Legal Considerations relevant to the Research of Ocean Alkalinity Enhancement

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Abstract. This article examines the legal considerations relevant to ocean alkalinity enhancement (OAE) and provides some best practice guidance for responsible (field) research of OAE. The article examines recent developments in international law in order to inform what may legally be required of researchers when planning and designing OAE research projects. To this end, the article acknowledges unavoidable differences in domestic legal systems but highlights the role of international law, especially as can be found in the London Convention and Protocol, in developing appropriate minimum rules and standards. The article notes that domestic legal systems may wish to account for such minimum international rules and standards when developing permitting conditions and laws for OAE research activities. Additionally, the article examines international agreements and customary international law that find general application to OAE research. This latter examination assists in the identification of areas where additional legal research may also be required. The article concludes by highlighting that it remains crucial for legal researchers to work with the scientific community and those from other disciplines to assist States in understanding the science-policy interface to develop a comprehensive legal framework for ocean-based carbon dioxide removal approaches. This will, in turn, guarantee that field research is carried out in a safe and responsible manner and in a manner that reduces the likelihood of adverse environmental and other consequences.

1 Introduction

This Chapter examines the legal considerations of relevance to ocean alkalinity enhancement (OAE) and, based on recent developments in international law, provides some recommendations that continued research, particularly field research, into OAE should consider. As is the case with other Chapters, nothing in this Chapter should be understood as either advocating for or restricting research into OAE. Rather, the Chapter acknowledges the inevitable application of international law to OAE activities and recommends some best practices that may facilitate responsible and transparent research and accountability.

The ocean is a global ~~"common pool"~~ resource and any activity that has the potential for negative transboundary impacts must be examined in accordance with the rules and principles of public international law. International law has grown exponentially since the turn of the century and includes numerous legal rules, procedures and institutions aimed at governing the rights and

obligations of States with respect to, amongst other things, the effect that their activities may have on the environment of neighboring States and the environment beyond national jurisdiction generally. As an activity that takes place in the ocean, the research and possible (future) deployment of OAE will necessarily be subject to a number of international laws.

35 Generally speaking, there are two primary sources of international law: (1) ~~customary international law, and (2)~~ international agreements or treaties, and (2) customary international law. The former impose obligations only on those States that have specifically consented to be bound by the relevant treaty. The ~~former~~ latter encompasses a set of obligations that are binding on all States~~.~~ unless a particular State has "persistently objected" to the rule/principle concerned (see Green 2016). This consideration is important to keep in mind when discussing OAE research, and especially when considering the application of the precautionary principle/approach to OAE research. ~~In contrast, the latter~~Source (2) ~~impose obligations only on those States~~ 40 ~~that have specifically consented to be bound by the relevant treaty~~.

It should be noted that international law does not generally impose obligations directly on private actors (such as researchers). However, to fulfill their international obligations, States may be required to adopt domestic laws to regulate the conduct of researchers and others operating under their jurisdiction or control. The manner in which States incorporate their international law obligations into domestic legal systems depends on the State in question, and a one-size-fits-all approach to ascertaining 45 *how* States apply international law within domestic contexts is not possible. However, international law is often relevant in ascertaining the minimum rules and standards that may be required by domestic authorities for researchers and their affiliated institutions to undertake OAE research in the marine environment. How then, do researchers ascertain which domestic laws apply to their proposed activity? As mentioned, the answer to this question will depend on the State in question but "objective connecting factors" include the geographic location where the activity is undertaken and the nationality, residence or domicile 50 of the actors involved (Mills 2023). Research projects that make use of vessels at sea, for example, may be subject to the jurisdiction of relevant coastal States as well as the flag State of the vessel concerned.

Considering the purpose of this Guide as well as the overarching legal considerations applicable to OAE, three general remarks must be stressed. First, the development of international environmental law is a direct response to the increased impact that humankind is having on the environment. Consequently, the environmental laws that may apply to OAE typically aim to 55 prevent or reduce the environmental harm that an activity may have and do not necessarily encourage research – the role of environmental law is centered around reducing and, in some cases, entirely preventing harm to the environment. Second, OAE is one of a suite of ocean-based carbon dioxide removal (CDR) approaches and in the absence of any law designed for OAE specifically, the laws that find application to ocean-based CDR generally should be assumed as also applying to OAE. Lastly, scientific research activities should be distinguished from (commercial) deployment of OAE. Both the national and 60 international regulation of research and deployment is likely to be different and, given the objective of this Guide, the focus of this Chapter is on research and not (commercial) deployment.

With these brief remarks in mind, this Chapter is divided into seven sections. Following this introduction, section 2 highlights the jurisdiction of States in the various maritime zones established by the 1982 United Nations Convention on the Law of the Sea (UNCLOS). Section 3 discusses framework international agreements relevant for OAE. This discussion emphasizes that

65 OAE, like all ocean-based CDR approaches, "is a prime example of an activity-based challenge that involves the overlap and interplay of different regimes under international law" (Proelss 2023, p. 112). Considering the vast literature available, section 3 only focuses on select international instruments of particular relevance, including UNCLOS (section 3.2), the Convention on Biological Diversity (CBD) (section 3.4) and the international climate change regime (section 3.5). Additionally, and in considering OAE research activities undertaken in the high seas, the imminent adoption of an agreement under UNCLOS on

70 the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction is also briefly discussed (section 3.3). Section 4 examines the currently most developed international instrument potentially applicable to OAE research – the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Protocol or LP). This section details the requirements of the not yet in force amendments to the London Protocol – serving as the basis for some reflection into what future permitting of OAE activities by national, local or municipal

75 authorities might entail. Section 5 highlights some best practice guidance for OAE (field) research projects, while section 6 notes that a number of areas relevant to the legal aspects of OAE research still require further research. This latter point is especially true with regards to liability regimes; how to respond to unregulated/unauthorized OAE research projects; the potential necessity for insurance; and the connection between national and international legal systems and associated needs for relevant national authorities to remain vigilant with regards to international legal developments. Finally, section 7 offers some

80 conclusions.

2 Jurisdiction over the ocean and defining OAE

The answer to which State has jurisdiction over a particular ocean activity generally depends on two considerations: (1) where in the ocean a particular activity takes place and (2) the legal classification of the activity concerned. As far as the "where" goes, an OAE activity that is restricted to the territorial sea, for example, may be subject to a different regulatory framework

85 than if the same activity was undertaken in the exclusive economic zone or in the high seas (see the discussion below). As far as the legal classification of the activity goes, an activity that has some OAE characteristics, but which does not meet any agreed legal definition of what in fact constitutes "OAE" may be regulated differently. In other words, it will be crucial that OAE research projects fulfil any agreed upon definitions found in relevant international instruments and domestic legislation. In this regard, examples can perhaps be drawn from recognized institutions such as the IPCC which reference can be made to

90 the definesition of OAE provided by the IPCC as a CDR method "that involves [the] deposition of alkaline minerals or their dissociation products at the ocean surface [to increase] surface total alkalinity, and may thus increase ocean carbon dioxide uptake and ameliorate surface ocean acidification" (Working Group III Report 2022, p. 1809). That said, it should be noted thatAs is often the case in the science-policy interface, legal and scientific definitions do not always align, and a definition of

OAE should remain flexible (to respond to rapid developments) and account for necessary legal and scientific requirements.
95 This is especially true in the context of ongoing efforts under the London Protocol to potentially regulate OAE projects which qualify as legitimate scientific research (see section 4). ~~With this in mind, it should be noted that the international regulation of OAE as an ocean-based CDR approach (having the co-benefit of addressing ocean acidification) may need to be distinguished from the use of OAE with the intention of combatting ocean acidification specifically. Whether or not this distinction will manifest in practice remains to be seen, but the nuances in regulating OAE as a CDR method and OAE as an~~
100 ~~ocean acidification mitigation measure should be borne in mind when legal and scientific definitions of OAE are proposed within different multilateral and international institutional settings ultimately aimed at regulating OAE.~~

Turning to the "where", the jurisdiction of coastal States (i.e. non-landlocked States) over various parts of the ocean is laid out in the 1982 UNCLOS. In line with this, the ocean is divided into various maritime zones and the rights and obligations of States are generally determined by where in the ocean (i.e. in which maritime zone) a particular activity is undertaken.

