus far not entered into force, the question arose whether the non-binding resolutions are applicable to ocean alkalinization. It was elaborated that the resolutions are arguably analogously applicable to ocean alkalinization activities. The London dumping regime has demonstrated that the precautionary principle limits ocean fertilization to scientific research. However, this is not consistent with the need to apply negative emissions technologies on a large scale to successfully combat climate change. The problematic conflict of objectives, which was a reoccurring theme in this thesis, was discussed in more detail in Section 5. The conflict exists between the UN climate change regime, which, with the interpretation of the precautionary principle pursuant to Art. 3 (3) LOSC argues in favour of States using ocean alkalinization (possibly also on a large scale) and the law of the sea, which is focused on the protection of the marine environment. Given that ocean alkalinization could potentially be harmful for the marine environment, the precautionary principle is applied and aimed to prevent environmental damage and therefore only allows marine scientific research until the potentially harmful effects of ocean alkalinization have been identified and eliminated. For ocean fertilization, it was determined that its application of precautionary principle indicated that States should only allow such activities as marine scientific research. There is a strong assumption that ocean iron fertilization technology is harmful for the environment and the applicability of the precautionary principle, from a law of the sea perspective, means such measures cannot be implemented on a large scale until the environmental consequences are known. Ocean alkalinization is similar to ocean iron fertilization, except the technology offers the possibility of combating ocean acidification. Increasing the alkalinity of the oceans could reduce atmospheric carbon dioxide and reverse ocean acidification, and thus could help mitigate climate change. In the context of the precautionary principle, therefore, a different view from ocean fertilization might be justifiable, so that it is arguable to carry out ocean alkalinization activities on a large-scale to combat climate change and its consequences. However, a balancing cannot be made between the negative impacts of ocean alkalinization and the negative impacts of climate change because the consequences for ocean alkalinization on the marine environment are uncertain. Despite the need to find a method which leads to a drastic reduction of emissions, it is more advisable not to use technologies which have not yet been fully researched. Premature action could have irreversible consequences for the marine environment, which in turn could exacerbate the dramatic effects of climate change. In order to meet their obligations, States must apply the precautionary principle to protect the environment, as the effects of ocean alkalinization on the marine environment are uncertain. The application of the precautionary principle makes it possible for ocean alkalinization to be investigated further. This could lead to measures being taken, possibly on a large-scale, when there is no uncertainty, which may lead to long-term success. Right now, more research and development are needed to ensure that ocean alkalinization, as an emission-reducing technology, is promising and can be used on a large scale. States are therefore initially only allowed to continue small-scale experiments to explore the benefits of ocean alkalinization.

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