5-28-2013

Engineering the Climate: Geoengineering as a Challenge to International Governance

David A. Wirth
Boston College Law School, wirthd@bc.edu

Recommended Citation
David A. Wirth. "Engineering the Climate: Geoengineering as a Challenge to International Governance." *Boston College Environmental Affairs Law Review* 40, no.2 (2013): 413-437.

ENGINEERING THE CLIMATE: GEOENGINEERING AS A CHALLENGE TO INTERNATIONAL GOVERNANCE

David A. Wirth*

Abstract: The challenge of global climate change has attracted recommendations for remediation from a number of professions, including engineering. The possibilities suggested for "geoengineering" the climate generally fall into one of two categories: (1) removing gaseous carbon dioxide from the air and storing it in long-term repositories ("carbon dioxide removal"); and (2) limiting or reducing the intensity of incoming electromagnetic waves from the sun ("solar radiation management"). Specific and often controversial proposals include the aerial dispersion of aerosols, launching reflective gratings into orbit around the Earth, and seeding the oceans with iron filings. These proposals share the following characteristics: (1) they can be undertaken within the territorial jurisdiction of a single state or in areas beyond national jurisdiction; (2) they are likely to, and are intended to, have extrajurisdictional—indeed, global—effects; and (3) they are largely unregulated at the international level. This Essay examines the existing international governance structures to address geoengineering and concludes that they are inadequate to the task. After reviewing those modest international measures that have been adopted to regulate climate geoengineering proposals, the Essay makes recommendations for structural adaptations in international governance to address the problem of climate change.

Introduction

From the point of view of environmental professionals, climate change, the warming of the planet caused by rising levels of heat-trapping greenhouse gases ("GHGs") accumulating in the Earth's atmosphere, seems to offer something for everyone. Not surprisingly,

---

* Professor of Law and Director of International Studies, Boston College Law School. The author gratefully acknowledges the assistance and comments of Flynn Barclay, William Burns, Nick Feinstein, and Susan Vaughn in the preparation of this Essay. The responsibility for all views expressed in this Essay, however, is the author's own. Portions of this Essay are based on the author's previously published writings. This project was supported by a generous grant from the Dr. Thomas F. Carney '47 Gift Fund.

training and specialization affect the perspective from which those from different disciplines approach the challenges of global warming. Differing skill sets and mission orientations inevitably find expression in varying approaches to the task. Scientists offer predictions of temperature increases for varying emissions scenarios, and attempt to anticipate the scope and magnitude of effects such as sea level rise and loss of biodiversity.[1] Lawyers write legislation, draft international instruments, and litigate with the aim of enforcing compliance with environmental requirements. Economists debate the relative merits of carbon taxes versus cap-and-trade proposals, and quibble over discount rates.[2]

As indicated by the dictionary definition of "engineering," that discipline can be expected to bring to the issue of climate change a predisposition toward the practical, real-world "application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people."[3] In other words, engineers build things. This propensity to look at the world as fertile ground for improving on nature has led to "geoengineering" proposals intended to respond to the problem of climate change through physical interventions in the biosphere. Geoengineering proposals are not intended to reduce emissions of greenhouse gases or facilitate adaptation to the inevitable increase in global temperature, but instead aim at removing carbon from the atmosphere, preventing solar radiation from reaching the Earth's surface, and implementing other mechanical and chemical interventions in the global ecosystem to offset or prevent global temperature rise.[4]

Although apparently novel in intent and design, geoengineering proposals that target the effects of climate disruption have much in common with other engineering projects, at least at first blush. From an international law perspective, climate engineering interventions can be analyzed, at least in part, using existing analytical approaches. Accordingly, this Essay first identifies a representative sample of geoengineering

---

[1] *See, e.g.*, Intergovernmental Panel on Climate Change, Climate Change 2007: The Physical Science Basis, 387–88 (Susan Solomon et al. eds., 2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4_wg1_full_report.pdf.

[2] *E.g.*, Nicholas Stern, The Economics of Climate Change: The Stern Review (2010). *But see* William Nordhaus, *Critical Assumptions in the Stern Review on Climate Change*, 317 Sci. Mag. 201 (2007) (criticizing the Stern Review).

[3] *Engineering*, Merriam Webster Online Dictionary and Thesaurus, http://www.merriam-webster.com/dictionary/engineering (last visited May 1, 2013).

[4] *See* David W. Keith, *Geoengineering the Climate: History and Prospect*, 25 Ann. Rev. Energy & Env't 245, 247 (2000).

schemes.[5] In Part II, the Essay characterizes those proposals from an international legal and structural point of view.[6] Potential multilateral settings for coordinated international action are examined, and those multilateral instruments that have been adopted are scrutinized.[7] Finally, in Part III the Essay evaluates climate engineering as a failure of multilateral governance and makes a number of suggestions for reform.[8]

I. Geoengineering Proposals

"Geoengineering" refers to large-scale techniques directed at mitigating the environmental harm caused by human beings.[9] In the context of climate change, geoengineering proposals often aim to minimize or offset the heating effects of GHGs.[10] Although pursuing the same goal, geoengineering as a strategy is distinct from the public policy of reducing emissions of GHGs to combat global heating trends.[11] Geoengineering proposals to combat global climate change vary widely, and run the gamut from those that are modest and self-evident to others that are esoteric and marginally plausible.[12]

Most serious proposals can be separated into two groups, based on their objectives: (1) removing carbon dioxide ("CO_2") from the atmosphere; and (2) reducing the amount of solar radiation reaching the planet's surface, thereby lessening heat absorption by land and water and in the atmosphere.[13]

Either of these strategies, if implemented safely and effectively, could slow or even stop the warming of the planet caused by the greenhouse effect.[14] While some approaches might be effective, unintended

---

[5] *See infra* notes 9–60 and accompanying text.

[6] *See infra* notes 61–77 and accompanying text.

[7] *See infra* notes 78–130 and accompanying text.

[8] *See infra* notes 131–170 and accompanying text.

[9] *See* United Nations Environment Programme, Oct. 18–19, 2010, *Biodiversity and Climate Change*, 5, n.3, UNEP/CBD/COP/DEC/X/33 (Oct. 29, 2010) [hereinafter *2010 COP*], *available at* https://www.cbd.int/doc/decisions/cop-10/cop-10-dec-33-en.pdf; David W. Keith, *Geoengineering*, 409 Nature 420, 420 (2001).

[10] *See* Albert C. Lin, *Geoengineering Governance*, 8 Issues in Legal Scholarship 1, 2 (2009).

[11] *Id.*

[12] *See infra* notes 16–60 and accompanying text.

[13] *See infra* notes 16–60 and accompanying text.

[14] *See* Sci. & Tech. Committee, Regulation of Geoengineering, 2009–10, H.C. 221, at 11–14 (U.K.).

consequences may be difficult to predict.[15] Several of the geoengineering proposals currently receiving some level of serious consideration are set out below, comprising a compendium that is intended to be illustrative rather than comprehensive.