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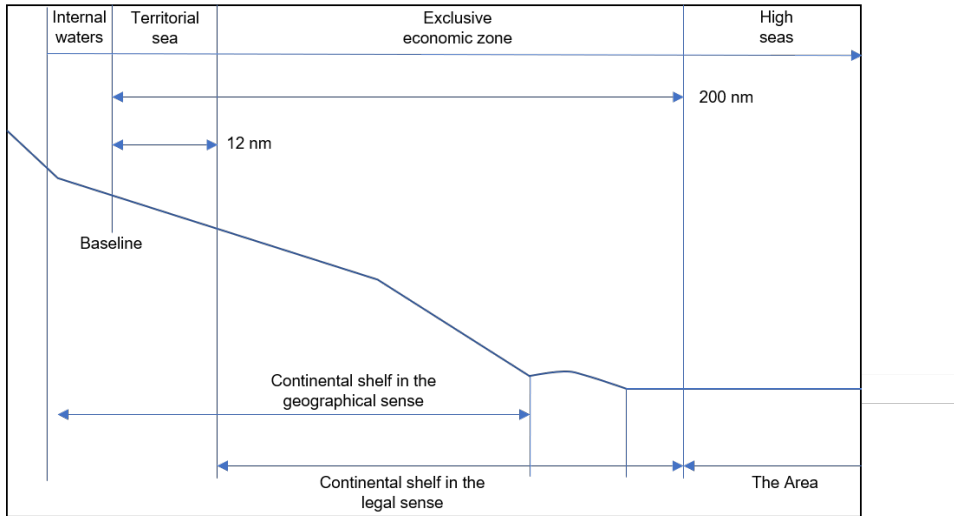
Figure 1 Maritime Zones (Tanaka, 2019)

Without detailing the legal nuances involved in every maritime zone, it should be understood that the classification of a zone is determined by the distance from a State's baseline – normally defined as the low-water line along the coast of a State (Article 5 UNCLOS). OAE activities that take place in the 0 to 12 nautical mile (nm) belt (as measured from the baseline) would
110 generally be subject to the legal regime of the territorial sea; those that take place in the 12 to 200 nm belt would generally be subject to the legal regime of the exclusive economic zone (EEZ); and those that take place beyond 200 nm would generally

be subject to the regime of the high seas, including the freedom to undertake scientific research (Article 87 UNCLOS). Over and above these specific zonal regimes, coastal States may also be subject to obligations covering all maritime zones, including the obligation to protect and preserve the marine environment.

115 Given that the coastline of a State is not drawn in a neat straight line, the general rules applicable in the various maritime zones are necessarily accompanied by a number of exceptions and deviations, including the fact that some States have not designated an EEZ or that the territorial sea of some States does not extend to the full 12 nm as measured from the baselines (see, for example, the practice of some coastal States bordering the Mediterranean Sea and the designation of Japan's territorial sea bordering the Tsushima, Osumi and Tsugaru Straits). Ascertaining where in the ocean a particular OAE activity is to take place 120 is, therefore, a crucial step in evaluating the appropriate legal regime.

The zonal approach enunciated in UNCLOS and the jurisdiction that States enjoy in each zone is briefly summarized in Table 1 below. Within each identified zone, States' must exercise their rights and obligations in accordance with international law, and in a manner that does not interfere with the rights and obligations of others. For example, States' exercise of sovereignty over their Territorial Sea is subject to UNCLOS and other rules of international law, including the right of "ships of all States 125 . . . [to] innocent passage through the territorial sea" of other States as recognized in UNCLOS (UNCLOS, Art. 2 & 18).

TABLE 1: Zones and Jurisdiction of States in the Ocean (largely reproduced from NASEM 2022, p. 41)

Zone	Location	Status
Territorial sea	Water column from 0 up to 12 nautical miles from the baseline	Part of the sovereign territory of the coastal States. States have sovereignty.
Exclusive economic zone	Water column from 12 up to 200 nautical miles from the baseline	States have sovereign rights to explore, exploit, conserve, and manage the natural resources and perform other activities for the economic exploitation of the zone. States have jurisdiction over artificial islands and other structures, over marine scientific research, and over the protection and preservation of the marine environment.
Continental Shelf	Seabed and subsoil from 12 to 200 nautical miles from the baseline *or* the outer edge of the continental margin (subject to certain limits)	States have sovereign rights to explore and exploit the natural resources in the continental shelf.
High Seas	Water column areas not included in other water column areas designated under UNCLOS	No State has sovereign rights. Freedom of the high seas applies and the zone is open for use to all States.

The Area	Seabed and ocean floor (including its subsoil) that are beyond the limits of national jurisdiction	The Area and its resources are the common heritage of humankind. Activities in the Area must be conducted "exclusively for peaceful purposes" and "for the benefit of mankind as a whole."

This brief discussion has shown that in order to identify the laws potentially applicable to an OAE activity, it first needs to be established where in the ocean an OAE activity takes place and the classification of the activity (the scale and intent of the activity often proving relevant for such classification). Following this, the international laws regulating ocean space can be consulted to determine the obligations of States in authorizing OAE research under their jurisdiction.

> **_Conclusion 1 – The regulation of OAE research: A top-down approach?_**
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> International law determines the rights and obligations of States. States then adopt domestic legislation that either meets the minimum standards or rules required by international law or, on the basis of domestic legal systems and individual State considerations, enact domestic legislation that is stricter than the minimum requirements. Thus, depending on where a particular OAE research activity occurs, researchers should (1) be aware of potentially applicable minimum international rules and standards, and (2) how the research activity is regulated domestically. Even if an activity is permissible under international law, it may be restricted or prohibited under domestic law. Indeed, situations do exist where domestic regulation of an activity may amount to total prohibition of the activity concerned.

130 In establishing the link between domestic and international law then, an essential question is what are the minimum international rules and standards that may be relevant to the research of OAE? There is currently no specific international legal regime that has been established to govern the research of OAE. That said, OAE activities do not take place in a legal vacuum. In particular, an evaluation of various international treaties (which individual States have consented to be bound by) as well as customary international law (comprising universal legal standards that are binding on all States) provides some insight into
135 what such minimum international rules and standards may, at this point in time, entail.

3 Customary international law and relevant framework agreements of general application

A wide body of literature has analyzed the application of existing international legal frameworks to OAE and other ocean CDR techniques (see, for example, Proelss and Steenkamp 2023; Scott 2023; Webb et al. 2023; Proelss 2023; Webb et al. 2021; Brent et al. 2019; GESAMP 2019; Brent et al. 2018; Du 2018; McGee et al. 2017; Armeni and Redgwell 2015; Lloyd and
140 Oppenheimer 2014; Kuokkanen and Yamineva 2013; Scott 2013). Applicable international law includes the customary international law obligations to prevent transboundary harm and the obligation to conduct environmental impact assessments (including associated procedural obligations to consult and notify potentially affected States); UNCLOS and its related instruments; the CBD; the international climate change regime (especially the United Nations Framework Convention on Climate Change (UNFCCC) and the 2015 Paris Agreement); and in the case of alkaline substances or material that may be

145 introduced into the marine environment, the international dumping regime established by the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and the Protocol to that Convention (London Protocol). Additionally, the recent ~~imminent~~ adoption of an agreement under UNCLOS on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ Agreement) may also prove relevant for OAE research undertaken in the high seas.

150 ~~UNCLOS, t~~The CBD and the UNFCCC are often referred to as framework agreements. While their framework nature necessitates that they have a wide scope of application, including to OAE research, it also means that the content of many of their most relevant obligations are often vague and ambiguous – requiring interpretation on a case-by-case basis. For its part, UNCLOS provides a comprehensive framework for regulating ocean space but it is "not a separate or self-contained legal regime" (Boyle 2005, p. 564). Those provisions of UNCLOS that refer to "rules of general international law" or which
155 incorporate "generally accepted international rules and standards" will need to be carefully examined in ascertaining both their potential application as well as the scope of any such application to OAE research activities.

Considering the comprehensive literature that is available, the discussion below on customary international law and some select international instruments offers only a brief snapshot. This discussion is, therefore, incomplete and serves rather as a foundation from which best efforts can be made to provide guidelines and recommendations for OAE research. Additionally,
160 this section should be read together with section 5.1.4 below, wherein the London Protocol and its not yet in force 2013 amendments – comparably the most developed international law concerning ocean-based CDR – are examined in detail. The focus on the international regime established under the London Protocol should not be understood as negating the relevance of the instruments discussed here or any other international laws. Rather, this should be seen as a consequence of the current regulatory regime and the opportunities that the London Protocol may present in facilitating (or not) OAE field research.

