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International Legal Regimes and Principles Relevant to Geoengineering

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1. INTRODUCTION

Geoengineering has only recently entered into serious scientific and policy discussions. Recognition of the need for geoengineering governance, whether formal or informal, is growing, but has yet to achieve a critical mass. At present, no international agreements directly address geoengineering. Nonetheless, various treaties as well as principles of international law are potentially relevant and will likely play a role in future geoengineering governance. These legal authorities fall into three categories: (1) treaties that may have applicability to geoengineering generally, regardless of the specific technique used; (2) treaties whose applicability may depend on the geoengineering method or the medium affected; and (3) non-treaty sources of law, including customary international law and other sources of legal norms. Given the arduous process of international treaty-making and the lack of specific treaty provisions that speak directly to geoengineering, the last of these categories could wind up playing the most significant role in international geoengineering governance; however this chapter will examine the potential role of all three of these categories

2. GENERAL TREATIES

This section considers the first category: international agreements whose ambit arguably extends to geoengineering projects and research in a general sense. Such agreements include: the United Nations Framework Convention on Climate Change,[1] the Convention on the Prohibition of Military or Any Other

[1] United Nations Framework Convention on Climate Change, May 9, 1992, S. TREATY DOC. NO. 102–38, 1771 U.N.T.S. 164 [hereinafter FCCC], *available at* http://untreaty.un.org/English/notpubl/unfccc_eng.pdf.

Hostile Use of Environmental Modification Techniques,[2] and the Convention on Biological Diversity.[3]

2.1 *United Nations Framework Convention on Climate Change*

The United Nations Framework Convention on Climate Change (UNFCCC) is a logical starting point for considering the potential locus of formal geoengineering governance because of its focus on addressing climate change. Addressing geoengineering through the UNFCCC is appealing because virtually all nations are parties to the UNFCCC, there are already well-established institutions for administering and implementing the treaty, and these institutions could coordinate any geoengineering efforts with mitigation and adaptation strategies to combat climate change.[4] Indeed, the UNFCCC is a framework convention that contemplates the formation of more-specific protocol agreements as further information develops and as support for international cooperation builds. As explained below, however, the commitments made in the UNFCCC are general in nature and create no clear obligations with respect to geoengineering.

The UNFCCC's objective, for example, is to "achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[5] As this statement suggests, the negotiations leading to the UNFCCC focused primarily on the reduction of greenhouse gas (GHG) emissions; geoengineering did not receive serious consideration as a means of dealing with the growing climate crisis.[6] Nonetheless, the UNFCCC's objective statement could serve as the basis for distinguishing between carbon dioxide removal (CDR) techniques, which can contribute to stabilizing GHG concentrations, and solar radiation management (SRM) techniques, which do not. Moreover, SRM techniques – and perhaps some CDR techniques – themselves may conflict with the UNFCCC's objective to the extent that they constitute dangerous anthropogenic interference with the climate system.[7]

[2] Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, May 18, 1977, 31 U.S.T. 333, T.I.A.S. 9614 [hereinafter ENMOD].

[3] Convention on Biological Diversity, Preamble, June 5, 1992, 1760 U.N.T.S. 143 [hereinafter CBD], *available at* http://www.cbd.int/convention/convention.shtml.

[4] *See* Albert C. Lin, *Geoengineering Governance*, ISSUES IN LEGAL SCHOLARSHIP, July 2009, at 15, 19.

[5] FCCC, *supra* note 1, art. 2.

[6] *See* Daniel Bodansky, *May We Engineer the Climate?*, 33 CLIMATIC CHANGE 309, 313 (1996).

[7] The use of stratospheric aerosols to block solar radiation, for example, could adversely modify the Asian and African summer monsoons. *See* Alan Robock et al., *Regional Climate Responses to Geoengineering with Tropical and Arctic SO_2 Injections*, 113 J. GEOPHYS. RES. D16101 (2008); It has also been suggested that ocean fertilization efforts could result in increased methane emissions that would undermine carbon removal efforts. *See* THE ROYAL SOCIETY, GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY 18 (2009), *available at* http://royalsociety.org/Geoengineering-the-climate/.

Other provisions of the UNFCCC are also arguably relevant to geoengineering, but their precise application would be open to varying interpretations. For example, among the principles set out in Article 3 is the requirement that parties "protect the climate system for the benefit of present and future generations of humankind."[8] Whether SRM techniques such as stratospheric aerosols or cloud whitening "protect the climate system" is debatable. These techniques promise to ameliorate temperature increases, but would likely have their own adverse climatic effects. Given the UNFCCC's focus on emissions reductions, the better interpretation of "protect the climate system" is one that involves the maintenance of existing climate dynamics to the extent possible, and not just the partial replication of earlier climate conditions.

The precautionary principle, found in Article 3.3, is another provision of which application to geoengineering will likely be the subject of serious debate. Article 3.3 states that "lack of full scientific certainty should not be used as a reason for postponing" measures "to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects."[9] Because the precautionary principle generally is understood as an appeal for caution in the face of uncertainty, commentators tend to assume that given potential side effects, application of the principle would block the deployment of geoengineering projects.[10] Nonetheless, if the uncertainties and risks posed by climate change come to overshadow those posed by a particular geoengineering technique, the precautionary principle might actually support the deployment of techniques that mitigate climate change's adverse effects.[11] For example, if the climate system were to reach a tipping point beyond which there would be catastrophic effects such as the sudden melting of the West Antarctic ice sheet, the precautionary response might be to deploy an SRM technique.

Several of the commitments set out in Article 4 of the UNFCCC also may be relevant. Article 4.1(d) articulates the parties' obligation to "[p]romote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases."[12] This language, it could be argued, may support the deployment of CDR geoengineering projects such as ocean fertilization. Similarly, Article 4.1(g) and (h) describe obligations to promote and cooperate in research

[8] FCCC, *supra* note 1, art. 3.1.