A. *Carbon Dioxide Removal*

In 2010, CO_2 accounted for approximately 84% of the GHGs emitted by human activity in the United States.[16] Consequently, reducing CO_2 concentration in the atmosphere could address a major contributor to global warming. In the United States, electricity generation contributes 40% of CO_2 emissions and industry accounts for 14%.[17] Although the concentration of CO_2 in the ambient atmosphere is only about 0.04%, the pollutant is many times more concentrated in power plant flue gases, in the neighborhood of 3 to 5%.[18] By contrast the sources of methane (natural gas, CH_4), another significant GHG, are more diffuse, including agriculture and forestry.[19] Accordingly, most of the attention to the global warming problem from an engineering perspective has focused on CO_2 removal.[20]

One method of CO_2 removal from the atmosphere involves capturing emissions from waste gases with relatively high concentrations of CO_2 emitted by discrete point sources. Such sources include power plants and large manufacturing facilities; from their gaseous effluent streams, CO_2 could be captured, compressed, and injected into geological reservoirs, for instance on the ocean floor.[21] This process, generally referred to as carbon capture and storage ("CCS"), would allow for the

---

[15] John Virgoe, *International Governance of a Possible Geoengineering Intervention to Combat Climate Change*, 95 Climatic Change 103, 107 (2009).

[16] *Overview of Greenhouse Gases: Carbon Dioxide Emissions*, Envtl. Prot. Agency, http://www.epa.gov/climatechange/ghgemissions/gases/co2.html (last visited May 14, 2013).

[17] *Id.*

[18] *See* K.S. Lackner, *Capture of Carbon Dioxide from Ambient Air*, 176 Eur. Phys. J. Special Topics 93, 94 (2009).

[19] A.R. Mosier et al., *Mitigating Agricultural Emissions of Methane*, 40 Climatic Change 39, 39–40 (1998).

[20] *See* The Royal Soc'y, Geoengineering the Climate: Science, Governance and Uncertainty 1 (2009), *available at* http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/8693.pdf (noting that "most if not all of the [geoengineering] methods proposed so far focus on CO_2 which is long-lived, and present at a relatively high concentration").

[21] Keith, *supra* note 9. Because this approach limits emissions, but does not remove existing CO_2 from the atmosphere, it is debatable whether it should be characterized as geoengineering or simply an emissions reduction technique. *Id.*

conversion of fossil fuels to clean energy products, such as electricity, while considerably reducing or eliminating atmospheric emissions.[22]

For CCS to be effective, CO_2 would need to be sequestered on a very large scale, and the attendant risks are potentially severe.[23] Leakage of sequestered CO_2 could cause harm to local wildlife, and in extreme cases, human death.[24] Despite the risk, several CCS initiatives have already been undertaken on the national level, including projects in the United States and Canada.[25]

As described in the following sections, there have also been proposals for geoengineering interventions to address the even more challenging task of capturing carbon from the ambient atmosphere. As a group, these are generally referred to as carbon dioxide removal ("CDR") schemes.

1. Ocean Fertilization

One of the most widely discussed geoengineering proposals to offset climate change is ocean fertilization.[26] Although it is technically another form of CO_2 removal, ocean fertilization takes a qualitatively different form from the CCS method described above.[27] The process consists of adding large deposits of nutrients to the ocean in order to spur the growth of marine algae and phytoplankton.[28] The increased numbers of these photosynthesizing organisms would be expected to enhance CO_2 uptake from the upper ocean and atmosphere.[29] Ultimately, as the marine organisms die, they, along with the carbon they

---

[22] *See id.*

[23] Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change and Carbon Sequestration: Assessing a Liability Regime for Long-Term Storage of Carbon Dioxide*, 58 EMORY L.J. 103, 107 (2008) ("For CCS to have a real impact on climate change, projects must sequester millions of tons of CO_2 per year at each individual storage site, with injected CO_2 potentially spreading over tens of square miles for a single project . . . .").

[24] *See id.* at 118.

[25] Klass & Wilson, *supra* note 24, at 117.

[26] *See, e.g.*, Daniel Bodansky, *May We Engineer the Climate?*, 33 CLIMATIC CHANGE 309, 314 (1996); Virgoe, *supra* note 15, at 108.

[27] Naomi E. Vaughan & Timothy M. Lenton, *A Review of Climate Geoengineering Proposals*, 109 CLIMATIC CHANGE 745, 754–55 (2011).

[28] *See* James Edward Peterson, *Can Algae Save Civilization?: A Look at Technology, Law, and Policy Regarding Iron Fertilization of the Ocean to Counteract the Greenhouse Effect*, 6 COLO. J. INT'L ENVTL. L. & POL'Y 61, 63–64 (1995); Vaughan & Lenton, *supra* note 27; Daniel Bodansky, *Governing Climate Engineering: Scenarios for Analysis* 10 (Harv. Project on Climate Agreements, Discussion Paper No. 11-47, 2011) http://belfercenter.ksg.harvard.edu/files/bodansky-dp-47-nov-final.pdf.

[29] Lin, *supra* note 10, at 6.

absorbed from the atmosphere, would sink to the ocean floor in what is called a "biological pump."[30]

Iron, which scientists believe is the limiting factor of phytoplankton growth in its natural environment, would most likely be the nutrient of choice for ocean fertilization.[31] Therefore, in practice, ocean fertilization would likely involve dumping a large quantity of iron filings into the ocean.[32] This approach is relatively untested. Preliminary experimentation revealed uncertainties regarding the optimal ocean fertilization method and questioned its ultimate effectiveness.[33] Potential negative consequences are also unpredictable.[34] For example, boosting carbon uptake by microorganisms could deplete the ocean's oxygen supply and have harmful effects on marine ecosystems.[35]

2. Enhanced Weathering

Enhanced weathering is another technique artificially to enhance natural CO_2 removal.[36] This process would involve adding minerals or chemicals to agricultural soils to accelerate the natural reaction of silicate rocks with CO_2, thus removing more CO_2 from the atmosphere.[37] The enhanced weathering approach would have considerable costs due to the quantity of minerals it would require.[38] It could also harm the fertility of the affected soil, and depending on the scale of such a project, have detrimental effects on nearby rivers and coastal areas.[39]

B. *Solar Radiation Management*

A large number of techniques have also been proposed to attenuate global warming by reducing the amount of sunlight that reaches

---

[30] The Royal Soc'y, *supra* note 20, at 75.

[31] Keith, *supra* note 9. Iron has been shown to yield a higher rate of carbon uptake than other nutrients. *Id.* Recently, however, nitrogen and phosphates have been suggested as more effective nutrients for ocean fertilization. Vaughan & Lenton, *supra* note 27, at 755. Excess amounts of nitrogen and phosphates in freshwater settings cause pollution for the same reason they could be useful for ocean fertilization, namely excess algal growth that can lead to eutrophication of waterways. *Id.* 755–57.

[32] *See* Keith, *supra* note 9; Vaughan & Lenton, *supra* note 27, at 755. Based on the global supply of iron, such an undertaking is estimated to be feasible and incur relatively moderate costs. Lin, *supra* note 10, at 6.

[33] Lin, *supra* note 10, at 6–7.

[34] Keith, *supra* note 9; Lin, *supra* note 10, at 7.

[35] Keith, *supra* note 9; Lin, *supra* note 10, at 7.

[36] *See* Sci. & Tech. Committee, *supra* note 14, at 12.

[37] The Royal Soc'y, *supra* note 20, at 12–14.

[38] *Id.* at 13–14.