165 **3.1 Customary international law**

Relevant customary international law includes the obligation that States must not allow or permit activities within their territories, or in common spaces (such as the high seas), without having regard for the rights of other States or for the protection of the environment, including the marine environment. From this, commentators have extrapolated two specific customary international law obligations:

170 1. "States must take measures to prevent, reduce and control pollution and environmental harm from activities that are under their jurisdiction or control; and
2. States must cooperate to mitigate environmental risks and emergencies through the related duties of notification, consultation, negotiation and, in some cases, by conducting environmental impact assessments (EIAs)" (Boyle and Redgwell, 2021, pp. 152-153).

175 Importantly, neither of these obligations prohibit transboundary harm in its entirety and both entail an obligation of conduct, not of result (see, for example, Maljean-Dubois 2021; Papanicolopulu 2020; Mayer 2019; Mayer 2018; Wolfrum 2011).

These rules are also reflected in a number of international instruments as well as in the jurisprudence of international courts and tribunals. According to the International Court of Justice (ICJ), it is "'every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States [and that a] State is thus obliged to use all the means at its
180 disposal in order to avoid activities which take place in its territory, or in any area under its jurisdiction, causing significant damage to the environment of another State" (2010 *Pulp Mills Case*, para. 101). Therefore, a State undertaking potentially risky activities must act with due diligence and failure to do so may result in the international responsibility of that State. The obligation of due diligence is variable – i.e. the obligation is susceptible to "change over time as measures considered sufficiently diligent at a certain moment may become not diligent enough in light, for instance, of new scientific or
185 technological knowledge" (ITLOS 2011 Advisory Opinion, para. 117).

> ### Conclusion 2 – OAE and States' international obligation of due diligence
> As scientific understanding of OAE advances, the threshold of a State's due diligence obligations may increase or decrease accordingly. Whether or not a State's due diligence obligations have been met must be analyzed on a case-by-case basis. However, to fulfill the obligations States must, at a minimum, ensure that adequate domestic legislation exists to mitigate the environmental impacts of OAE activities and that such legislation obligates a certain level of vigilance on the part of the State "in their enforcement and the exercise of administrative control applicable to public and private operators" (2010 *Pulp Mills Case*, para. 197). Therefore, a strong case can be made that domestic legislation needs to remain flexible in order to adequately respond and adapt to changing circumstances in light of developments surrounding OAE research.

Connected to the second customary international law rule highlighted above, is the procedural obligation to undertake an EIA for proposed activities that "may have a significant adverse impact in a transboundary context" (2015 *Certain Activities Case*, para. 104). Recent international case law indicates that prior to an EIA, there may also exist a *preliminary* obligation on States to ascertain risk (2015 *Certain Activities Case*, paras. 153-156). The preliminary requirement to first ascertain risk can be
190 connected to the due diligence obligation mentioned above. In other words, establishing the "risk" of an activity and minimizing or preventing the "actual harm/damage" of the activity are two distinct obligations owed by States (Viñuales 2020, p. 112). How States satisfy these two separate obligations is not always evident, but researchers may wish to keep this distinction in mind when clarifying with permitting authorities what their proposed projects may need to fulfill in terms of (1) any necessary EIA, and (2) the risk assessment that may be required prior to the EIA itself.

> ### Conclusion 3 – What constitutes "harm"?
> As mentioned, the fact that there is some measurable harm does not necessarily mean that an activity is illegal. In the context of international law, reference can be made to various thresholds of harm, including harm that is "serious" or "significant". The International Law Commission has noted that the term "significant" is "not without ambiguity" but that it could be

understood as "something more than 'detectable' but [not necessarily] at the level of 'serious' or 'substantial'" (ILC Draft Articles 2001, p. 152). In the context of OAE research, an evaluation of the degree of harm that an activity may cause could include examining the sensitivity of the proposed research area and the nature, scale and permanence of the effects that any research may have on the area (Brent *et al.*, 2019). Ultimately, however, the evaluation of harm must be done on a case-by-case basis by the State that has jurisdiction over the activity, and researchers should remain aware that "harm" may be defined differently for similar OAE activities in different jurisdictions. This conclusion is connected to the incorporation of international law into domestic law, and how national legal systems may have different thresholds for what harm may be legally tolerated in connection to an authorized research activity.

195   If the activity in question is deemed to require an EIA, a question remains as to what the EIA should, at a minimum, include? The answer to this question is developed further below but, at this point, it should be stressed that international courts and tribunals have unfortunately not yet provided clear guidance on what the actual content of an EIA should entail. Instead, it has been highlighted that "it is for each [State] to determine in its domestic legislation or in the authorization for the project, the specific content […] required in each case" (2010 *Pulp Mills Case*, para. 205).

> ### Conclusion 4 – Preliminary assessments, EIAs and the London Protocol?
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> The relationship between due diligence, preliminary assessments and subsequent EIAs is not always clearly demarcated. However, ~~and in adherence of customary international law,~~ an attempt to capture this relationship can ~~is~~ nevertheless ~~captured~~be found in the 2013 amendments to the London Protocol. In particular, the general assessment framework in the new annex 5 envisages both an initial and subsequently detailed EIA for legitimate "marine geoengineering" research projects. This is not to say that the London Protocol informs the content of any established customary international law. Rather, the regulation envisioned in the London Protocol is reflective of customary international law in requiring, first, an initial EIA and, subsequently, a more detailed assessment. Following this~~Seen through the lens of customary international law~~, the London Protocol may provide essential guidance in giving content to what an initial and subsequent EIA in the context of an OAE research project may entails and, ultimately, the future regulation of any OAE research activity (see 3.6 below).

200   **3.2 The United Nations Convention on the Law of the Sea**

With 169 States parties, UNCLOS enjoys near universal adherence. Even States that are not party to UNCLOS acknowledge the customary international law – and therefore binding nature – of many of its provisions, including those most pertinent to OAE research, such as the provisions regulating marine scientific research (MSR) and requiring protection and preservation of the marine environment (Burns 2023, p. 52).

> ### Conclusion 5 – Inevitable application of UNCLOS

> Any activity that involves a maritime component, no matter whether it can strictly be regarded as an ocean-based CDR approach or not, must be measured against the pertinent requirements of the jurisdictional framework codified in UNCLOS.

205 Part XIII of UNCLOS, concerning MSR, is particularly relevant for the research stage of OAE (Proelss 2023, pp. 103-105). Part XIII establishes a number of general principles applicable to MSR, including that research activities (i) be conducted exclusively for peaceful purposes; (ii) be conducted with appropriate scientific methods and means; (iii) not unjustifiably interfere with other legitimate uses of the sea; and (iv) be conducted in compliance with all relevant provisions of the Convention, including those for the protection and preservation of the marine environment (Article 240 UNCLOS). The

210 primary responsibility to ensure that research vessels, including those undertaking OAE research, comply with the relevant provisions of UNCLOS lies with the flag State in question (Burns 2023, p. 53).

Following the maritime zones established under UNCLOS (see 2 above), States have the right to conduct MSR within their own territorial seas and EEZs; within the terrestrial sea and EEZs of other States (subject to such other States' prior consent); and in the high seas (Articles 245, 246 and 87 UNCLOS respectively). As far as MSR in the EEZ of another State is concerned,

215 such other State "shall, in normal circumstances, grant their consent for [MSR] projects by other States or competent international organizations" (Article 246(3) UNCLOS). However, the expectation that such consent normally be granted by, for example, issuing necessary permits will most probably not apply to OAE research projects. This is due to the fact that a coastal State may withhold their consent if the proposed MSR involves "the introduction of harmful substances into the marine environment" (Article 246(5)(b)).

220 Concerning the protection and preservation of the marine environment, UNCLOS is one of several international treaties that require States to take active steps to avoid and/or mitigate harm to the marine environment, including harm caused by pollution. Article 1(1)(4) of UNCLOS defines pollution as the direct or indirect introduction by humans of "substances or energy into the marine environment […] which results or is likely to result in […] 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

225 use of sea water and reduction of amenities". OAE activities, including research activities, might be considered "pollution" under this definition. Specifically, the definition would capture OAE activities that involve the introduction of alkaline material or electric current (as energy) into the marine environment, at least where that introduction will or is likely to result in harm to the environment or humans.