[9] *Id.*, art. 3.3.

[10] *See, e.g.*, Bodansky, *supra* note 6, at 319–20.; John Virgoe, *International Governance of a Possible Geoengineering Intervention to Combat Climate Change*, 95 CLIMATIC CHANGE 103, 111 (2009); William Daniel Davis, Note, *What Does "Green" Mean?: Anthropogenic Climate Change, Geoengineering, and International Environmental Law*, 43 GA. L. REV. 901, 931–32 (2009).

[11] FCCC Article 3.3's declaration that the policies adopted should "cover all relevant sources, sinks and reservoirs of greenhouse gases" is arguably consistent with CDR geoengineering techniques.

[12] FCCC, *supra* note 1, art 4.1(d).

and information exchange relating to "the economic and social consequences of various response strategies," broad language that could be supportive of geoengineering research.[13]

In addition to the provisions already discussed, the UNFCCC regime may intersect with geoengineering in one other significant way: the issuance of carbon credits. Private interest in geoengineering, particularly ocean fertilization, has been sparked by the possibility that such projects could serve as a source of carbon credits, perhaps under the Clean Development Mechanism (CDM) of the Kyoto Protocol or in voluntary carbon markets.[14] However, satisfying CDM requirements that emissions reductions be "additional to any that would occur in the absence of the certified project activity" and that benefits be "real, measurable, and long-term"[15] is likely to be difficult.[16] Ascertaining the amount of carbon sequestered by ocean fertilization, for instance, requires not only accurate measurement of carbon flux over extended periods of time, but also complex modeling of the depletion of other nutrients that would no longer be available for phytoplankton growth.[17] Determining who should receive credits – the private entrepreneur undertaking a project, nations on whose territory the project is initiated, nations suffering adverse effects from the project, or the international community if a project takes place beyond national boundaries – is also likely to be a contentious issue.[18]

2.2 *ENMOD*

Another treaty with potential implications for geoengineering governance is the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, or ENMOD.[19] Developed in response to American attempts to use weather modification techniques as a tool of warfare during the Vietnam War, ENMOD prohibits parties from "engag[ing] in military or any hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any

[13] *Id.*, art. 4.1(g), (h). Relatedly, Article 4.1(f) requires parties to conduct impact assessments of projects undertaken to mitigate climate change.

[14] *See* ELI KINTISCH, HACK THE PLANET: SCIENCE'S BEST HOPE – OR WORST NIGHTMARE – FOR AVERTING CLIMATE CATASTROPHE 132–36 (2010); Sallie W. Chisholm et al., *Dis-Crediting Ocean Fertilization*, 294 SCI. 309 (2001).

[15] Kyoto Protocol to the United Nations Framework Convention on Climate Change art. 12.5, Dec. 10, 1997, U.N. Doc. FCCC/CP/1997/L.7/ADD.1, 37 I.L.M. 32.

[16] *See* David Freestone & Rosemary Rayfuse, *Ocean Iron Fertilization and International Law*, 364 MARINE ECO. PROGRESS SERIES 227, 231 (2008) (noting that so far, almost none of projects approved under the CDM have involved carbon sinks of any type).

[17] *See* Chisholm et al., *supra* note 14, at 310.

[18] *See* ROYAL SOCIETY, *supra* note 7, at 41; Freestone & Rayfuse, *supra* note 16, at 231.

[19] *See* ENMOD, *supra* note 2.

other State Party."[20] There are thus three key elements required to trigger ENMOD: (1) environmental modification; (2) widespread, long-lasting or severe effects; and (3) military or hostile use. The treaty defines "environmental modification" as "any technique for changing – through the deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere, and atmosphere or of outer space."[21] This broad definition encompasses virtually any geoengineering techniques that might be developed. Moreover, in order to be effective, geoengineering deployment would necessarily generate, or at least seek to generate, "widespread [or] long-lasting ... effects." The primary difficulty with applying ENMOD to geoengineering, however, is that the treaty is aimed specifically at the military or hostile use of environmental modification techniques. ENMOD explicitly provides that the use of such techniques for peaceful purposes is outside the treaty's scope.[22]

Under some circumstances, however, the deployment of geoengineering to counter climate change arguably would constitute hostile use. For example, suppose that a low-lying nation threatened by rising seas decided to implement a geoengineering project unilaterally, regardless of the adverse consequences on other countries. Although that nation might argue that its purpose was benign, adversely affected nations would certainly object, particularly if they were not warned or consulted. ENMOD's distinction between "military or any other hostile use" and "the use of environmental techniques for peaceful purposes" suggests that an actor's purpose is critical in determining the treaty's applicability. Nonetheless, objecting nations could reasonably argue that a party's failure to consult with affected nations or its knowledge of, recklessness, or even negligence with respect to the effects of a unilateral geoengineering project suffices to constitute "hostile use."[23]

Compared to other environmental treaties, ENMOD provides a relatively powerful mechanism for enforcement. Potential treaty violations are referred to the United Nations Security Council. If the Security Council's investigation determines that a violation has harmed or is likely to harm a party, other parties to ENMOD are to provide assistance to that party.[24]

[20] *Id.*, art. I. ENMOD neither addresses environmental modification undertaken by nonparties, including private actors nor does it govern the use of such techniques against nonparty states.

[21] *Id.*, art. II.

[22] *Id.*, art. III.

[23] The United States and the Soviet Union, which compiled the draft version of ENMOD, intended the term "hostile use" to be limited to hostile acts designed to cause destruction, damage, or injury to another state party. They did not intend to prohibit, for example, the use of environmental techniques during military training maneuvers or for scientific or economic purposes. *See* Susana Pimento & Edward Hammond, A Political Primer on the Environmental Modification Convention (ENMOD), CCD Negotiations: Article I (2002), http://www.sunshine-project.org/enmod/primer.html.