[39] *Id.* at 14.

the Earth's surface.[40] Some proposals in this category are as simple as painting roofs white instead of darker colors.[41] Another proposal that has attracted serious consideration involves injecting sulfates and other foreign matter into the stratosphere.[42] Natural processes would be expected to transform these substances into aerosols, minuscule particles that remain in the stratosphere for a year or longer.[43] The reflective property of these aerosols would keep some sunlight from reaching the lower layers of the atmosphere where it is absorbed as heat.[44] This technique, which is sometimes called stratospheric scatter,[45] is one of the more credible geoengineering proposals, but still includes a significant risk of unwanted adverse impacts.[46]

Stratospheric scatters, while potentially slowing the Earth's rise in temperature, could also harm the environment in several ways.[47] First, the proposed aerosol injections would contain sulfur particles, which could convert to sulfuric acid in the upper atmosphere and return to Earth as acid rain.[48] In addition to the terrestrial problems it can cause, acid rain would exacerbate the acidification of the oceans already caused by GHGs, likely increasing harm to the marine environment.[49] Second, there is evidence indicating that stratospheric injections of sulfur could damage or slow the recovery of the stratospheric ozone layer, which protects the Earth from ultraviolet rays.[50] Finally, there are concerns about the injections' adverse effects on Asian monsoons.[51] Clearly, the aerosols injected into the atmosphere could be expected to drift beyond the jurisdiction of the state where the action occurred, and the consequences of stratospheric scatters, for better or worse, would necessarily be felt on an international and likely global scale.

A similar solar radiation management ("SRM") approach would be to enhance the reflectivity of clouds, which already provide the Earth

---

[40] *See* Lin, *supra* note 10, at 3.

[41] David A. Fahrenthold, *White Rooftops May Help Slow Warming*, WASH. POST, June 14, 2009, at A3.

[42] Lin, *supra* note 10, at 4.

[43] *Id.*

[44] *See id.*

[45] Keith, *supra* note 9.

[46] Lin, *supra* note 10, at 4.

[47] *See id.* at 4–5; Virgoe, *supra* note 15, at 108.

[48] Virgoe, *supra* note 15, at 108.

[49] *See* Lin, *supra* note 10, at 5.

[50] *Id.*

[51] *See, e.g.*, Philip J. Rasch et al., *An Overview of Geoengineering of Climate Using Stratospheric Sulphate Aerosols*, 366 PHIL. TRANSACTIONS OF THE ROYAL SOC'Y 4007, 4026–30 (2008).

some protection from the sun's rays.[52] This so-called "cloud whitening" process would involve spraying sea salt particles into the air to augment natural cloud formation.[53] The salt particles would provide surfaces on which water vapor in the air would condense, resulting in whiter clouds.[54] According to some estimates, global warming could be significantly offset by a fleet of fifteen hundred boats equipped with cloud whitening spray.[55] Cloud whitening presents its own potential risks on an international scale, however, including droughts caused by reduced evaporation from the ocean and unpredictable effects on local weather patterns.[56]

Yet another SRM proposal would be to send reflective objects into outer space.[57] These reflectors would orbit the Earth, blocking a small but significant percentage of light from the sun.[58] This approach would avoid the atmospheric side effects of stratospheric scatters, but would not be altogether free from risk.[59] It would also come with a much larger price tag, estimated at five trillion dollars.[60]

II. Existing International Governance Structures

Although seemingly novel from the perspective of both intent and design, climate engineering proposals can be at least partially characterized according to well-established principles of international law. Several multilateral treaties cover subject matter that could be interpreted to address either climate management strategies or the effects of geoengineering interventions, leading to the inference that those agreements might serve as vehicles for coordinated international efforts in this area.[61] A number of modest efforts have already been undertaken to address iron fertilization proposals.[62]

---

[52] The Royal Soc'y, *supra* note 20, at 27.

[53] *Id.*; Oren Dorell, *Researchers Exploring Cloud Whitening*, USA Today, June 11, 2010, at 2A.

[54] Geoengineering the Climate: Science, Governance and Uncertainty, *supra* note 20, at 27.

[55] *See id.*

[56] *See id.* at 28; Dorell, *supra* note 53.

[57] *See* Lin, *supra* note 10, at 5–6.

[58] Oliver Morton, *Is This What It Takes to Save the World?*, 447 Nature 132, 135–36 (2007).

[59] *See, e.g.*, Lin, *supra* note 10, at 5–6 (noting that reflectors in space could interfere with spacecraft orbiting the Earth).

[60] Morton, *supra* note 58, at 136.

[61] *See, e.g.*, 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Nov. 7, 1996, 36 I.L.M. 1; United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 165 [hereinafter FCCC], *avail-*

A. *Climate Engineering in the International Legal System*

From a legal perspective, geoengineering proposals can be divided into a number of categories. First, the effects of all climate engineering interventions can be expected—and, indeed, are intended—to be global in scope. Because the principal greenhouse gases ("GHGs") are "well-mixed," meaning evenly distributed over the planet, emissions anywhere on Earth affect everyone, everywhere. More particularly, interventions in the climate system, whether exacerbating the problem (as in the form of increased emissions of GHGs) or beneficial (as in the form of emissions reductions) affect all states,[63] the principal subjects of international law.

The climate, moreover, can plausibly be characterized from a legal point of view as a global commons, like the high seas or Antarctica, beyond the reach of national jurisdiction.[64] From this perspective, no one state would have the authority to govern in the legal space occupied by the climate. And, of course, no single state has the practical capacity to alter the climate in a manner that affects only itself. Because emissions of GHGs originate from all over the planet, no one state has the ability unilaterally to determine the concentrations of GHGs in the atmosphere, and hence the integrity of the global climate. Consequently, climate policy necessarily involves issues of commons management, at a magnitude and urgency rarely if ever before encountered.[65]

While all geoengineering interventions will necessarily have global effects, at least in theory one could divide proposals into two categories: those that could be expected to have only beneficial effects, and those that might also have adverse consequences. Proposals that fall into the latter category would benefit from policies that encourage or require investigation and identification of harmful effects that may not be ini-

---

able at http://unfccc.int/resource/docs/convkp/conveng.pdf; Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques art. I, May 18, 1977, 31 U.S.T. 333, 1108 U.N.T.S. 152 [hereinafter ENMOD], *available at* http://treaties.un.org/doc/Treaties/1978/10/19781005%2000-39%20AM/Ch_XXVI_01p.pdf; London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972, 26 U.S.T. 2403, 1046 U.N.T.S. 120 [hereinafter The London Convention], *available at* www.gc.noaa.gov/documents/gcil_lc.pdf.

[62] *See, e.g.*, Int'l Maritime Org., *Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization*, IMO Doc. LC30/16 (Oct. 31, 2008) [hereinafter *Resolution LC-LP.1*], *available at* www.imo.org/blast/blastData.asp?doc_id=14101&filename=1.

[63] *See* Bodansky, *supra* note 26, at 309.

[64] *See id.* at 310, 312.

[65] *See* Garrett Hardin, *A Tragedy of the Commons*, 162 Sci. Mag. 1243, 1244–45 (1968) ("Freedom in the commons brings ruin to all.").

tially apparent in advance of deploying those proposals.[66] This might include further laboratory investigations, or perhaps limited field trials. In practice, however, it may be difficult or impossible to anticipate unintended negative consequences either qualitatively or quantitatively.