Part XII of UNCLOS sets out an overarching legal regime to protect and preserve the marine environment, requiring States to

230 take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from "any source" (Article 194(1)), including pollution caused by dumping (Article 210), by vessels (Article 211), and pollution from or through the atmosphere (Article 212). Pollution caused by dumping is particularly relevant for OAE (see 3.6 below). UNCLOS requires States to adopt domestic laws and regulations to prevent, reduce and control pollution caused by dumping and to ensure that dumping is not carried out without permission of the competent State authorities (Articles 210(1) and (3)). In the territorial sea

235 or EEZ, coastal States have the right to permit, regulate and control dumping, but must consider any such dumping together with other potentially affected States (Article 210(5)). Any domestic laws, regulations and measures that States may adopt in this regard shall be no less effective in preventing pollution than global rules and standards (Article 210(6)). It is generally accepted that the London Convention and Protocol contain the relevant "global rules and standards" that national measures must be evaluated against (see section 3.6 below).

240 Also relevant to OAE is the obligations on State parties to UNCLOS not to transform one type of pollution into another (Article 195 UNCLOS) and to prevent pollution of the marine environment "resulting from the use of technologies under their jurisdiction or control" (Article 196(1) UNCLOS). Concerning the former obligation articulated in Article 195, some commentators have noted that this may have implications for OAE and other ocean CDR "projects that remove [carbon dioxide], which may be considered a form of pollution, from ocean waters by adding other materials, which may also constitute

245 pollutants, into the water" (NASEM 2022, p. 48). UNCLOS provides that, where there are reasonable grounds to believe that a planned activity may "cause substantial pollution of or significant and harmful changes to the marine environment, [States shall] assess the potential effects of such activities on the marine environment" (Article 205). The assessment of these "potential effects" should be understood as incorporating the customary international law obligation to undertake an EIA - and possibly also a preliminary risk assessment - into the framework of UNCLOS (see 3.1 above).

250 **3.3 The BBNJ Agreement**

~~Although t~~The BBNJ Agreement was formally adopted in June 2023~~has not yet been formally finalized, the adoption of the Agreement appears imminent. Following a decision of the General Assembly (see UNGA Doc. A/77/L.62 (29 March 2023)), a further resumed fifth session is scheduled for 19 and 20 June 2023, with a view to formally adopting the BBNJ Agreement.~~ It opened for signature in September 2023 and will enter into force 120 days after the 60th State ratifies it.

255 The objective of the ~~BBNJ~~ Agreement is "to ensure the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction, for the present and in the long term" (BBNJ Agreement, Art. 2 ~~of the Draft Agreement of 4 March 2023~~). The Agreement will only apply to areas beyond national jurisdiction but there is, as yet, limited knowledge of what impact the Agreement may have on OAE and ocean-based CDR generally. However, ~~considering the currently available Draft Agreement,~~ there is considerable reason to believe that aspects of the Agreement will potentially apply to OAE research

260 activities that take place in ocean areas beyond national jurisdiction.

The ~~current Draft~~ Agreement makes specific reference to "general principles and approaches" (BBNJ Agreement, Art. 7) including the freedom to undertake MSR; the precautionary principle/approach; and approaches aimed at building ecosystem resilience to the adverse effects of climate change and ocean acidification. Various provisions of the ~~Draft~~ Agreement~~, if adopted,~~ may be relevant for OAE research insofar as:

1. The establishment of area-based management tools are concerned. This includes the objective of such tools to protect, preserve, restore and maintain biodiversity and ecosystems and to strengthen resilience to stressors such as climate change, ocean acidification and marine pollution;

2. The obligation on States to undertake EIAs. The ~~Draft~~ Agreement contains comparably detailed provisions on EIAs, including screening requirements for activities that may have more than minor or transitory effects or where the effects are unknown or poorly understood (potentially relevant for OAE research), the process for undertaking EIAs, and the monitoring, reporting and review of the impacts of any authorized activities; and

3. The establishment of institutional arrangements. The ~~Draft~~ Agreement foresees the establishment of a number of institutions, including a Scientific and Technical Body, a Clearing-house Mechanism and, most notably, a Conference of the Parties (COP). The COP could potentially regulate a broad range of ocean-based activities undertaken in ocean areas beyond national jurisdiction (including research) but will, at a minimum, keep under review and evaluate the implementation of the BBNJ Agreement.

Most, if not all, of the obligations under the ~~Draft~~ BBNJ Agreement which might find application to OAE research – as an activity that may have unforeseen consequences if undertaken in ocean areas beyond national jurisdiction – are explicitly linked to an obligation on States to authorize/facilitate the actions of actors under their jurisdiction or control. One additional consideration potentially relevant to OAE research, is the fact that the Agreement does not require that an activity be screened or that any subsequent EIA be undertaken if a State determines that the impacts of the activity in question "have been assessed in accordance with the requirements of other relevant legal instruments or frameworks" (BBNJ Agreement, Art. 29(4)). Considering the ongoing work of the Contracting Parties to the London Protocol, including the evaluation of whether OAE activities can be considered as legitimate scientific research under the assessment framework of the London Protocol (see below), the interaction between these two international instruments in relation to OAE research should not be underestimated.

Conclusion 6 – The ~~Draft~~ BBNJ Agreement and OAE Research

While ~~Tt~~he BBNJ Agreement has ~~not yet been~~ formally been adopted ~~and, following any successful adoption~~, it ~~will~~ still needs to attract the required number of State ratifications before it enters into force. However, ~~If /~~ when it does enter into force, the BBNJ Agreement could have implications for OAE research undertaken in the high seas. Particularly relevant may be the comparably comprehensive EIA requirements in the Agreement for activities planned in the high seas. These relatively detailed requirements – which may be adapted and improved upon by the COP – may prove useful in providing guidance to what may be required of currently ambiguous EIA requirements under other law of the sea instruments such as, for example, UNCLOS. Additionally, the screening and EIA requirements under the Agreement can potentially be displaced/replaced by the ongoing work of the Contracting Parties to the London Protocol related to legitimate OAE research activities, and States and relevant authorities should remain aware of this cross-instrument fertilization as and when the work of the COP to the BBNJ finally commences.

3.4 The Convention on Biological Diversity

With 196 Contracting parties, the CBD enjoys near universal participation, and has been found to form "part of the corpus of general international law" (2016 *South China Sea Case*, para. 956). As with UNCLOS, the broad mandate and wide scope of application of the CBD means that Contracting parties have the opportunity to address a range of projects that may have an

290 impact on the environment, including the marine environment. The CBD imposes a number of substantive obligations on Contracting parties, including to identify activities that "have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and [to] monitor their effects" (Article 7(c) CBD); to adopt measures for in situ and ex situ conservation of biological diversity (Articles 8 and 9 CBD); to assess the impacts of projects on biological diversity (Article 14 CBD); to regulate access to genetic resources (Article 15 CBD); and with respect to access to and transfer

295 of technology (Article 16 CBD). In addition to these substantive obligations, the CBD also establishes a number of institutional arrangements for the further development, monitoring and implementation of the Convention.

As the governing body of the CBD, the Conference of the Parties (COP) has adopted a number of non-binding decisions related to "climate geoengineering". These decisions have been extensively discussed in previous publications (see e.g., Webb et al. 2023; Brent et al. 2019) and will thus not be analyzed in detail here. However, certain key aspects of the decisions are worth

300 noting. First, the decisions have continuously acknowledged that foundational principles of the CBD, including the precautionary approach, necessarily apply to "geoengineering activities", but concluded that these general obligations offer insufficient international regulation (see CBD COP Doc. CBD/COP/DEC/XIII/14 (8 December 2016), para. 2). Second, and given this, the COP has determined that "no climate-related geoengineering activities that may affect biodiversity [should] take place" at the current time but has stated that "small scale scientific research studies that could be conducted in a controlled

305 setting" may be allowed "if justified by the need to gather specific scientific data and [...] subject to a thorough prior assessment" (see CBD COP Doc. CBD/COP/DEC/X/33 (29 October 2010), para. 8(w)). Here, "climate-related geoengineering activities" mean activities that involve "[d]eliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and its impacts" (CBD COP Doc. CBD/COP/DEC/XI/20 (5 December 2012), para. 5). This definition would encompass large-scale OAE projects that are undertaken with the goal of mitigating climate

310 change (Webb et al., 2021). However, small-scale research projects would likely not be included. As noted above, the COP has indicated that small-scale research projects may be conducted in "a controlled setting" (provided certain other requirements are met), but has not elaborated on what that means. As some scholars have noted, it "could be argued that only research conducted in a laboratory or mesocosm… occurs in a 'controlled setting'", but the COP has not commented on this (Webb et al., 2023). As such, and given that the COP decisions are not legally binding, it will be up to individual States to decide whether

315 and how to apply them to OAE research projects.