[24] *Id.*, art. V.3-V.5.

ENMOD is nevertheless subject to significant limitations. First, no party has ever been formally accused of violating ENMOD, and thus no referrals to the Security Council have taken place. Indeed, the treaty is rarely invoked and has been the subject of only two review conferences.[25] Moreover, less than half of the world's nations are parties to the agreement; nonparties include France, Indonesia, Saudi Arabia, and South Africa.[26] ENMOD's limited membership, combined with its narrow coverage, undermines its potential applicability.

The hypothetical situation described above, however, does underscore the importance of international norms of conduct, whether or not embodied in a formal treaty. Even relatively limited treaties such as ENMOD can serve as a foundation for the establishment of general norms. Thus, the principles underlying ENMOD would likely be invoked against nonparties who undertake hostile uses of geoengineering. Or, as other commentators have suggested, ENMOD might serve as a normative precedent against the use of geoengineering even for peaceful purposes.[27]

2.3 *Convention on Biological Diversity*

The Convention on Biological Diversity (CBD) is another treaty that could apply to geoengineering generally, and as described below, it has already come into play with respect to the governance of ocean fertilization geoengineering efforts. Signed in 1992, the CBD identifies the conservation of biodiversity as a "common concern" of humankind.[28] The CBD does not directly address geoengineering or climate change, but obviously is relevant to these topics insofar as they affect biodiversity. Rather than establishing comprehensive and binding international standards, however, the treaty relies primarily on national laws and policies to promote biodiversity.[29] Article 7(c), for instance, requires parties to "[i]dentify processes and categories of activities which have or are likely to have significant impacts on the conservation and sustainable use of biological diversity," but establishes no substantive duty to avoid or limit such impacts.

[25] *See* Susana Pimento Chamorro & Edward Hammond, *Addressing Environmental Modification in Post-Cold War Conflict* (2001), http://www.edmonds-institute.org/pimiento.html.

[26] *See* Status of Multilateral Arms Regulation and Disarmament Agreements: ENMOD, http://disarmament.un.org/TreatyStatus.nsf/ENMOD%20(in%20alphabetical%20order)?OpenView (listing 73 parties) (last visited Apr. 12, 2010).

[27] *See, e.g.*, Davis, *supra* note 10, at 936; William Pentland, *Is Geoengineering Legal?*, CLEANBETA, June 1, 2009, http://cleantechlawandbusiness.com/cleanbeta/index.php/2009/06/is-geoengineering-legal/.

[28] CBD, *supra* note 3, Preamble.

[29] *Id.*, arts. 8, 9, 10 (setting out obligations with respect to *in situ* conservation, *ex situ* conservation, and sustainable use of biological resources). The treaty does encourage parties to enter into agreements to notify and consult other states when activities carried out under a party's jurisdiction or control are likely to significantly and adversely affect biodiversity beyond that state. *Id.*, art. 14.1(c).

Growing interest in ocean fertilization prompted parties to the CBD to become involved in geoengineering governance. In May 2008, the Conference of the Parties to the CBD issued a decision "request[ing]" member states to ensure that ocean fertilization projects do not occur unless "there is an adequate scientific basis on which to justify such activities" and "a global, transparent and effective control and regulatory mechanism is in place for these activities."[30] The decision, however, does allow "small-scale scientific research studies within coastal waters" to proceed in the meantime, subject to several conditions.[31] Namely, such projects must be: (1) "justified by the need to gather specific scientific data"; (2) "subject to a thorough prior assessment of the potential impacts ... on the marine environment"; (3) "strictly controlled"; and (4) "not ... used for generating and selling carbon offsets or any other commercial purposes."[32]

One subsequent ocean fertilization experiment has raised serious questions about the administration of this exception and about potential conflicts between the CBD decision and treaties that address ocean pollution more specifically. In the February 2009 LOHAFEX experiment, German and Indian scientists released six tons of iron over a 300 km^2 section of the southern Atlantic Ocean.[33] Opponents contended that this release was neither small-scale nor within coastal waters. Proponents responded that the project was research-oriented and "coastal" because it was located in a region influenced by land.[34] Although the experiment ultimately went forward after the German government conducted further environmental review, the controversy highlighted criticisms of the scope of the CBD moratorium. Namely, critics have contended that limiting the research exception to small-scale studies in coastal waters is "arbitrary[] and counterproductive."[35] Small-scale studies in sensitive

[30] Ninth Meeting of the Conference of the Parties to Convention on Biological Diversity, Decision IX 16: Biodiversity and Climate Change, § C(4), UNEP/CBD/COP/DEC/IX/16 (Oct. 9, 2008), *available at* http://www.cbd.int/doc/decisions/cop-09/cop-09-dec-16-en.pdf. More recently, a scientific subcommittee of the CBD recommended that the Conference of the Parties adopt a similar position with respect to climate-related geoengineering generally. *See* Convention on Biological Diversity Subsidiary Body on Scientific, Technical and Technological Advice, *In-Depth Review of the Work on Biodiversity and Climate Change*, § A.5.(w), UNEP/CBD/SBSTTA/14/L.9 (May 14, 2010), *available at* http://www.cbd.int/sbstta14/meeting/in-session/?tab=2.

[31] *Id.*

[32] *Id.*

[33] *See* Richard Black, *Setback for Climate Technical Fix*, BBC NEWS, Mar. 23, 2009, http://news.bbc.co.uk/2/hi/7959570.stm. The experiment's outcome cast doubt on the efficacy of iron fertilization as a means of sequestering carbon because much of the resultant phytoplankton growth entered the food chain rather than sinking to the bottom of the oceans.

[34] *See* Editorial, *The Law of the Sea*, 2 GEOSCI. 153 (2009).