The structure of the international legal system suggests a second line of cleavage based on an attribute other than the effect of a particular intervention: whether a proposed action occurs within national jurisdiction. International law includes in this category actions taken within a state's territorial sea and those undertaken aboard vessels flying a state's flag outside that state's area of exclusive jurisdiction.[67] Based on the established structure of the international legal system, this category of activities could be regulated only by the state within whose jurisdiction the intervention takes place.[68]

For example, a carbon capture and storage initiative[69] might be undertaken within a single state's territory, with the byproduct permanently stored in that state's land mass or territorial sea. In such a situation, the activity concerned would fall within the sovereign jurisdiction of the state in which the undertaking occurs, and would be subject to the exercise of the police power and regulatory control only of that state, whose government by definition has a monopoly on the exercise of governmental authority within its territory.[70]

That said, actions taking place within a national jurisdiction may also be constrained by international legal obligations, such as a customary duty to refrain from transboundary pollution, expectations of decision-making based on precaution,[71] or obligations undertaken in bilateral or multilateral treaties addressing environmental pollution.[72] Additionally, it may be difficult to determine whether a particular action—such as one undertaken in the upper atmosphere—falls within the acting state's national jurisdiction. But because geoengineering actions are certain to have global effects whether or not they occur within

---

[66] *See infra* notes 169–170 and accompanying text.

[67] United Nations Convention on the Law of the Sea art. 90–92, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS], *available at* http://treaties.un.org/doc/Publication/UNTS/Volume%201833/volume-1833-A-31363-English.pdf.

[68] *Id.*

[69] *See supra* notes 21–25 and accompanying text.

[70] *See* David A. Wirth, *The Rio Declaration on Environment and Development: Two Steps Forward and One Back, or Vice Versa?*, 29 Ga. L. Rev. 599, 622 (1995) ("After all, the state's right to exploit its resources . . . is an inherent attribute of sovereignty.").

[71] *See infra* notes 169–170 and accompanying text.

[72] Bodansky, *supra* note 26, at 312; *see, e.g.*, Convention on Long-Range Transboundary Air Pollution, Nov. 13, 1979, 34 U.S.T. 3043, 1302 U.N.T.S. 217.

a single state's jurisdiction, one might consider all climate engineering proposals to be governed by the corpus of international environmental law, a considerable portion of which addresses extraterritorial effects of domestic actions.[73]

A second class of actions defined by territorial location is composed of interventions whose physical location lies beyond national jurisdiction, such as on the high seas or in outer space. In contrast to an activity that takes place within a state's territory, many actions occurring in areas outside national jurisdiction lie beyond the reach of law, as by definition no state has the legal authority to regulate there.[74] These extraterritorial actions are constrained, if at all, only by a patchwork of international custom and agreements that neither encompass all transboundary activity nor necessarily bind every state.[75]

Some proposals, such as the suggestion for sending orbiting reflectors into space, necessarily occur beyond national jurisdiction in areas of the global—or, in the case of outer space, the celestial—commons.[76] In many other areas related to climate management, however, there may be grey or uncertain areas. For example, although a geoengineering intervention may involve delivery of a physical agent into the oceans on the high seas, chances are that a readily identifiable state will have jurisdiction over the vessel from which such an action is initiated.[77] Alternatively, ocean fertilization might take place in coastal waters subject to a state's exclusive jurisdiction, but quite obviously the nutrients involved would likely, if not inevitably, drift into and across international waters.

B. *Multilateral Initiatives Related to Climate Engineering*

On a truly global issue such as climate change, multilateral fora tend to play a predominant role. International institutions, and particularly multilateral organizations, are settings in which a great deal of law is made and non-binding good practice standards are established.[78] Despite the variety of settings and policy instruments available in the

---

[73] *See, e.g.*, PHILIPPE SANDS ET AL., PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW (3d ed. 2012); ALEXANDRE CHARLES KISS & DINAH SHELTON, INTERNATIONAL ENVIRONMENTAL LAW 86–88 (3d ed. 2004).

[74] *See* THE ROYAL SOC'Y, *supra* note 20, at xi, 40.

[75] *See id.*

[76] *See id.* at 32.

[77] *See* UNCLOS, *supra* note 67, arts. 90–92.

[78] David A. Wirth, *The EU's New Impact on U.S. Environmental Regulation*, 31 FLETCHER F. WORLD AFF. 91, 92 (2007).

multilateral system to coordinate and harmonize states' actions on the national and international levels, relatively little by way of concrete measures have been adopted with respect to climate engineering.

A number of existing instruments might provide legal authority for action on geoengineering, either by encouraging or constraining proposals for such interventions in the ecosystem. Several of the more obvious are identified below, although the list is not intended to be exhaustive. The small number of concrete but modest efforts actually addressed to geoengineering, chiefly ocean fertilization, are then analyzed.

1. Potential Instruments and Settings for Addressing Geoengineering

The United Nations Framework Convention on Climate Change ("FCCC"), to which almost every United Nations ("U.N.") Member State is party, establishes a global architecture for coordinating national and international efforts to deal with many aspects of the climate change problem.[79] The FCCC addresses efforts that include most notably mitigation (emissions reductions) and adaptation (responses to climate change that has already occurred or is inevitable).[80] As such, that agreement is a natural starting place for considering geoengineering techniques.

Although not specifically identified in the agreement,[81] some geoengineering proposals, most particularly carbon dioxide removal ("CDR"), can plausibly be considered as a component of larger mitigation strategies. The FCCC also encourages states parties to enhance sinks and reservoirs for carbon dioxide and other GHGs.[82] Although the illustrative examples in the relevant provision include biomass and forests,[83] the concept would seem equally applicable to CDR proposals.

Solar radiation management ("SRM") proposals, which are less obviously mitigation measures because they involve neither emissions reductions nor sequestration in sinks, might nonetheless be covered by other portions of the agreement. Climate change, as specified in the FCCC, is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmos-

---

[79] *See Background on the UNFCCC: The International Response to Climate Change*, FCCC, http://unfccc.int/essential_background/items/6031.php (last visited May 14, 2013); *see also* FCCC, *supra* note 61.

[80] *See Background on the UNFCCC*, *supra* note 79.

[81] *See* FCCC, *supra* note 61.

[82] *Id.* art. 4, ¶ 1(d).

[83] *Id.*

phere."[84] The SRM proposals of stratospheric scatters and cloud whitening appear to fall within this definition. The FCCC also identifies constraints on mitigation measures that might have adverse environmental effects, including a requirement for prior analysis of effects in an environmental assessment.[85] The FCCC also creates avenues through which states could share and assess geoengineering proposals.[86] The treaty, however, does not establish binding law with regard to geoengineering.[87]

One international agreement that may have specific but limited application to the field of geoengineering is the U.N. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques ("ENMOD"),[88] which prohibits interventions in the environment such as weather modification for military or hostile purposes but specifically allow actions taken for "peaceful purposes."[89] Thus, it is unclear which geoengineering proposals, if any, would fall under the treaty's purview.[90] The subjective criterion of intent may be difficult to establish with certainty and, indeed, may invite disputes. With only seventy-six parties, ENMOD does not enjoy the near-universal acceptance of the FCCC.[91] ENMOD both regulates and protects states parties to the agreement, but it has no legal force with respect to the obligations or rights of the many nonparty states.[92] In other words, ENMOD parties are only prohibited from harming one another; they are *not* barred by the agreement from taking environmental actions that harm nonparty states.[93]

---

[84] *Id.* art. 1, ¶ 2.

[85] *Id.* art. 4, ¶ 1(f); *see* Bodansky, *supra* note 28, at 13–14 (noting the FCCC's applicability to geoengineering); *infra* notes 113, 121 and accompanying text (IMO resolutions and CBD decisions on ocean fertilization identify need for prior environmental impact assessments).

[86] *See* FCCC, *supra* note 61, art. 5.

[87] *See* Bodansky, *supra* note 26, at 313; Lin, *supra* note 10, at 15; *see also* Virgoe, *supra* note 15, at 114.

[88] ENMOD, *supra* note 61.

[89] *Id.* art. III.

[90] *See* Bodansky, *supra* note 26, at 311.