The COP to the CBD has called for "transparent and effective" regulation of geoengineering activities (CBD COP Doc. CBD/COP/DEC/X/33 (29 October 2010), para. 8(w)). Additionally, and following this, a subsequent decision of the COP in 2014 noted – for the first time – the 2013 amendment to the London Protocol and invited "Parties to the London Protocol to

ratify this amendment and other Governments to apply measures in line with this" (CBD/COP/DEC/XII/20 (17 October 2014),

320 para. 1). In 2016, the COP also adopted a decision that emphasized the primacy of the UNFCCC in, amongst other things, the removal of carbon dioxide through "sinks" – the definition of which arguably includes CDR approaches such as OAE (see 3.5 below) (CBD/COP/DEC/XIII/14 (8 December 2016), para. 3).

Conclusion 7 – OAE under the CBD framework

Decisions of the COP to the CBD, including those that may find specific application to OAE research, are not legally binding. As long as the substantive obligations in the CBD are fulfilled (such as those associated with EIAs for example), nothing in the CBD prevents States from either undertaking or authorizing OAE research projects.

Brief reference should also be made to the recently agreed Kunming-Montreal Global Biodiversity Framework. This non-binding framework includes four overall goals and 23 targets to be achieved by 2030. Among other things, it calls for action

325 on the part of States to:

> "[m]inimize the impact of climate change and ocean acidification on biodiversity and increase its resilience through mitigation, adaptation, and disaster risk reduction actions, including through nature-based solution and/or ecosystem-based approaches, while minimizing negative and fostering positive impacts of climate action on biodiversity" (CBD COP Doc. CBD/COP/15/L.25 (18 December 2022)).

330 This broad wording leaves room for future decisions of the COP to possibly (re)address ocean-based CDR approaches. This is especially true for those approaches that may be deemed necessary by the COP of the CBD to combat ocean acidification and/or to increase the resilience of biodiversity by undertaking climate change mitigation action. This could include OAE. The Kunming-Montreal framework may, therefore, provide renewed opportunity for the COP to the CBD to guide ocean-based CDR policy and research – including OAE as an approach that could have co-benefits in combating other ocean stresses such

335 as ocean acidification.

3.5 The international climate change regime

Similar to the CBD and UNCLOS, the climate change regime enjoys near universal support and is also a framework regime – leaving the content of vaguely worded obligations open to interpretation by States. The foundation of the international climate change regime is the 1992 UNFCCC which has suitably been referred to as "nested" (Rajamani and Werksman, 2021, p. 497).

340 This apt description is in reference to the intrinsic relationship that exists between States parties and three related instruments, namely the UNFCCC, the 1997 Kyoto Protocol and the 2015 Paris Agreement. In line with this, "the parties to each instrument rely on most of the same institutions, including the governing body of the [Conference of the Parties], to serve all three instruments" (Rajamani and Werksman, 2021, p. 497). In outlining the current state of affairs under the climate regime as it relates to OAE research, this section focuses on the UNFCCC and the Paris Agreement.

345 The ultimate aim of the UNFCCC is to stabilize "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the global climate system" (Article 2 UNFCCC). Numerous studies have noted that the UNFCCC regime, including the Paris Agreement, approve the use of CDR approaches to mitigate climate change (see Honegger et al., 2021; Craik and Burns, 2019; Brent et al., 2019; Proelss and Steenkamp, 2023; NASEM, 2022). The reason for this finding is linked to the fact that States parties are required to limit greenhouse gas emissions, including by protecting

350 and enhancing sinks (Article 4(2)(a) UNFCCC). The definition of "sinks" in the UNFCCC includes "any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere" (Article 1 UNFCCC). This broad definition appears to extend beyond natural processes to also include human interventions such as OAE (NASEM 2022, p. 44).

For its part, the Paris Agreement aims to hold the increase in global temperatures to well below 2°C, ideally pursuing efforts

355 to limit such increase to 1.5°C (Article 2(1)(a) Paris Agreement). The manner in which States achieve this goal is left to their own nationally determined contributions (NDCs) – i.e. States determine both the extent to which, and the means by which, they contribute to the achievement of the objectives of the Paris Agreement. The Paris Agreement does, however, call on States parties to "reach global peaking of greenhouse gas emissions as soon as possible" and to "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" (Article 4(1) Paris Agreement). Additionally,

360 the Paris Agreement expressly calls on States to "conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases" (Article 5(1) UNFCCC). Since the definition of "sinks" in the UNFCCC applies *mutatis mutandis* to the Paris Agreement (Article 1 Paris Agreement), OAE and other ocean-based CDR approaches may, in certain circumstances, constitute mitigation action under the Paris Agreement (Honegger et al., 2021). That said, it should be stressed that neither the Paris Agreement nor the UNFCCC require States to engage in ocean-based CDR and, to date, no specific rules or guidelines

365 have been adopted under the Paris Agreement to regulate ocean CDR. However, important developments in recent years regarding the climate change regime, including as this relates to institutional arrangements, should be highlighted.

In 2019, the COP to the UNFCCC and the Paris Agreement (the CMA) agreed on the "Chile Madrid Time for Action", which recognized the need to strengthen understanding of, and action on, ocean and climate change under the UNFCCC (Doc. FCCC/CP/2019/13/Add.1 (16 March 2020)). In 2022, the COP and CMA adopted the Sharm el-Sheikh Implementation Plan,

370 encouraging State parties to consider, as appropriate, ocean-based action in their national climate goals, including in their NDCs (UNFCCC, Doc. FCCC/CP/2022/10/Add.1 (17 March 2023); UNFCCC, Doc. FCCC/PA/CMA/2022/10/Add.1 (17 March 2023)).

As one of two permanent subsidiary bodies established by the COP, the Subsidiary Body for Scientific and Technological Advice (SBSTA) regularly considers emerging science and research, including maritime technologies that have potential to

375 contribute to achieving the the goals of the UNFCCC and Paris Agreement (UNFCCC Contribution 2023). Within the forum of the SBSTA research dialogue, experts have emphasized the continued uncertainty surrounding ocean-based CDR approaches and have noted that OAE "may have transboundary risks that are already constrained by international agreements

such as the London Protocol and Convention, and by the CBD" (14th Meeting of the Research Dialogue, para. 187). The SBSTA has recently encouraged States "[p]arties and relevant organizations to strengthen research and research capacity and to address related research needs" including on the potential opportunities, governance needs, risks and costs of CDR approaches (UNFCCC, Doc. FCCC/SBSTA/2022/6 (28 July 2022), para. 62).

Another recent development concerns a controversial information note on "removal activities under the Article 6.4 mechanism" that was issued in May 2023. This information note was prepared by the UNFCCC Secretariat at the request of the Supervisory Body that is charged with supervising the market-based mechanism established in Article 6.4 of the Paris Agreement. Unlike the SBSTA mentioned above, this supervisory body is non-permanent, is fully accountable to the CMA and has been specifically established to supervise the Article 6.4 mechanism. In response to a request from the Supervisory Body for "technical information on… activities involving removals", the Secretariat issued the information note (see Art. 6.4 Mechanism information note, para. 2). The information note lists OAE as an "engineering-based removal activity" and provides brief information on the cost, potential, risks and impacts, co-benefits, and trade-off and spillover effects of OAE (Art. 6.4 Mechanism information note, appendix I). While the information note does not address the feasibility of OAE directly, it does mention that "[e]ngineering-based removal activities [including OAE] are technologically and economically unproven" and that these activities "do not contribute to sustainable development, are not suitable for implementation [and] therefore do not serve any of the objectives of the Article 6.4 mechanism" (Art. 6.4 Mechanism information note, para. 39 (table 3)). This conclusion has drawn considerable criticism, with the information note labeled as "imbalanced" and "ignoring science" (see, for example, Eve Tamme 2023). It should be stressed that the information note is *not* an operative document – i.e., it does *not* regulate OAE or other CDR approaches in a binding manner – but may provide insight into the current work of the UNFCCC to develop a general framework to guide the methodologies needed for removals.