[35] Intergovernmental Oceanographic Commission (of UNESCO), *Report on the IMO London Convention Scientific Group Meeting on Ocean Fertilization*, at 4, IOC.INF-1247 (June 15, 2008), http://www.ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=2002; *See also* Editorial, *supra* note 34, at 153. The United Nations General Assembly, in contrast, issued a resolution "welcom[ing]" the CBD decision. Oceans and the Law of the Sea, G.A. Res. 63/111, ¶ 116, U.N. Doc. A/RES/63/111 (Dec. 5, 2008), *available at* http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N08/477/45/PDF/N0847745.pdf?OpenElement.

coastal areas could be more environmentally damaging than large-scale studies in less-sensitive areas, and useful information may not be available without performing large-scale experiments.[36] Furthermore, the CBD moratorium is arguably inconsistent with restrictions issued under the London Convention and Protocol, which are discussed below.

3. MEDIA-SPECIFIC TREATIES

In contrast to treaties of general applicability such as the UNFCCC, other treaties may apply only to particular types of geoengineering projects, depending on the nature of the projects or their potential environmental impacts. Specialized treaty regimes can offer potential advantages in terms of expertise and contextual considerations, but exclusive reliance on these regimes may result in gaps or inadequacies in oversight.[37] And as with the general treaties already discussed, these specialized (or media-specific) treaties were developed in response to other circumstances and may ultimately represent a poor fit for geoengineering regulation.[38]

3.1 *Ocean Fertilization*

For geoengineering projects involving ocean fertilization, the London Convention and London Protocol,[39] United Nations Convention on the Law of the Sea,[40] and various regional agreements may be relevant.[41]

[36] Intergovernmental Oceanographic Commission, *supra* note 35, at 2.

[37] , *See, e.g.*, ROBERT V. PERCIVAL ET AL., *Criticisms of Media-Specific Statutes in U.S. Environmental Regulation*, *in* ENVIRONMENTAL REGULATION: LAW, SCIENCE, & POLICY 96 (5th ed., 2006), may apply similarly to patchwork global regulation of geoengineering.

[38] *Cf.* Bodansky, *supra* note 6, at 316 (urging caution "about drawing conclusions from existing legal rules, for the simple reason that these rules were not developed with climate engineering in mind").

[39] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972, 1046 U.N.T.S. 120 [hereinafter London Convention]; 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, Nov. 7, 1996, 36 I.L.M. 1 [hereinafter London Protocol].

[40] United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS], *available at* http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm.

[41] The discussion here does not consider the storage of CO_2 in or under the seabed, which is generally categorized as a form of carbon capture and storage rather than as a type of geoengineering. For analyses of regulatory issues with respect to those techniques, see Ray Purdy, *The Legal Implications of Carbon Capture and Storage under the Sea*, 7 SUSTAINABLE DEV. L. & POL'Y 22 (2006); INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC SPECIAL REPORT ON CARBON DIOXIDE CAPTURE AND STORAGE 254–55, 308–09 (2005).

3.1.1 London Convention/London Protocol

The London Convention and London Protocol (LC/LP) seek to control sources of marine pollution by regulating the dumping of waste into the sea. The 1972 Convention, which eighty-six nations have ratified or acceded to,[42] prohibits, or requires a permit for, the dumping of specifically listed items at sea.[43] The more stringent 1996 Protocol, which is intended to replace the 1972 Convention and currently has been ratified by thirty-eight nations,[44] bans ocean dumping in general except for explicitly listed items.[45] Under each treaty, 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."[46] "Placement of matter for a purpose other than the mere disposal thereof," in contrast to dumping, is allowed as long as such placement is not contrary to the purposes of the treaty.[47]

Recent ocean fertilization proposals, including proposals to generate carbon offsets through commercial projects, have attracted the attention of the LC/LP parties.[48] In 2007, the meeting of the parties agreed that ocean fertilization falls within the jurisdiction of the LC/LP and that "given the present state of knowledge regarding ocean fertilization ... large-scale operations [are] currently not justified."[49] In 2008, the meeting of the parties adopted a resolution distinguishing between "legitimate scientific research" – which would be regarded as "placement of matter for a purpose other than the mere disposal thereof" – and other ocean fertilization activities, which "should not be allowed."[50] Drawing the line between legitimate

[42] *See* International Maritime Organization, Status of Conventions Summary (Feb. 28, 2011), http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx.

[43] London Convention, *supra* note 39, art. IV.1.

[44] *See* Conventions Summary, *supra* note 42.

[45] London Protocol, *supra* note 39, art. 4.1. The dumping of items listed in Annex 1 to the Protocol is subject to a permitting process. *Id.*, art. 4.1.2. One category of materials listed in Annex 1 is "inert, inorganic geological material," which arguably includes the iron dust that would be used in fertilization efforts. *See* Jennie Dean, *Iron Fertilization: A Scientific Review with International Policy Recommendations*, 32 ENVIRONS 321, 336 (2009).

[46] London Protocol, *supra* note 39, art. 1.4.1; London Convention, *supra* note 39, art. III.1(a).

[47] London Protocol, *supra* note 39, art. 1.4.2.2; London Convention, *supra* note 39, art. III.1(b)(ii).

[48] *See* Chris Vivian, *Towards Regulation of Ocean Fertilisation by the London Convention and London Protocol – The Story So Far*, GEOENGINEERING QUARTERLY (Mar. 20, 2010).

[49] International Maritime Organization [IMO], *Report of the Twenty-Ninth Consultative Meeting and the Second Meeting of Contracting Parties*, ¶ 4.23, LC 29/17 (Dec. 14, 2007), *available at* http://www.imo.org/includes/blastDataOnly.asp/data_id%3D20797/17.pdf. The meeting also endorsed a "Statement of Concern" prepared by scientific working groups declaring that "knowledge about the effectiveness and potential environmental impacts of ocean iron fertilization currently was insufficient to justify large-scale operations and that this could have negative impacts on the marine environment and human health." *Id.* ¶¶ 4.14, 4.23 (quoting LC/SG 30/14, ¶¶ 2.23 to 2.25).