[91] *Compare Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)*, U.N. Office of Disarmament Affs., http://disarmament.un.org/treaties/t/enmod (last visited May 14, 2013) (listing seventy-six states parties to ENMOD), *with Background on the UNFCCC*, *supra* note 79 (listing one hundred ninety-five states parties to the FCCC).

[92] *See* Lin, *supra* note 10, at 20.

[93] *Id.* Furthermore, ENMOD contains no sanctions or enforcement mechanisms for parties that violate its provisions. *See* ENMOD, *supra* note 61; *see also* Lin, *supra* note 10, at 20.

Because of its focus on hostile environmental actions and its limited acceptance internationally, ENMOD appears to have little applicability to climate engineering.[94] By contrast, treaties that address atmospheric pollution, most notably the 1979 Convention on Long-Range Transboundary Air Pollution ("LRTAP"),[95] are more likely to be sources of binding norms that might govern SRM proposals with potential adverse environmental effects. More particularly, LRTAP's three protocols addressing sulfur,[96] intended to limit atmospheric acidification, would be particularly relevant to stratospheric scatters. Although covering a large area including North America, Europe, Russia, Central Asia, and Israel, LRTAP is a regional and not a universal instrument and consequently does not articulate globally applicable standards.[97] As in the case of ENMOD, the agreement and its protocols—which contain the bulk of the regime's substantive regulatory measures—bind only those states parties to them. Although the United States is a party to the Convention, it has not accepted two of the important protocols on sulfur.

Another treaty with potential implications for geoengineering is the 1982 U.N. Convention on the Law of the Sea ("UNCLOS").[98] UNCLOS sets out obligations for the use of marine natural resources located outside states' coastal jurisdiction, and confirms every state's right to use international waters for peaceful purposes.[99] Part XII of the agreement specifically addresses protection of the marine environment, and thus could potentially apply to ocean fertilization proposals.[100] UNCLOS requires measures to prevent marine pollution in areas and for actions that fall under national jurisdiction,[101] but specifically

---

[94] *See* Bodansky, *supra* note 26, at 311.

[95] Convention on Long-Range Transboundary Air Pollution, *supra* note 72.

[96] 1999 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-Level Ozone, U.N. Doc. EB.AIR/1999/1 (Nov. 30, 1999), *available at* http://www.unece.org/fileadmin/DAM/env/lrtap/full%20text/1999%20Multi.E.Amended.2005.pdf; Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reductions of Sulfur Emissions, June 14, 1994, 2030 U.N.T.S. 122, *available at* http://www.unece.org/fileadmin/DAM/env/lrtap/full%20text/1994.Sulphur.e.pdf; Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Reduction of Sulfur Emissions or Their Transboundary Fluxes by at Least Thirty Per Cent (Helsinki Protocol), July 8, 1985, 1480 U.N.T.S. 215, *available at* http://www.unece.org/fileadmin/DAM/env/lrtap/full%20text/1985. Sulphur.e.pdf; Convention on Long-Range Transboundary Air Pollution, *supra* note 72.

[97] *Convention on Long-range Transboundary Air Pollution*, United Nations Econ. Comm'n for Eur. (May 24, 2012), http://www.unece.org/env/lrtap/status/lrtap_st.html.

[98] UNCLOS, *supra* note 67.

[99] *See id.* arts. 11, 88, 145; Bodansky, *supra* note 26, at 314.

[100] *See* UNCLOS, *supra* note 67, pt. XII.

[101] *Id.* art. 194.

allows scientific research on the high seas, leaving open the possibility of geoengineering experiments in international waters.[102]

2. Multilateral Responses to Date

The international community has so far addressed only one form of geoengineering in detail: ocean fertilization.[103] That has occurred in only two fora, and the resulting instruments are non-binding exhortations and good practice standards.[104]

a. *London Convention and Protocol*

The 1972 London Convention (the "London Convention") and 1996 London Protocol (the "Protocol"), adopted under the auspices of the International Maritime Organization ("IMO"), are intended to prevent dumping of wastes and other harmful substances at sea.[105] Adopting a precautionary approach designed to anticipate and prevent uncertain harms, parties to the Protocol are required to prohibit all potentially hazardous dumping at sea, but are allowed to grant dumping permits for certain less hazardous wastes.[106]

The parties to the London Convention and Protocol addressed ocean fertilization in a 2008 resolution.[107] Defining ocean fertilization as "any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans," the activity falls within the scope of the Protocol and therefore is presumptively prohibited.[108] However, the resolution also anticipates the possibility of "legitimate scientific research," which should be "assessed on a case-by-case basis using an assessment framework to be developed" by scientific bodies operating under the auspices of the Convention.[109] The non-binding resolution further anticipates the development of "specific guidance" for evaluating ocean fertilization proposals, and exhorts parties to the

---

[102] *See id.* arts. 194, 256–57; Bodansky, *supra* note 26 (suggesting that "so long as ocean fertilization were done more than 200 miles from shore, it would arguably be permissible under [UNCLOS]").

[103] *See infra* notes 26–35 and accompanying text.

[104] *See supra* notes 105–130 and accompanying text.

[105] The London Convention, *supra* note 61; 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 and Resolutions Adopted by the Special Meeting, Nov. 7, 1996, 36 I.L.M. 7 (1997) [hereinafter London Protocol].

[106] London Protocol, *supra* note 105, arts. 3–4.

[107] *Resolution LC-LP.1*, *supra* note 62, ¶ 2.

[108] *Id.* ¶¶ 2, 8.

[109] *Id.* ¶¶ 3–4.

London Convention and Protocol in the meantime to "use utmost caution" in evaluating individual research proposals.[110]

A second resolution on the assessment framework for scientific research on ocean fertilization, adopted in 2010, elaborates on the earlier instrument.[111] The 2010 resolution contains an annex "designed for Contracting Parties [to the London Convention and Protocol] to evaluate proposed activities that fall within the scope of" the earlier resolution.[112] Among the components of the analysis is environmental assessment—a well-recognized tool for evaluating the anticipated environmental effects of a proposed action before it is undertaken[113]—with particular attention to ocean fertilization.[114] Neither resolution anticipates approval of any proposals by a multilateral body.[115] Instead, pursuant to the London Convention and Protocol, authorization to engage in scientific research on ocean fertilization—which translates legally into permission to engage in otherwise prohibited dumping—is granted by national authorities, presumably in a manner consistent with the multilaterally-agreed guidance contained in the 2010 resolution.[116]

b. *Convention on Biological Diversity*

In addition to the resolutions adopted under the London Convention and Protocol, the 193 parties to the Convention on Biological Diversity ("CBD") also took up the question of ocean fertilization at much the same time.[117] Rather than protecting the marine environment from dumping, which is the functional purpose of the London Convention

---

[110] *Id.* ¶ 6.

[111] IMO, *Resolution LC-LP.2 (2008) on the Assessment Framework for Scientific Research Involving Ocean Fertilization*, IMO Doc. LC32/15 (Oct. 14, 2010) [hereinafter *Resolution LC-LP.2*], *available at* http://www.imo.org/blast/blastDataHelper.asp?data_id=31100&filename=2010resolutiononAFOF.pdf.

[112] *Id.* annex 6, ¶ 1.1.

[113] *See, e.g.*, David A. Wirth, *International Technology Transfer and Environmental Impact Assessment*, *in* Transferring Hazardous Technologies and Substances: The International Legal Challenge 83 (Günther Handl & Robert E. Lutz eds., 1989).