Conclusion 8 *– Interaction between the Three Relevant Framework Treaties*

The framework nature of UNCLOS, the CBD and the climate change regime means that they will apply to OAE research. The extent to which they apply, however, is decidedly variable. Relevant CBD institutions have not directly addressed ocean-based CDR approaches since 2016. However, their potential to do so remains. UNCLOS and the climate change regime do not specifically regulate ocean-based CDR but are arguably more relevant for OAE activities, especially as this relates to marine scientific research, the protection and preservation of the marine environment and enhancing sinks, including in the ocean. The uniform development of the currently *ad hoc* and largely ambiguous international obligations found within these framework agreements will be crucial. Researchers, appropriate government departments and permitting authorities should, therefore, remain acutely aware of new developments and strive to enhance international coordination and cooperation when ocean-based CDR approaches, and OAE specifically, are discussed across various international regulatory regimes.

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4 The international regulation of "dumping"

As discussed above, UNCLOS imposes a general obligation on States to "prevent, reduce, and control pollution of the environment by dumping." UNCLOS further directs States to establish more detailed "global and regional rules, standards and recommended practices and procedures" with respect to dumping. Relevant global rules are set out in the London Convention and Protocol. The London Convention was adopted in 1972 with the goal of promoting "the effective control of all sources of pollution of the marine environment," particularly those resulting from the "dumping" of "waste or other matter" at sea. In November 1996, the parties to the London Convention adopted a new protocol, which set more ambitious goals for marine protection, aiming to "protect and preserve the marine environment from all sources of pollution" and to "prevent, reduce and where practicable eliminate pollution caused by dumping" of "waste or other matter." As explained further below, the definition of "dumping" in the London Convention and Protocol is arguably broad enough to encompass the discharge of materials into ocean waters in connection with OAE projects, at least in some circumstances. Nevertheless, questions remain about whether and how OAE will be regulated under the London Convention and Protocol. This section discusses how those instruments have been applied to similar activities – most notably ocean fertilization to evaluate their (potential) application to OAE.

The Contracting Parties to the London Convention and Protocol have concluded that the two instruments apply to ocean fertilization and, in 2010, adopted an assessment framework to guide the permitting of ocean fertilization research projects. Subsequently, in 2013, the Parties to the London Protocol adopted an amendment that effectively codified the approach set out in the assessment framework. The amendment has not yet entered into force and thus is not yet legally binding on Parties to the London Protocol, but could provide an indication of how the parties might approach other ocean CDR activities, including OAE.

> ***Conclusion 9** – OAE as pollution caused by "dumping"*
>
> Certain OAE research will necessarily involve the introduction of substances into ocean waters. The placement of alkaline minerals or their dissociation products into the marine environment may, at least in some situations, be classified as dumping under international law.

4.1 The London Convention and Protocol

The London Convention was the first global treaty adopted to regulate the dumping of wastes and other matter at sea. In 1996, the London Protocol was adopted with the intention that it would, as between the Contracting Parties, replace the Convention (i.e., if and when ratified by all Contracting Parties). However, this has not yet happened, and more than 30 Contracting Parties to the London Convention are yet to ratify the London Protocol. At the time of writing, the London Convention has 87 parties and the Protocol has 53.

The purpose of both the London Convention and Protocol is to prevent pollution of the marine environment by the dumping of wastes and other matter (Articles I LC and 2 LP). Both the London Convention and Protocol require dumping to be permitted by the State under whose jurisdiction it occurs. The two instruments establish quite different constraints on when countries may permit dumping. Under the London Convention, countries may permit the dumping of all substances, except those listed in its annexes. In contrast, the London Protocol reverses the burden of proof, prohibiting countries from issuing permits for the dumping of all substances except those listed in an annex to the Protocol.

4.2 Is OAE "dumping" under the London Convention and Protocol?

Previous studies have concluded that "non-research [OAE projects] could be permitted under the London Convention, but not the London Protocol" (see Webb et al., 2021). The below discussion is not concerned with non-research activities, and instead focuses on the extent to which the placement of alkaline material in the ocean in connection with OAE research might constitute "dumping" under the London Convention and Protocol.

Under the London Convention and Protocol, "dumping" is defined to include

> "any deliberate disposal into the sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea".

The phrase "wastes or other matter" is defined to mean "material and substance of any kind, form or description", while the term "sea" is defined as "all marine waters other than the internal waters of States" (Articles III(3) LC and 1(7) LP). Although internal waters are excluded from the definition of "sea", Article 7 of the London Protocol requires Contracting Parties to apply the provisions of the Protocol or other effective measures "to control the deliberate disposal of wastes or other matter in marine internal waters where such disposal would be 'dumping'" (Churchill et al., 2022, p. 670).

The London Convention and Protocol identify a number of activities that, while involving discharges into the ocean, do not constitute "dumping". Most notably, an activity is not dumping if it involves the "placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of" the London Convention or Protocol (Article III(1)(a) LC and Articles 1 (4.2.2) and (4.2.3) LP). This exception is of particular importance for OAE. It may be argued that, even if OAE involves the placement of matter (such as alkaline minerals) into the marine environment, this placement is aimed at increasing the alkalinity of seawater and increasing the uptake of carbon dioxide, rather than the "mere disposal" of the matter. If this view is accepted, OAE will not involve "dumping" within the terms of the London Convention and Protocol, provided that the placement of alkaline material into ocean waters is found not to be "contrary to the aims of" those instruments.

The objective of both the London Convention and London Protocol is to prevent pollution of the marine environment caused by dumping. Thus, where an OAE research activity is assessed to potentially result in pollution of the marine environment, that activity would be contrary to the objective of the London Convention and Protocol. It would, therefore, not qualify for the

455 placement exception in the definition of "dumping" in the London Convention and Protocol. That is, an OAE activity that results or is likely to result in pollution would likely be regulated as a form of "dumping" under the London Convention and Protocol.

4.3 Lessons from the treatment of ocean fertilization under the London Convention and Protocol for OAE research

The way in which the Contracting Parties to the London Convention and Protocol have thus far dealt with ocean fertilization
460 is perhaps indicative of how OAE might be dealt with in the future. The legal developments surrounding ocean fertilization under the London Convention and Protocol have been summarized as follows:

> "the meetings of the parties [to the London Convention and Protocol] adopted a resolution in 2008 in which they agreed that, given the then state of knowledge, ocean fertilization activities other than legitimate scientific research should not be allowed. To this end, such other activities should be considered as contrary to the aims of the Convention
465 and Protocol and not currently to qualify for any exemption from the definition of dumping. "Legitimate scientific research" into ocean fertilization requires a permit. In 2010 the meetings adopted an Assessment Framework to guide States when dealing with applications for such [legitimate scientific research] permits" (Churchill et al., 2022, p. 670).

The above-mentioned 2008 resolution, together with the subsequent assessment framework developed to evaluate legitimate scientific research involving ocean fertilization, formed the basis for amendments to the London Protocol in 2013.

470 In October 2013, the Meeting of Contracting Parties of the London Protocol adopted, by consensus, an amendment designed to regulate "marine geoengineering" activities (IMO Doc. LC 35/15, Resolution LP.4(8)). However, as commentators have rightly noted, the 2013 amendment is an amendment to "an existing environmental protection treaty and its capacity to provide a comprehensive governance framework for marine geoengineering activities will therefore be limited by the aims, scope and membership of the London Protocol itself" (Brent et al., 2019, p. 45).

475 The 2013 amendment will, when it enters into force, add two new Articles and two new annexes to the London Protocol . The first new Article, Article 1.5*bis*, defines "marine geoengineering" as the:

> "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".

480 This definition would seem to include OAE activities. The second new Article, Article 6*bis*, consists of three paragraphs. Article 6*bis*(1) prohibits the placement of matter for "marine geoengineering activities listed in [the new] annex 4, *unless* the listing provides that the activity or the subcategory of an activity may be authorized under a permit" (emphasis added). Thus, any activity that meets the definition of "marine geoengineering", that involves the placement of matter into the ocean, and that is listed in annex 4 is generally prohibited. There is, however, an exception for activities "authorized under a permit".
485 Article 6*bis*(2) requires Contracting Parties to:

"adopt administrative or legislative measures to ensure that the issuance of permits and permit conditions comply with provisions of annex 5 and takes into account any Specific Assessment Framework developed for an activity and adopted by the Meeting of the Contracting Parties. A permit shall only be issued after the activity has undergone assessment which has determined that pollution of the marine environment from the proposed activity is, as far as practicable, prevented or reduced to a minimum. A permit shall only be issued if the outcome of the assessment is that the activity is not contrary to the aims of the Protocol".