[50] IMO, *Thirtieth Meeting of the Contracting Parties to the London Convention and the Third Meeting of the Contracting Parties to the London Protocol, Resolution LC-LP.1 (2008) on the Regulation of Ocean Iron Fertilization*, Res. LC-LP.1 (2008) (Oct. 31, 2008), http://www.imo.org/includes/blastDataOnly.asp/data_id%3D24337/LC-LP1%2830%29.pdf.

research and non-research activities, of course, will pose a challenging task. As for legitimate research, parties are to evaluate such proposals using "utmost caution and the best available guidance" pending the development of an assessment framework by scientific advisory groups to the LC/LP.[51] As of this writing, working groups continue to develop that framework and to analyze options for further regulating ocean fertilization under the LC/LP.[52] Significant questions to be resolved include: whether research activities should be subject to a permit; whether treaty amendments specifically addressing ocean fertilization are necessary; and how potential commercial benefits (e.g., from generating and selling carbon credits) should be addressed.[53] The governing bodies for the LC/LP are expected to consider adoption of the assessment framework in October 2010.[54]

3.1.2 Law of the Sea

The UN Convention on the Law of the Sea (UNCLOS) is a general regime for ocean governance that largely codifies existing customary international law. The duties set out in the treaty may relate to geoengineering in two fundamental ways. First, states have a general obligation to "protect and preserve the marine environment,"[55] including the obligation to "take ... all measures ... necessary to prevent, reduce and control pollution of the marine environment from any source."[56] To the extent that ocean fertilization projects generate marine pollution or harm the marine environment, those projects may be regulated or even prohibited. Second, the requirement to protect the marine environment arguably creates an affirmative obligation to adopt measures to combat ocean acidification and other adverse effects of higher GHG concentrations, including ocean fertilization and other carbon removal techniques.

With respect to the first theory, UNCLOS broadly defines "pollution of the marine environment" as "the introduction by man, directly or indirectly, of substances or energy into the marine environment, ... which results or is likely to result in such deleterious effects as harm to living resources and marine life [and] hazards

[51] *Id.*

[52] *See* IMO, *Report of the Thirty-First Consultative Meeting and the Fourth Meeting of Contracting Parties*, ¶¶ 4.14–4.39, LC 31/15 (Nov. 30, 2009), *available at* http://www.imo.org/includes/blastDataOnly.asp/data_id%3D27809/15.pdf. For a draft version of the assessment framework, see Draft "Assessment Framework for Scientific Research Involving Ocean Fertilization," LC/SG 32/15 Annex 2 (June 29, 2009), *available at* http://www.imo.org/includes/blastDataOnly.asp/data_id%3D26427/15.pdf.

[53] *See* LC 31/15, *supra* note 52, ¶¶ 4.33–4.39.

[54] *See* Vivian, *supra* note 48.

[55] UNCLOS, *supra* note 40, art. 192.

[56] *Id.*, art. 194.1.

to human health...."[57] Ocean fertilization undoubtedly would change the composition of the phytoplankton community and as a result would alter food webs and biogeochemical cycles and decrease oxygen levels in the oceans.[58] The duty to control pollution set out in UNCLOS includes the duty to ensure that pollution from activities under a state's control does not cause damage to other states and the duty not to transform one type of pollution into another.[59] Ocean fertilization projects will run afoul of this latter duty to the extent that they transform atmospheric pollution into marine pollution. Moreover, Article 210 of UNCLOS specifically requires states to adopt measures governing pollution of the marine environment by dumping, and such measures are to be no less stringent than global rules and standards[60] – that is, the standards set out under the LC/LP.[61] Although UNCLOS, like the LC/LP, distinguishes between dumping and placement for purposes other than disposal, ocean fertilization efforts are more accurately characterized as dumping rather than placement. Granted, iron fertilization would not be undertaken for the purpose of disposing iron. However, as David Freestone and Rosemary Rayfuse have argued, iron fertilization would serve as the means of placing excess carbon dioxide in the ocean for purposes of disposal.[62]

As under the LC/LP, one might distinguish between ocean fertilization research and ocean fertilization deployment under UNCLOS. UNCLOS explicitly protects the right to conduct marine scientific research.[63] Nonetheless, researchers hoping to conduct ocean fertilization experiments do not have free rein because this right is subject to the treaty's provisions for protecting the marine environment.[64] In other words, ocean fertilization research that may harm living resources and marine life would be subject to regulation under UNCLOS.

Although the standards applied under UNCLOS largely reiterate those established by the LC/LP, UNCLOS does offer some advantages in terms of enforcement. The LC/LP lacks an enforcement mechanism,[65] whereas UNCLOS prescribes compulsory dispute resolution procedures.[66] In addition, because of its near-universal membership,[67] UNCLOS also offers potentially broader coverage than the LC/

[57] *Id.*, art. 1.1(4).
[58] *See* Chisholm et al., *supra* note 14, at 310.
[59] *Id.*, arts. 194.2, 195.
[60] *Id.*, art 210.6.
[61] *See* Freestone & Rayfuse, *supra* note 16, at 229.
[62] *Id.*
[63] UNCLOS, *supra* note 40, art. 238.
[64] *Id.*, art. 240.
[65] *See* DAVID HUNTER ET AL., INTERNATIONAL ENVIRONMENTAL LAW & POLICY 819 (3d ed. 2007).
[66] UNCLOS, *supra* note 40, arts. 279–99.
[67] As of January 1, 2010, 160 nations have ratified or acceded to UNCLOS. *See* Table Recapitulating the Status of the Convention and of the Related Agreements, http://www.un.org/Depts/los/reference_files/status2010.pdf.