[114] *Resolution LC-LP.2*, *supra* note 111, annex 6, ¶ 1.1.

[115] *See Resolution LC-LP.1*, *supra* note 62, ¶ 6 (urging only that parties "use utmost caution and the best available guidance" when evaluating research proposals). *See generally Resolution LC-LP.2*, *supra* note 111 (providing contracting parties with a guide for assessing proposed ocean fertilization projects).

[116] *See Resolution LC-LP.2*, *supra* note 111, ¶¶ 5–7, nn.1–2.

[117] *2010 COP*, *supra* note 9; United Nations Environment Programme, May 19–20, 2008, *Biodiversity and Climate Change*, pt. C, UNEP/COP/DEC/IX/16 (Oct. 9, 2008) [hereinafter *2008 COP*], *available at* https://www.cbd.int/doc/decisions/cop-09/cop-09-dec-16-en.pdf; *List of Parties*, Convention on Biological Diversity, https://www.cbd.int/information/ parties.shtml (last visited May 23, 2013).

resolutions, the motivation for the CBD is the preservation of biological diversity.[118]

In a decision adopted at its 2008 meeting—which, like the London Convention resolutions is not legally binding—the Conference of the Parties to the CBD dealt expressly with ocean fertilization.[119] While noting the earlier resolution under the London Convention and Protocol and "urg[ing] Parties and other [non-party] Governments to act in accordance with [it],"[120] the decision made specific recommendations:

> [The Conference of the Parties] *requests* Parties and *urges* other Governments, in accordance with the precautionary approach, to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities, including assessing associated risks, and a global, transparent and effective control and regulatory mechanism is in place for these activities; with the exception of small scale scientific research studies within coastal waters. Such studies should only be authorized if justified by the need to gather specific scientific data, and should also be subject to a thorough prior assessment of the potential impacts of the research studies on the marine environment, and be strictly controlled, and not be used for generating and selling carbon offsets or any other commercial purposes.[121]

The 2008 CBD decision diverges from its London Convention counterpart in a number of important respects. First, the CBD decision invokes the precautionary principle. Notably, the CBD decision anticipates a *global*—and presumably multilaterally-administered—mechanism as a condition precedent for approval of those ocean fertilization activities that go forward.[122] The transparency requirement apparently anticipates public notification of proposals and an opportunity for citizen input.[123] Inclusion of the word "regulatory" is significant, as this term is infrequently used in international instruments because it may be interpreted as encroaching upon states' sovereign prerogatives.[124]

---

[118] *2008 COP*, *supra* note 117, pt. A, ¶ 1.
[119] *Id.* pt. C.
[120] *Id.* pt. C, ¶ 2.
[121] *Id.* pt. C, ¶ 4.
[122] *Id.*
[123] *Id.*
[124] *See 2008 COP*, *supra* note 117, pt. C, ¶ 4.

In addition to expressly invoking a precautionary perspective, the 2008 CBD decision also anticipates a stricter standard for approval of scientific research projects.[125] Among other things, the decision confines scientific research to coastal waters, presumably within a state's exclusive jurisdiction, and not in areas of the global commons such as the high seas—a restriction not found in the IMO scheme.[126]

The Conference of the Parties to the CBD revisited the issue of ocean fertilization at its next meeting in 2010, expanding its earlier decision with some important additions.[127] Most importantly, the revision significantly expanded the coverage of the earlier decision to include not only ocean fertilization, but also "any technologies that deliberately reduce solar insolation [solar radiation received at the earth's surface] or increase carbon sequestration from the atmosphere on a large scale that may affect biodiversity (excluding carbon capture and storage from fossil fuels when it captures carbon dioxide before it is released into the atmosphere)."[128]

Structured as a blanket ban with limited exceptions authorized through a multilateral prior approval scheme, the CBD decision is intended to apply to virtually all ecosystem interventions that might plausibly be considered geoengineering.[129] Restricted interventions might include both CDR and SRM schemes. The second CBD decision also expanded the impacts requiring prior assessment from effects on biodiversity and the environment to include "associated social, economic and cultural impacts."[130]

III. Climate Engineering as Multilateral Failure

New challenges like climate engineering proposals tend to throw multilateral institutional failures into sharp relief. The limited and tepid response to the challenge of setting normative standards for geoengineering pointedly spotlights the inadequacy of the existing architecture for international governance. Of the numerous international insti-

---

[125] *Id.*

[126] *Id.* pt. A, ¶ 3, pt. C, ¶ 4.

[127] *2010 COP*, *supra* note 9.

[128] *Id.* ¶ 8(w) n.3. The decision also "noted that solar insolation is defined as a measure of solar radiation energy received on a given surface area in a given hour and that carbon sequestration is defined as the process of increasing the carbon content of a reservoir/pool other than the atmosphere." *Id.*

[129] *See id.*

[130] *Id.* ¶ 8(w). Unlike the previous CBD decision and the two IMO resolutions, the 2010 CBD decision does not specifically address scientific research in coastal waters. *See id.*

tutions that could effectively contribute to addressing the benefits and risks from climate engineering, only two have even begun to grapple with those demands, and only then in the form of non-binding, potentially contradictory instruments.[131]

More than one thousand multilateral agreements address environmental concerns.[132] For better or worse, multilateral environmental management has become increasingly compartmentalized and fragmented.[133] The United Nations Environment Program ("UNEP") is the only international institution whose mission is exclusively environmental.[134] Numerous other international organizations have within their broader purview some role in addressing global environmental challenges.[135] For example, the 1972 London Convention and 1996 London Protocol, and other marine pollution agreements, have been negotiated under the auspices of the International Maritime Organization ("IMO").[136] Additionally, the United Nations ("U.N.") Economic Commission for Europe has overseen a number of important regional negotiations regarding traditional air pollution questions;[137] the Organization for Economic Co-operation and Development has provided an important forum for addressing transboundary pollution; and the U.N. Food and Agriculture Organization has played a significant role in creating international policy on pesticides.[138]

These legal and institutional settings are not only different in kind from those encountered in municipal law; international public policy interventions diverge significantly from the regulatory mechanisms normally available to national governments.[139] Coordinated multilateral initiatives often take the form of binding international agreements, but also include non-binding, hortatory resolutions unlike the regulatory tools typically encountered at the national level.[140] Further complicating the analysis, supranational authorities like the European Un-

---

[131] *See supra* notes 105–130 and accompanying text.

[132] See Ronald B. Mitchell, *International Environmental Agreements (IEA) Database Project*, Univ. Or., http://iea.uoregon.edu/ (last visited May 15, 2013).

[133] David A. Wirth, *Globalizing the Environment*, 22 Wm. & Mary Envtl. L. & Pol'y Rev. 353, 368 (1998).

[134] *Id.*

[135] *Id.*

[136] *Id.*; *see* The London Convention, *supra* note 61.

[137] *See* Convention on Long-Range Transboundary Air Pollution, *supra* note 72.

[138] Wirth, *supra* note 133.

[139] David A. Wirth, *Hazardous Substances and Activities*, *in* Oxford Handbook of International Environmental Law 394, 397 (Daniel Bodansky, Jutta Brunée & Ellen Hey eds., 2007).

[140] *Id.*

ion possess some, but not all, of the regulatory powers ordinarily reserved to sovereign states.[141] Finally, private voluntary standards as a means for industry self-regulation have attracted increasing attention as a public policy strategy in recent years.[142]

Although much standard-setting and lawmaking occurs under the auspices of international organizations, many subject-matter specific regimes, typically constituted by multilateral agreements now frequently known as "framework conventions," are free-standing functional bodies, typically with their own professional secretariats.[143] To further complicate the situation, many of these formally autonomous regimes are the products of initiatives of existing organizations and frequently retain both formal and informal ties with them.[144] This is particularly so with respect to agreements intended to be global or universal in scope.