Ocean fertilization is currently the only marine geoengineering activity listed in annex 4. The annex provides that an ocean fertilization project "may only be considered for a permit if it is assessed as constituting legitimate scientific research taking into account" the general assessment framework set out in annex 5, and "any specific placement assessment framework" (2013 amendments, annex 4 1(3)). Annex 5 largely mirrors the assessment framework adopted by the Contracting Parties to the London Convention and Protocol in 2010. The Parties have agreed that the 2010 framework "should continue to be used" to evaluate proposed ocean fertilization projects (Resolution LP.4(8)). The assessment framework states that only projects meeting the following requirements "should" be viewed as involving legitimate scientific research:

- "the proposed activity [should be] designed to answer questions that will add to scientific knowledge";
- "the research methodology to be applied should be appropriate and based on best available scientific knowledge and technology";
- the project should be "subject to scientific peer review at appropriate stages";
- "economic interests [should] not influence the design, conduct and/or outcomes" of the project and there "should not be any financial and/or economic gain arising directly from the experiment or its outcomes";
- the project proponent should "make a commitment to publish the results in peer reviewed scientific publications" and have a plan for making "data and outcomes publicly available"; and
- the project proponent should have "the financial resources available before the work commences to fulfill the program of work".

The assessment framework also outlines requirements for evaluating the impacts of ocean fertilization projects, including a review of the proposed site for the project, the materials to be placed in the marine environment, and the "expected consequences" of that placement, with a particular focus on environmental consequences. According to the assessment framework, a project should only take place if "conditions are in place to ensure that, as far as practicable, environmental disturbance and detriment would be minimized" (2013 amendments, annex 5, para. 26).

After considering the scientific attributes and environmental impacts of an ocean fertilization project, a State may decide to (1) issue a permit for the project, (2) request additional information about the project (if it determines that the information provided is inadequate), or (3) refuse to issue a permit for the project. If a decision is taken to issue a permit, the permit:

"should be reviewed at regular intervals, taking into account the results of monitoring, the objectives of monitoring programmes and relevant research. Review of monitoring results will indicate whether field programmes need to be continued, revised or terminated and will contribute to informed decisions regarding the continuance, modification or revocation of permits. Monitoring provides an important feedback mechanism into future permitting decisions for the protection of human health and the marine environment" [2013 amendments, annex 5, para. 29].

Conclusion 10 – Regulation under the 2013 amendment is precautionary not prohibitory

The relatively strict regulation of scientific research in the 2013 amendment exemplifies the precautionary approach encapsulated in the London Protocol itself – relying on elements of risk characterization and risk management – and, thereby, connects the law of the sea as encapsulated in the London Protocol with international environmental law generally. Importantly, and despite these strict requirements, the regime established under the 2013 amendment to potentially regulate ocean-based CDR research is precautionary and not prohibitory.

4.4 Applying the "marine geoengineering" amendment to OAE research

As noted above, and despite not yet being in force, the 2013 amendment currently only applies to ocean fertilization. However, it could be expanded in the future to also apply to other ocean CDR activities that involve the placement of matter in the ocean in connection with "marine geoengineering". The definition of "marine geoengineering" is arguably broad enough to encompass OAE projects, at least where those projects have the potential to negatively affect the marine environment.

Conclusion 11 – The 2013 amendments and OAE research permitting

The potential applicability of the 2013 amendment to an OAE activity follows a step-by-step process:

(i)   OAE must be recognized as "marine geoengineering" and, subsequently, listed in annex 4;

(ii) once listed in annex 4, and assuming the parties treat OAE similarly to ocean fertilization, the general rule is that the placement of matter in the ocean for OAE will not be permissible unless it is permitted as legitimate scientific research;

(iii) any permit must meet the requirements of the general assessment framework included in annex 5 and/or any "special assessment framework" adopted for OAE.

There is reason to believe that the Contracting Parties to the London Protocol may be open to regulating OAE as a form of "marine geoengineering" under the 2013 amendment. In early 2022, the *GESAMP Working Group on Ocean Interventions for Climate Change Mitigation* (Working Group 41) identified seven marine geoengineering approaches "that the London Protocol Parties might wish to consider for listing in the new Annex 4 of the Protocol" (IMO Doc. LC/SG 44/16, para. 3.6). One of the identified approaches was "alkalinization of the ocean by adding alkaline material directly to the ocean or by electrochemistry" (GESAMP 49/4/8, para. 6.5).

At a meeting of the Scientific Groups of the London Convention and Protocol in April 2022, "a number of delegations generally agreed with the seven marine geoengineering techniques identified by GESAMP" (GESAMP 49/4/8, para. 7). The Scientific Groups re-established the Correspondence Group on Marine Geoengineering and directed it to "provide recommendations on the possible inclusion of marine geoengineering activities in the new annex 4 to the London Protocol" (GESAMP 49/4/8, PARA. 8). In its first progress report, issued in August 2022, the Correspondence Group identified four marine geoengineering techniques – including "enhancing ocean alkalinity" – as requiring "priority evaluation" (IMO Doc. LC 44/5, para. 4). The progress report further recommended that the Contracting Parties "(1) consider whether the four marine geoengineering techniques identified are within the scope of the London Convention and London Protocol; (2) consider how existing assessment frameworks apply and if they are adequate for assessing these four techniques; (3) if needed, adjust existing frameworks or develop new frameworks to address gaps; and (4) consider which of the techniques are suitable for listing in annex 4 to the London Protocol" (IMO Doc. LC 44/5, para. 9).

Subsequently, in October 2022, the Contracting Parties to the London Convention and Protocol adopted a "Statement on Marine Geoengineering" (IMO website (10 October 2022)). This statement agrees with the four techniques identified by the Correspondence Group as requiring priority evaluation and declares:

> "taking into account the precautionary approach outlined in Article 3 of the London Protocol (LP), and while the LP amendment on marine geoengineering awaits entry into force . . . Contracting Parties [are encouraged] to apply annex 5 (the marine geoengineering assessment framework) to evaluate proposed marine geoengineering projects, including the four techniques mentioned above, to apply the utmost caution to their consideration, and to provide information to LP/LC about ongoing and planned marine geoengineering activities" (IMO website (10 October 2022)).

Thus, regardless of whether OAE is listed as a marine geoengineering activity in annex 4, it seems likely that Contracting Parties to the London Convention and Protocol will evaluate OAE projects under the assessment framework in annex 5. ~~While such an evaluation is not legally required – because the October 2022 statement is not legally binding and the 2013 amendment has not yet entered into force – it does appear to have support within a fairly large segment of the international community.~~

5. Best practice guidance for OAE (field) research

As a matter of best practice, a few general points regarding OAE (field) research should be stressed. First, coherence should be sought at every available opportunity when designing OAE research projects. In this context, coherence refers to best effort attempts at establishing minimum requirements and thresholds for designing and implementing OAE research projects. The need for such coherence is rooted in the different but related mandates of various international regimes and the need for domestic legislation to align with any internationally agreed rules and standards of relevance to OAE research. To this end, best practice surrounding OAE research should account for the general considerations detailed above. These considerations include where in the ocean the project takes place; what exactly may be required by relevant authorities in the context of

preliminary risk assessments and any subsequent EIAs; and contemporary developments surrounding new international

565 regulation such as those ~~that may soon be~~ codified in the BBNJ Agreement (see generally Honegger et al. 2022, and Smith et al. 2023). Following this, OAE research projects could then apply the assessment framework set out in the 2013 amendment to the London Protocol. Such a step-by-step approach would assist in coherence and ensure that international and domestic legal systems – in their application of international law – adopt similar methods and processes for the authorization and subsequent permitting of OAE research projects. This strive for coherence will facilitate transparency and allow researchers

570 to more accurately pinpoint necessary considerations and legal requirements when designing and undertaking OAE research activities.

Second, OAE research objectives need to be aligned with the overarching policy considerations related to achieving the sustainable development goals of the United Nations, especially as this concerns human rights and biodiversity (see generally Enevoldsen et al. 2022 and Mace et al. 2021, pp. 28–37). In the words of the IPCC, mitigation action (which arguably includes

575 OAE) must "resolve tradeoffs with [the] sustainable development goals" (IPCC 2023, p. 31).

Third, it will be necessary to differentiate between large-scale field research and actual deployment. Given the potential need to test certain parameters and experimental designs at scale, this distinction may prove difficult in practice. However, some factors may be indicative of where to draw distinctions between research and deployment. These factors include particular OAE projects meeting agreed upon legal definitions for what constitutes "research", transparency requirements akin to research

580 and that ensure that every aspect of a project is publicised, and the size/scale of the project. In this regard, size/scale could refer to geographic scale of application/effect of the project as well as the total volume of carbon dioxide removed by a particular OAE activity (see Webb and Silverman-Roati 2023). Concerning the geological storage of carbon dioxide, the European Union distinguishes between projects "undertaken for research, development or testing of new products and processes" and which projects have a "total intended storage below 100 kilotonnes" (EU Directive, Art. 2(2)).