LP. However, both regimes rely on member states to implement standards adopted under the respective treaties, which may lead to uneven application and enforcement. As ocean fertilization projects will most likely occur on the high seas, flag states will have primary responsibility for enforcing applicable standards.[68] As such, project sponsors will have incentives to arrange for their projects to occur under the flag of states with weak or nonexistent enforcement regimes.[69]

As to the second theory, UNCLOS's duty to protect the marine environment could provide authority that would support ocean fertilization and other carbon sequestration projects. UNCLOS neither prescribes specific measures states must take in carrying out this duty nor does it specifically address climate change. Nevertheless, given that ocean acidification is associated with higher atmospheric carbon dioxide levels and the resultant adverse consequences on coral reefs and other marine life,[70] some CDR techniques could be defended as consistent with this duty. In particular, UNCLOS parties have an obligation to adopt laws to reduce and control pollution of the marine environment from or through the atmosphere.[71]

3.1.3 Regional Treaties

Regional agreements may also be relevant to particular ocean fertilization projects, depending on their location. For example, a number of experiments have focused on the "Southern Ocean," a region where iron fertilization might be effective because of the relatively large quantities of surface macronutrients returning to the deep ocean in that area.[72] For projects south of 60° south latitude, the Antarctic Treaty System would come into play.[73] The 1959 Antarctic Treaty addresses environmental matters only in passing; it recognizes the preservation and conservation of living resources in Antarctica as a "matter[] of common interest."[74] The 1991 Protocol on Environmental Protection, however, requires that activities in the Antarctic Treaty area be planned and conducted so as to avoid or limit adverse impacts on the environment.[75] The Protocol also requires the preparation of prior environmental

[68] UNCLOS, *supra* note 40, art. 216. Coastal states have enforcement authority over dumping occurring in their territorial waters and exclusive economic zones, and states where material to be dumped is loaded also have enforcement authority. *Id.*
[69] *See* Freestone & Rayfuse, *supra* note 16, at 230.
[70] *See, e.g.*, James C. Orr et al., *Anthropogenic Ocean Acidification over the Twenty-First Century and Its Impact on Calcifying Organisms*, 437 NATURE 681 (2005).
[71] UNCLOS, *supra* note 40, art. 212.
[72] *See* Ken O. Buesseler & Philip W. Boyd, *Will Ocean Fertilization Work?*, 300 Sci. 67 (2003).
[73] Antarctic Treaty art. VI, Dec. 1, 1959, 19 I.L.M. 860 (defining geographical scope of treaty provisions).
[74] *Id.*, art. IX.1(f).
[75] Protocol on Environmental Protection to the Antarctic Treaty art. 3, Oct. 4, 1991, 30 I.L.M. 1455.

assessments.[76] None of these provisions specifically addresses ocean fertilization. Nevertheless, as Daniel Bodansky has contended, any ocean fertilization projects in the Antarctic Treaty area would almost certainly be reviewed by the treaty parties, who have established a fairly well-developed and manageable system of international governance that includes a mandatory dispute settlement procedure.[77]

Another example of a potentially relevant regional agreement is the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), whose members include fifteen European countries bordering the Atlantic Ocean.[78] In prohibiting ocean dumping, OSPAR essentially tracks the London Convention and Protocol regime. By providing a regional governance mechanism, however, OSPAR does offer an additional and potentially more credible enforcement option.[79]

3.2 *Atmosphere-Based Geoengineering*

Proposals in this category include the release of sulfur aerosols into the stratosphere to block the sun's radiation,[80] as well as the seeding of clouds with seawater particles to increase their reflectivity.[81] The discussion here focuses on proposals involving stratospheric aerosols, which have received much attention because of their apparent advantages in cost and flexibility of deployment.[82] In contrast to the UNCLOS governance regime for the oceans, no global instrument governs the atmosphere.[83] Rather, states have sovereignty over the air space above their territories, subject to international norms regarding transboundary harm.[84] Regional air pollution agreements, however, as well as the Montreal Protocol,[85] may come into play.

[76] *Id.*, art. 8.

[77] *Id.*, arts. 18–20; *see* Bodansky, *supra* note 6, at 315.

[78] Convention for the Protection of the Marine Environment of the North-East Atlantic, Sept. 22, 1992, 32 I.L.M. 1069, http://www.ospar.org/html_documents/ospar/html/OSPAR_Convention_e_updated_text_2007.pdf [hereinafter OSPAR]; *see also* OSPAR Commission, About OSPAR, http://www.ospar.org/content/content.asp?menu=00010100000000_000000_000000 (last visited Apr. 2, 2010).

[79] OSPAR Annex II; *see* HUNTER ET AL., *supra* note 65, at 824.

[80] *See* Paul Crutzen, *Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?*, 77 CLIMATIC CHANGE 211, 211–12 (2006).

[81] *See* John Latham, *Control of Global Warming?*, 347 NATURE 339 (1990); John Latham et al., *Global Temperature Stabilization via Controlled Albedo Enhancement of Low-Level Maritime Clouds*, 366 PHIL. TRANS. ROY. SOC'Y A 3969 (2008), http://rsta.royalsocietypublishing.org/content/366/1882/3969.full.pdf.

[82] *See* David G. Victor et al., *The Geoengineering Option*, FOREIGN AFF., Mar./Apr. 2009, at 64, 69; Graeme Wood, *Moving Heaven and Earth*, ATLANTIC, July/Aug. 2009, at 70, 72.

[83] ROYAL SOCIETY, *supra* note 7, at 40.

[84] *Id.*

[85] Montreal Protocol on Substances That Deplete the Ozone Layer, Sept. 16, 1987, S. Treaty Doc. No. 100-10, 1522 U.N.T.S. 29 [hereinafter Montreal Protocol].