For example, the initial multilateral response to concerns about the integrity of the global climate in the late 1980s took the form of creating the Intergovernmental Panel on Climate Change, a U.N.-sponsored body which was, and continues to be, a joint undertaking of the World Meteorological Organization, a U.N. specialized agency, and UNEP.[145] Another entity, the Intergovernmental Negotiating Committee, was given responsibility for the subsequent negotiation of the U.N.-sponsored multilateral climate change convention.[146] The resulting U.N. Framework Convention on Climate Change was one of the principal outputs from the 1992 Conference on Environment and Development, the so-called "Earth Summit," also a U.N. undertaking.[147] Notably, the Conven-

---

[141] *Id.*

[142] *Id.* Alternatively, scholars have recognized the potential for wealthy individual actors to undertake geoengineering projects on their own initiative. David G. Victor et al., *The Geoengineering Option: A Last Resort Against Global Warming?*, 88 FOREIGN AFF., Mar.–Apr. 2009, at 64, 72 ("Although it may sound like the stuff of a future James Bond movie, private-sector geoengineers might very well attempt to deploy affordable geoengineering schemes on their own."). The task of government regulators would then include the added role of keeping such "freelancers" in check. *See id.*

[143] *See* Robin R. Churchill & Geir Ulfstein, *Autonomous Institutional Arrangements in Multilateral Environmental Agreements: A Little-Noticed Phenomenon in International Law*, 94 AM. J. INT'L L. 623, 623 (2000) (describing "a common pattern of institutional arrangements" in the international environmental field).

[144] *See generally id.* (describing the structure and functions of various bodies created pursuant to multilateral environmental agreements).

[145] *History*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, http://www.ipcc.ch/organization/organization_history.shtml (last visited May 15, 2013).

[146] Wirth, *supra* note 133.

[147] *Background on the UNFCCC*, *supra* note 79.

tion on Biological Diversity ("CBD") was also opened for signature at the same conference.[148]

Any or all of these settings—existing international organizations or free-standing functional regimes—could potentially serve as venues for effectively addressing geoengineering proposals in a coordinated, harmonized manner at the international level. Similarly, the variety of available policy instruments is expansive, ranging from precatory exhortations of concern to non-binding codified good practice standards and even binding prohibitions or bans.

Despite the number and variety of agreements and institutional settings concerned with the environment, the international regime still evinces serious deficiencies and gaps. In everyday practice, these lacunae translate into structural impediments to much-needed policies in response to emerging issues like climate engineering. Furthermore, the international community's fragmented approach to environmental governance parcels out jurisdiction over different functional problems in sometimes piecemeal fashion.[149] The authority to address issues such as acid rain, stratospheric ozone depletion, and climate change is divided by numerous agreements into an assortment of organizations and regimes, resulting in uneven and incomplete coverage.[150] For instance, the United States is not party to the CBD,[151] one of the few international settings in which the challenge of climate engineering has been taken up with any sense of purpose. The United States is also not party to the 1982 Convention on the Law of the Sea ("UNCLOS").[152] Even if these treaties were to bind every state, the professional secretariats servicing these agreements would still be scattered literally across the globe, yet another impediment to effective action.[153]

The resulting governance structure lacks focus and coherence, encumbering international cooperation, which is quite disturbing given the scale and urgency of the threat of climate change. The situation is exacerbated by the lack of effective decision-making procedures as an alternative to the sometimes crippling need for consensus, and the

---

148 *History of the Convention*, CONVENTION ON BIOLOGICAL DIVERSITY, http://www.cbd.int/history (last visited May 15, 2013).

149 *See* Wirth, *supra* note 133.

150 *See* Douglas J. Caldwell & David A. Wirth, *Trade and the Environment: Equilibrium or Imbalance?*, 17 MICH. J. INT'L L. 563, 576 (1996) (book review).

151 *See List of Parties*, *supra* note 117.

152 *Chronological Lists of Ratifications of, Accessions and Successions to the Convention and the Related Agreements as at 23 January 2013*, UNITED NATIONS, http://www.un.org/Depts/los/reference_files/chronological_lists_of_ratifications.htm (last updated Jan. 23, 2013).

153 *See* Caldwell & Wirth, *supra* note 150, at 577.

near absence of effective mechanisms for implementation.[154] Inspired by the greater internal consistency of the system of free trade agreements and the more centralized institutional precedent of the World Trade Organization, several influential observers have proposed the creation of a new international organization with greater powers in the environmental field.[155] But, so far, such innovative suggestions have not been transformed into reality.[156]

Past systematic attempts at genuine multilateral management of the global commons are not encouraging. One example of such an effort is Part XI of UNCLOS, addressing deep sea mining on the high seas.[157] This portion of the agreement establishes an International Seabed Authority to authorize individual proposals for seabed exploration and mining as well as to collect and distribute a portion of the proceeds from those undertakings.[158]

The International Seabed Authority is now functioning and operational,[159] but it can hardly be considered a success. As has been well documented elsewhere, the United States declined to sign UNCLOS because of the provisions of Part XI, and actively encouraged its allies to oppose the agreement.[160] Although UNCLOS has enjoyed strong support from many lawmakers, industry leaders, and high-ranking officials, the U.S. Senate has never voted on the agreement.[161] This resistance persists even after the parties to UNCLOS renegotiated and re-

---

[154] *See id.* at 576–78; Wirth, *supra* note 133, at 366.

[155] *See* Caldwell & Wirth, *supra* note 150, at 577–78 (discussing Daniel C. Esty's and C. Ford Runge's proposals for new global environmental governing bodies).

[156] Wirth, *supra* note 133, at 369.

[157] *See* UNCLOS, *supra* note 67, arts. 156–157.

[158] *Id.* pt. XI & annexes III & IV.

[159] *See, e.g.*, Seabed Disputes Chamber of Int'l Tribunal for the Law of the Sea, Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to activities in the Area (2011), *available at* http://www.itlos.org/fileadmin/itlos/documents/cases/case_no_17/adv_op_010211.pdf; *see also About Us*, Int'l Seabed Auth., http://www.isa.org.jm/en/about (last visited May 14, 2013).

[160] *See, e.g.*, Burns H. Weston & David Bollier, Green Governance: Ecological Survival, Human Rights, and the Law of the Commons 217–18 (2013).