585 Fourth~~Additionally~~, and more specifically, OAE researchers should design projects to meet the requirements set out in the assessment framework ~~described above~~. The necessity for this is related to the strive for consistency and a possible centralized regime, as well as the fact that this would allow for the identification of shortcomings and subsequent improvements in the application of the assessment framework. In line with the assessment framework, OAE research projects should, therefore, have genuine scientific attributes – they should be designed to answer scientific questions; subject to peer review and

590 transparency requirements; and their conduct and outcomes should not be influenced by economic interests. Additionally, projects should also be designed so as to avoid, minimize, or mitigate any adverse environmental impacts.

While this is the minimum required to ensure OAE projects are conducted in accordance with the assessment framework for "marine geoengineering", in some instances, best practice may require that project proponents go further. This may be the case where, for example, research is proposed for coastal or other areas with existing human users. In such cases, researchers should

595 consider and take steps to minimize or mitigate any adverse social impacts (e.g., on coastal communities), in addition to

addressing environmental impacts as required by the assessment framework. Moreover, whereas the assessment framework focuses on avoiding adverse impacts from research, researchers should also consider potential benefits (both environmental and social). Projects should be designed to maximize any benefits and ensure that such benefits are equitably distributed. This will, necessarily, require effective engagement with potentially affected communities. For further discussion of this see Satterfield et al. (2023, this Guide)~~Chapter XXX~~ ~~in this issue~~ dedicated to the social considerations relevant to OAE.

6. OAE and additional legal research needs

The above discussion has highlighted some of the key legal considerations relevant to OAE research, especially for projects undertaken in the field. Importantly, most of the international laws discussed in this Chapter, including the 2013 amendment to the London Protocol, aim to prevent harm to the environment and do not necessarily "consider the growing need to develop geoengineering technologies to ameliorate climate change" (Brent et al., 2019 p. 46).

The above discussion has provided some reflections on how OAE research projects could be designed to fulfill general legal requirements (especially as this relates to environmental law) and the specific requirements under the 2013 amendment to the London Protocol. However, and as noted at the start of this Chapter, this discussion has only provided a "snapshot" and additional legal research is needed in a number of areas relevant to the design and subsequent implementation of OAE and CDR research projects generally. A full listing of all research gaps that should be addressed is beyond the scope of this chapter, but some examples are noted below.

International law's traditional regulation of States, rather than non-State actors, raises important questions for domestic legal systems that should be considered as a matter of priority. There is also an urgent need for research into the exact substantive and procedural requirements of any mandated preliminary risk assessments and subsequent EIAs (see 3.1 above). It may be valuable for legal researchers to undertake similar initiatives to those of the Code Project, which recently examined domestic and international EIA practice in order to identify essential features of what an EIA regime within the context of deep seabed mining may require (Code Project, 2023). This may prove useful if done in relation to OAE research – considering the requirements of the 2013 amendment to the London Protocol, instrument specific obligations requiring EIAs and the jurisprudence of international courts and tribunals.

Conclusion 12 – International and domestic legal systems

There is no one-size-fits-all approach to ascertaining how States incorporate international law within domestic contexts. Especially for activities that may have transboundary impacts however, international law remains relevant in demarcating minimum rules and standards that States are required to incorporate into domestic legislation. The incorporation of international law into domestic systems – particularly in the context of environmental law – is often connected to the discharge of a State's due diligence obligations. As OAE lab research transitions to field research, domestic legislation will need to regulate the activities of public and private researchers and their affiliated institutions. Therefore, States and their

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relevant authorities will need to remain aware of international developments in order to, at the very least, remain in line with developing international rules and standards specifically relevant to OAE research.

620 Other additional legal research needs surrounding OAE include issues related to liability and compensation; the responsibility of States for transboundary harm and the associated problems of unregulated/unauthorized research projects by State and non-state actors; the role of soft law instruments and principles of international (environmental) law (Armeni and Redgwell, 2015); and the impact of voluntary codes of conducts and principles for research on ocean-based CDR approaches generally (see, for example, Loomis et al., 2022; The Aspen Institute, 2021; and Hubert, 2021). With reference to the issue of liability and

625 compensation, more research is required in assessing what this may mean for situations where OAE research activities result in adverse pollution or other harmful consequences to the marine environment. Notably, both the London Convention and the London Protocol require that "Contracting Parties undertake to develop procedures regarding liability arising from […] dumping" (Article 15 LP, see also the Convention's equivalent in Article X LC). However, despite continued inclusion on the meeting agendas, the establishment of such procedures has thus far eluded the Contracting parties (Birchenough and Haag,

630 2020, p. 276).

> ### Conclusion 13 – Insurance and liability
>
> In line with established and developing principles surrounding international liability for operators and private actors, questions of insurance may be crucial for OAE research and (if deemed necessary) commercial deployment. The assessment framework contained in annex 5 of the 2013 amendments requires that sufficient "financial resources [be] available before the work commences" (annex 5, para. 8). However, there is no mention in the framework if "financial resources" also includes insurance should the research result in harm to the marine environment. Further research is needed to ascertain whether requiring insurance is necessary to account for situations where a permitted activity results in harm to the marine environment, or whether requiring insurance for research activities is an unnecessary burden for researchers and their institutions. In some cases, this may have far-reaching consequences for national authorities in whose legal systems the freedom of research is constitutionally guaranteed.

Lastly, it should be noted that although this Chapter has generally focused on framework treaties of general application and one not yet in force instrument that may offer specific application, this does not mean that other international instruments are not applicable. Given that ocean-based CDR approaches are generally aimed at mitigating the effects of climate change, their regulation has traditionally been dealt with as a matter for environmental law. However, the nature and potential transboundary

635 impact of ocean-based CDR approaches results in overlapping scenarios for regulation. In this regard, commentators have noted the connection between CDR approaches and international peace and security (Maas and Scheffran, 2012); intellectual property rights; matters of food security and international trade (Armeni and Redgwell, 2015); human rights related instruments (see Webb et al., 2023); and other international instruments specific to the conservation of migratory species and their natural habitats (see, for example, the 1979 Convention on the Conservation of Migratory Species of Wild Animals). These

640 traditionally distinct regimes are, to various degrees, captured in the Sustainable Development Goals (SDGs) of the United

Nations. The potential for an activity such as OAE to straddle several SDGs and the impact that this may have on international cooperation and coordination – especially in reaching climate, ocean, poverty eradication and other related SDG targets – also requires further consideration and research.

7. Conclusion

645 It has recently been determined that OAE "[f]ield trials are urgently needed in both coastal and open-ocean waters" (NASEM 2022, p. 203). Conclusions such as these, coupled with the urgent need for States to fulfill their climate obligations under various international instruments and the growing number of active projects, necessitates careful regulation of OAE. Any domestic regulatory regimes adopted by States must fulfill their international responsibilities with respect to protecting and preserving the marine environment and safeguarding potentially affected global or local communities. Among other things,
650 States must fulfill their due diligence obligations in ensuring that the activities of researchers, operators and other private actors within their jurisdiction or control are adequately regulated. At the same time, however, any domestic regulations must remain flexible enough to adapt to rapid technological developments and changing international frameworks.

How States regulate OAE research activities will ultimately depend on the State in question and differences in domestic legal systems are unavoidable. However, developing a robust framework within international law may increase transparency and
655 assist States in adopting uniform requirements associated with preliminary risk assessments; environmental impact assessment; subsequent monitoring; and permitting conditions and procedures for OAE research.

There is a need for further legal research on issues related to OAE research. For example, the relationship between OAE research (as an activity with potentially harmful impacts on the marine environment and/or local coastal communities) and the liability of States and private operators requires further consideration. This is especially true with regard to issues of insurance
660 and the impact that this may have on the freedom of research and the role of private investors.

It remains crucial that legal researchers work with the scientific community and those from other disciplines to assist States in understanding the science-policy interface in order to develop a comprehensive legal framework for ocean-based CDR approaches that will, in turn, guarantee that field research is carried out in a safe and responsible manner and in a manner that reduces the likelihood of adverse environmental and other consequences.

665 **Competing interests**

The contact author has declared that none of the authors has any competing interests.

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