3.2.1 LRTAP

The Convention on Long-Range Transboundary Air Pollution (LRTAP)[86] is a regional framework agreement that obligates parties "to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution."[87] LRTAP's coverage is fairly broad, encompassing fifty-one nations in North America, Europe, and the former Soviet Union.[88]

LRTAP defines air pollution broadly as "the introduction by man ... of substances or energy into the air resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems and material property."[89] Although LRTAP itself contains relatively "soft" requirements, eight subsequent protocols to the agreement do set out binding obligations governing specific classes of pollutants.[90] Two of those protocols address sulfate emissions: the 1985 Protocol requires parties to reduce such emissions by 30 percent, and the 1994 Protocol mandates further reductions.[91] More specifically, the 1994 Protocol requires parties to "control and reduce their sulphur emissions in order to protect human health and the environment from adverse effects, in particular acidifying effects."[92] These protocols, which were intended to reduce acid precipitation, at first glance might appear to be a potentially significant hurdle to the implementation of sulfate aerosol geoengineering. The ultimate effect of these protocols, however, would depend largely on the amount of sulfur injected into the stratosphere in any geoengineering effort. Sizeable uncertainty surrounds the amount of sulfur that ultimately would be needed, given the complexities of atmospheric processes and unresolved details regarding how sulfur would be released and the aerosol particle sizes that would result.[93] Nonetheless, one study concluded that "the additional sulfate deposition that would result from geoengineering will not be sufficient to negatively impact

[86] Convention on Long-Range Transboundary Air Pollution, Nov. 13, 1979, 18 I.L.M. 1442 [hereinafter LRTAP].

[87] *Id.*, art. 2.

[88] *See* U.N. Economic Commission for Europe, Status of Ratification of the 1979 Geneva Convention on Long-Range Transboundary Air Pollution as of 1 March 2011, http://www.unece.org/env/lrtap/status/lrtap_st.htm (last visited June 10, 2010).

[89] LRTAP, *supra* note 86, art. 1(a).

[90] *See* PHILIPPE SANDS & PAOLO GALIZZI, DOCUMENTS IN INTERNATIONAL ENVIRONMENTAL LAW 33 (2d ed. 2004).

[91] Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the Reduction of Sulphur Emissions or Their Transboundary Fluxes by at Least 30 Per Cent, July 8, 1985, 27 I.L.M. 707, 1480 U.N.T.S. 217; Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions, June 14, 1994, 33 I.L.M. 1542 [hereinafter 1994 Protocol]. The United States is a party to LRTAP, but not to either of the Sulphur Protocols.

[92] 1994 Protocol, *supra* note 91, art. 2.1.

[93] *See* Philip J. Rasch et al., *Exploring the Geoengineering of Climate Using Stratospheric Sulfate Aerosols: The Role of Particle Size*, 35 GEOPHYS. RES. LETT. L02809 (2008).

most ecosystems"[94] in terms of the direct effects of acid precipitation. In other words, the LRTAP Protocols would most likely not be an insuperable barrier to the use of sulfate aerosols, unless their scope is more expansively understood to include adverse environmental effects other than acid precipitation.

3.2.2 Montreal Protocol

The Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer restricts the consumption and production of ozone-depleting substances.[95] Sulfate aerosols themselves do not destroy ozone directly. If injected into the stratosphere, however, they provide a surface for the activation of ozone-destroying chlorine gases already present, thereby intensifying their ozone-depleting effect and delaying recovery of the ozone layer.[96] The Montreal Protocol regime does not presently regulate sulfates that could wind up in the stratosphere.[97] However, given the potential for stratospheric aerosols to undermine the fundamental objective of the Protocol, the parties to the Protocol would likely take action to address geoengineering projects involving the release of stratospheric aerosols.[98] The Protocol requires the parties to assess and review its control measures at least every four years, and it authorizes the adoption of new control measures as needed.[99]

3.2.3 Space-Based Geoengineering

Serious geoengineering discussions to date have focused primarily on ocean fertilization and on land-based or atmosphere-based proposals. Nonetheless, there are also proposals to deploy shields or other means of blocking solar radiation in outer space.[100] Compared to the use of stratospheric aerosols, such an approach would be far more costly and would face more complicated barriers to implementation.[101]

[94] Ben Kravitz et al., *Sulfuric Acid Deposition from Stratospheric Geoengineering with Sulfate Aerosols*, 114 J. GEOPHYS. RES. D14109 (2009).

[95] Montreal Protocol, *supra* note 85.

[96] *See* Simone Tilmes et al., *The Sensitivity of Polar Ozone Depletion to Proposed Geoengineering Schemes*, 320 SCI. 1201 (2008).

[97] Montreal Protocol (as amended), *supra* note 85, art. 2A-2I, Annex A-Annex C.

[98] *Cf.* Virgoe, *supra* note 10, at 111.

[99] Montreal Protocol (as amended), *supra* note 85, arts. 2.10, 6. The parties to the Protocol have made frequent use of the Protocol's adjustment and amendment processes. *See* HUNTER ET AL., *supra* note 65, at 589–94.

[100] *See, e.g.*, Roger Angel, *Feasibility of Cooling the Earth with a Cloud of Small Spacecraft Near the Inner Lagrange Point*, 103 PROC. NAT'L ACAD. SCI. 17,184 (2006).

[101] Under one proposal, approximately 16 trillion discs would need to be manufactured and placed in orbit, at an estimated cost of $5 trillion. *See* Oliver Morton, *Is This What It Takes to Save the World?*, 447 NATURE 132, 136 (2007).

With respect to space-based geoengineering, the most pertinent international agreement is the 1967 Outer Space Treaty.[102] Established to prevent a race to militarize or colonize outer space, this treaty declares outer space to be the "province of all mankind," "free for exploration and use by all States."[103] The treaty further provides that parties are to conduct research or activities in outer space "with due regard to the corresponding interests" of other parties "so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter."[104] Although one can imagine arguments that a space-based geoengineering project would be contrary to the interests of a party and adverse to the environment,[105] the language of these provisions is hardly definitive or dispositive, particularly because it focuses on harms "resulting from the introduction of extraterrestrial matter." In addition, the treaty lacks a dispute settlement mechanism that might address objections to a geoengineering project.[106] Nonetheless, like ENMOD, the treaty might serve as a source of norms regarding international consultation and cooperation with respect to geoengineering.