[161] *See* Kevin Drawbaugh, *U.S. Senate Panel Backs Law of the Sea Treaty*, Reuters, Oct. 31, 2007, *available at* http://www.reuters.com/article/2007/10/31/idUSN31335584; Kristina Wong & Sean Lengell, *DeMint: Law of the Sea Treaty Now Dead*, Wash. Times, July 16, 2012, http://www.washingtontimes.com/news/2012/jul/16/demint-says-law-sea-treaty-now-dead/?page=all (reporting that thirty-four senators—enough to prevent the Treaty from attaining the necessary two-thirds support in the Senate for advice and consent to ratification—pledged their intent to oppose the treaty if it were put to a vote). *But see* Editorial, *Secretary Kerry Still Pushing Law of the Sea Treaty*, Investors.com, Mar. 28, 2013 6:39 PM, http://news.investors.com/ibd-editorials/032813-649779-kerry-wants-law-of-the-sea-treaty.htm?p=full (noting, with disappointment, continued support for the Treaty's ratification).

wrote the controversial Part XI in an ultimately unsuccessful attempt to secure U.S. participation.[162]

In the process, the term "common heritage of mankind"—code for collective multilateral management and benefits from resources of the global commons—has been firmly associated with objections to the New International Economic Order dating from the late 1970s, and has become something of a third rail in international practice.[163] Presumably for this reason, the U.N. Framework Convention on Climate Change ("FCCC") refers instead to the climate as a "common concern of humankind."[164] The FCCC's wordsmithing could be regarded as an attempt to distance itself from the acrimonious debates that still surround Part XI of UNCLOS.[165]

The situation is not entirely bleak, as indicated by the content of the two IMO resolutions[166] and, especially, the two CBD decisions.[167] Environmental impact assessments, called for by both sets of instruments, are at least a first line of defense in avoiding unintended environmental harm from geoengineering proposals. Unfortunately, no environmental impact assessment can provide an all-purpose inoculation against the possibility of unanticipated adverse consequences, as by definition no one can predict the unpredictable. The field of climate science, and global climate policy in particular, remains notoriously rife with uncertainty.

Similarly, a precautionary approach, explicitly referenced by the CBD decisions,[168] counsels a policy bias in favor of anticipating and

---

[162] *See* Ernest Z. Bower & Gregory Poling, *Advancing the National Interests of the United States: Ratification of the Law of the Sea*, 3 SE. ASIA FROM THE CORNER OF 18TH & K STREETS, May 25, 2012, at 1, 2, *available at* http://csis.org/files/publication/120525_SoutheastAsia_Vol_3_Issue_10.pdf.

[163] *See, e.g.*, Harry G. Johnson, *The New International Economic Order*, U. CHI. BOOTH SCH. OF BUS.: SELECTED PAPERS 1, 1 (2004) (calling the new international economic order "propaganda"), *available at* http://www.chicagobooth.edu/~/media/0ABF9E91CCDB42C4BBA92737DCE91EEA.pdf (transcript of the Woodward Court Lecture, delivered by Harry G. Johnson on Oct. 5, 1976 at The University of Chicago). *See generally* G.A. Res. 3201 (S-VI), U.N. GAOR, 6th Sess., Supp. No. 1, U.N. Doc. A/9559 (May 1, 1974), *available at* http://www.cetim.ch/en/documents/ag-resolution-3201-ang.pdf (declaring the establishment of a new international economic order).

[164] FCCC, *supra* note 61, at 1.

[165] *Cf.* WESTON & BOLLIER, supra note 160, at 216 (mildly endorsing Antarctic Treaty System as having "proven to work reasonably well . . . as a vehicle for multilateral cooperation").

[166] *See supra* notes 62, 111.

[167] *See supra* notes 9, 117.

[168] *See 2010 COP*, *supra* note 9, ¶ 8(w); *2008 COP*, *supra* note 117, pt. C, ¶ 4; *supra* note 121 and accompanying text.

preventing potential harm in the face of scientific uncertainty, particularly appropriate when applied to climate engineering.[169] While initially grounded in such everyday heuristics as "a stitch in time saves nine" and "look before you leap," precaution has enjoyed increasingly wide acceptance as a public policy.[170] But such a broad principle can hardly be expected to bear the weight of preventing all unanticipated effects from interventions in the ecosystem—especially considering how massive and unpredictable in outcome some of the more outlandish geoengineering proposals appear.

Conclusion

In 2012, the amount of sea ice covering the Arctic Ocean reached a record low,[171] and to an extent greater than predicted by the computer models used by scientists to forecast effects of climate change.[172] The diminution in ice cover, widely regarded as correlated with the heating of the Earth's climate, is predicted further to accelerate the warming trend.[173] Reflective white ice is replaced by dark ocean water with a greater rate of solar radiation absorbance—an example of a "positive feedback," in which the effects of climate change further exacerbate the warming phenomenon, potentially with irreversible effects or in a highly discontinuous manner.[174]

A quarter century ago, scientists rang alarm bells, warning of potentially catastrophic consequences of human-induced climate disrup-

---

[169] *See, e.g.*, David A. Wirth, *Precaution in International Environmental Policy and United States Law and Practice*, 10 N. Am. Envtl. L. & Pol'y 219, 237 (2002) (monograph published by North American Commission for Environmental Cooperation).

[170] *See id.* at 237, 242.

[171] Roxanne Palmer, *Arctic Sea Ice Coverage Sets Record Low*, Int'l Bus. Times (U.S. edition), Aug. 28, 2012 4:09 PM, http://www.ibtimes.com/arctic-sea-ice-coverage-sets-record-low-759577.

[172] Robin McKie, *Rate of Arctic Summer Sea Ice Loss Is 50% Higher Than Predicted*, Guardian, Aug. 11, 2012 4:52 PM, http://www.guardian.co.uk/environment/2012/aug/11/arctic-sea-ice-vanishing.

[173] *Id.*; *see* Christophe Kinnard et al., *Reconstructed Changes in Arctic Sea Ice over the Past 1,450 Years*, 479 Nature 509, 509 (2011); Mark C. Serreze et al., *Perspectives on the Arctic's Shrinking Sea-Ice Cover*, 315 Science. Mag. 1533, 1533 (2007). *See generally* Intergovernmental Panel on Climate Change, *supra* note 1, at 376–77 ("Observations show a global-scale decline of snow and ice over many years . . . .").

[174] *See* Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 538 F.3d 1172, 1191 (9th Cir. 2008) ("Several studies also show that climate change may be nonlinear, meaning that there are positive feedback mechanisms that may push global warming past a dangerous threshold (the 'tipping point').").

tion.[175] What were then prognostications are now a consistent component of routine news reports, each more disturbing than the last. Because of the enormous uncertainties associated with the ongoing anthropogenic alteration of our global climate, even more dramatic, nonlinear, knife-edge, and potentially irreversible effects may yet be in store.[176]

If there is a positive message to take from these developments, it may be that the need to respond to the risks and realities of climate disruption is urgent. Public appreciation of how close we may be to a tipping point might well catalyze policy demand for creative solutions.[177] Lawmakers, both domestic and international, would be remiss not to seriously consider geoengineering proposals to mitigate the harm of global warming. Geoengineering techniques—especially those directed toward increasing the reflectivity of the Earth with a low likelihood of unanticipated adverse effects—could be at the very least viable short-term options to supplement traditional emissions reduction approaches, whose progress is slow.

But there are risks, perhaps unanticipated ones, as well. Currently, there are few international constraints to prevent states from unilaterally undertaking geoengineering projects that could, for better or worse, affect the entire planet. The global nature of the potential harm requires meaningful oversight by international institutions. Only a strong international legal framework can assure that geoengineering interventions are safe, effective, and fully disclosed and debated before deployment. As counseled by a precautionary perspective, we need to anticipate and prevent harms, including those that may result from otherwise well-intentioned interventions. The time to put an effective structural, institutional, and normative architecture in place to address geoengineering is now.

---

175 Philip Shabecoff, *The Heat Is On: Calculating the Consequences of a Warmer Planet Earth*, N.Y. Times, June 26, 1988, at E1.

176 *See Ctr. for Biological Diversity*, 538 F.3d at 1191.

177 *See* Massachusetts v. EPA, 549 U.S. 497, 535 (2007) (Roberts, C.J., dissenting) (acknowledging that "[g]lobal warming may be a "crisis," even "the most pressing environmental problem of our time").