4. NORMS

Although a sizeable number of existing multilateral agreements could apply to geoengineering, none of them provides a complete or direct response to the challenges raised. Given the significant gaps left by existing treaties, customary international law and general principles will likely play a critical, if not predominant, role in geoengineering governance. Several international environmental norms reflected in various treaties and other international documents are likely to be invoked. These norms include principles regarding transboundary harm, the precautionary principle, and the principle of intergenerational equity.[107]

With respect to transboundary harms, there are several relevant norms. First, a nation that carries out an activity resulting in transboundary harm has an obligation

[102] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205, *reprinted in* 6 I.L.M. 386 (1967).

[103] *Id.*, Preamble, art. I.

[104] *Id.*, art. IX.

[105] For example, a country that benefits from more moderate temperatures and increased rainfall as a result of climate change might object that it would be harmed by geoengineering efforts.

[106] *See* Bodansky, *supra* note 6, at 314.

[107] *See* ROYAL SOCIETY, *supra* note 7, at 40. The U.N. Environment Programme's Weather Modification Guidelines, although concerned with modification of weather rather than climate, articulate several of these norms. U.N. Environment Programme, *Provisions for Cooperation between States in Weather Modification*, Dec. 8/7/A of the Governing Council (Apr. 29, 1980), http://www.unep.org/Law/PDF/UNEPEnv-LawGuide&PrincN03.pdf.

to notify and consult with potentially affected states.[106] Given the potential for intended and unintended consequences of geoengineering efforts to affect many nations, notification, consultation, and transboundary environmental impact assessment would almost certainly be required.[109] Second, a nation has an obligation not to cause environmental harm to others, or at least to take practicable steps to control such harm.[110] Although this norm is well-established,[111] its applicability may depend on the amount of harm resulting from a geoengineering project and the degree of care taken by the responsible state. Third, to the extent that harm does occur, a nation is responsible for the costs of mitigating or compensating such harm.[112] This norm may well require the establishment of a compensation fund and a procedure for making and resolving compensation claims prior to the execution of a geoengineering project.

The roles and effects of other potentially relevant norms are less clear. As discussed above, the precautionary principle would likely counsel caution in the deployment of geoengineering,[113] but the principle is a subject of some controversy and arguably has not attained the status of customary international law.[114] The principle of intergenerational equity, which counsels that present generations not leave future generations in a worse position with respect to options and resources,[115] is more widely accepted. But its precise application with respect to geoengineering efforts is unclear; one of the attractions of at least some types of geoengineering is their apparent cost advantage over emission reduction efforts. Assuming that such a cost advantage exists, some might contend that geoengineering would not run afoul of the principle so long as it leaves future generations with greater financial resources,

[106] *See* Rio Declaration on Environment and Development Principle 19, June 14, 1992, U.N. Doc. A/CONF. 151/5, 31 I.L.M. 8744 (1992) [hereinafter Rio Declaration].

[109] *See* HUNTER ET AL., *supra* note 65, at 532 ("In the transboundary context, many commentators believe that the duty to conduct an EIA is probably now a requirement of customary law."); NEIL CRAIK, THE INTERNATIONAL LAW OF ENVIRONMENTAL IMPACT ASSESSMENT: PROCESS, SUBSTANCE AND INTEGRATION 15 (2008) (noting "existence of a large number of treaty-based EIA commitments").

[110] *See* Stockholm Declaration of the United Nations Conference on the Human Environment Principle 21, June 16, 1972, U.N. Doc. A/CONF.48/14 (1972), *reprinted in* 11 I.L.M. 1416 (1972) [hereinafter Stockholm Declaration]; Rio Declaration, *supra* note 108, Principle 2.

[111] *See, e.g.*, HUNTER ET AL., *supra* note 65, at 502 (describing the obligation not to cause environmental harm as "[a] central principle of international environmental law" and "a part of customary international law").

[112] *See* Stockholm Declaration, *supra* note 110, Principle 22; Rio Declaration, *supra* note 108, Principle 2.

[113] *See supra* text accompanying notes 9–11.

[114] *See* Rio Declaration, *supra* note 108, Principle 15; Jutta Brunnee, *The Stockholm Declaration and the Structure and Processes of International Environmental Law*, *in* THE STOCKHOLM DECLARATION AND LAW OF THE MARINE ENVIRONMENT 67, 77 (Myron H. Nordquist et al. eds., 2003).

[115] *See* Stockholm Declaration, *supra* note 110, Principles 1, 2; Rio Declaration, *supra* note 108, Principle 3.

even if they would be living in a world with lesser natural bounty. Conversely, many geoengineering schemes, once deployed, would potentially tie the hands of future generations by requiring them to continue geoengineering efforts for many years in order to avoid a rebound effect from their sudden cessation.

5. CONCLUSION

International cooperation on deciding how to proceed with geoengineering, if at all, is hardly assured. Global governance of geoengineering could occur through existing treaties, new treaty instruments, or ad hoc responses to individual geoengineering proposals or projects. Whatever governance does occur is likely to be driven by international norms such as those regarding transboundary harm and equity, rather than by the formal requirements of existing treaty regimes. Developing a governance structure to address geoengineering research and deployment at an early stage, rather than relying on ad hoc responses to later crises, would be preferable for a number of reasons: it can help assure that research is carried out with the blessing of the international community and with proper safeguards, establish oversight of geoengineering efforts, and minimize the influence that vested interests might have on governance structures and decisions.[116] But even in the absence of specifically applicable treaty provisions, geoengineering will be too important a subject, with effects too universal, for the international community to ignore.

[116] *See* Lin, *supra* note 4, at 19–20.