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ARTICLE

Sowing Seeds Uncertain: Ocean Iron Fertilization, Climate Change, and the International Environmental Law Framework

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INTRODUCTION

In a world plagued by the effects of climate change, ocean iron fertilization and other geoengineering techniques[1] could help

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1. Ocean iron fertilization is just one facet of a much larger debate on whether geoengineering—the use of technology to manipulate naturally occurring environmental processes—presents a viable means to combat global climate change. For an excellent overview of the potential of geoengineering techniques, *see generally* Alan Carlin, *Global Climate Change Control: Is There a Better Strategy Than Reducing Greenhouse Gas Emissions?*, 155 U. PA. L. REV. 1401 (2007). For an overview and analysis of geoengineering techniques discussed on the floor of the United States House of Representatives, *see Geoengineering: Assessing the Implications of Large-Scale Climate Intervention: Hearing Before the H. Comm. on Science and Technology*, 111th Cong. (Nov. 5, 2009). For a review of geoengineering techniques that specifically involve the use of the ocean, *see also* Peter Liss, Professor, Univ. of E. Anglia Sch. of Envtl. Sci., Keynote Presentation at the International Ocean Stewardship Forum 2009: Geoengineering the Oceans: Miracle Cure or Snake Oil? (June 10, 2009), *available at* http://www.oceanstewardship.com/IOSF%202009/Keynotes_2009/ PLiss_2009.pdf. Professor Liss provides examples of geoengineering proposals such as: launching turbine-fitted vessels that would spray out a mist to whiten clouds; installing wave-driven upwelling systems to bring nutrient-rich cold water to the surface of the ocean; increasing ocean

to respond and adapt to this global environmental crisis. Nevertheless, the international community, consistent with its reactions to other science-inspired responses to modern problems,[2] has approached the promise of ocean iron fertilization with a half-hearted embrace and a surplus of healthy skepticism.[3]

The controversy surrounding ocean iron fertilization reached a critical juncture in the past year. On January 7, 2009, a team of researchers from Germany's Alfred Wegener Institute for Polar and Marine Research and India's National Institute of Oceanography embarked on an expedition to the Antarctic Peninsula to assess the potential of ocean iron fertilization as a new approach to address climate change.[4] The LOHAFEX[5] team

alkalinity electrochemically; and enhancing the natural sulfur cycle to slow global warming.

2. For example, the potential risks posed by genetically modified food as a response to the global food shortage, and nuclear energy as a component of the response to the global energy crisis, have generated significant public outcry that continues to this day. *See generally* Katharine Van Tassel, *Genetically Modified Food, Risk Assessment and Scientific Uncertainty Principles: Does the New Understanding of the Networked Gene Trigger the Need for Post-Market Surveillance to Protect Public Health?*, 15 B.U. J. SCI. & TECH. L. 220 (2009); Martin Peder Maarbjerg, *The Global Nuclear Energy Partnership: Is the Cure Worse Than the Disease?*, 16 U. BALT. J. ENVTL. L. 127 (2009).

3. For background information on the controversy surrounding ocean iron fertilization, *compare* Jennie Dean, *Iron Fertilization: A Scientific Review with International Policy Recommendations*, 32 ENVIRONS ENVTL. L. & POL'Y J. 321 (2009) (arguing further scientific research is not warranted because negative consequences outweigh sequestration potential and recommending outright ban), *and* Aaron Strong et al., *Ocean Fertilization: Time to Move On*, 461 NATURE 347 (2009) (arguing iron fertilization is not an effective way to fight climate change and no further research is needed), *with* William Daniel Davis, *What Does Going Green Mean?: Anthropogenic Climate Change, Geoengineering, and International Environmental Law*, 43 GA. L. REV. 901 (2009) (recognizing its potential as an "insurance policy against the risk of catastrophic climate change" and calling for the creation of a new United States agency to lead research efforts), *and* Kenneth Coale, Moss Landing Marine Lab., Address at the 2009 American Physical Society April Meeting: Recent Results from Iron Enrichment Experiments: Implications for Geoengineering (May 4, 2009) (noting that natural iron inputs have had major impact on past climate changes and that the role of iron fertilization as a geoengineering solution to climate change can only be evaluated through experimental manipulations designed for that purpose).

4. Press Release, Alfred Wegener Inst., Background Information on the Project LOHAFEX as of 22 January 2009 (Jan. 22, 2009) (on file with author) [hereinafter AWI Background Information]; Press Release, Nat'l Inst. of Oceanography, India, LOHAFEX: An Indo-German Open Ocean Experiment to

proposed to dump six tons of dissolved iron sulfate over 116 square miles of ocean surface between 200 and 500 nautical miles north or northwest of South Georgia Island to induce rapid growth of a phytoplankton bloom.[6] In theory, such blooms can absorb massive amounts of carbon dioxide from the atmosphere and subsequently fall to the ocean floor, creating a "carbon sink" that effectively sequesters carbon, offsets global emissions of carbon dioxide, and mitigates some of the impacts of global warming.[7]

Despite its laudable intentions, the LOHAFEX ocean iron fertilization proposal drew significant opposition. On January 13, 2009, the German Environment Ministry requested that the German Research Ministry immediately halt the expedition.[8] The Environment Ministry raised concerns about the compatibility of the project with the decisions of the 9th Meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD); the lack of an independent assessment into the potential environmental impacts of the experiment; and the adverse international response to the project by members of the media, who might view the project as a government-subsidized entrance into what could become a multi-billion dollar market.[9] The German Research Ministry responded to these concerns by temporarily halting the project.[10]

Several days later, however, the German Environment Ministry reversed its course and decided to allow the project to

Test the Effects of Iron Fertilization on the Ecology and Carbon Uptake Potential of the Southern Ocean (Jan. 12, 2009) (on file with author).

5. "LOHA" means iron in Hindi and "FEX" is shorthand for fertilization experiment. *Id.*

6. AWI Background Information, *supra* note 4, at 2.

7. RAPHAEL SAGARIN ET AL., DUKE UNIV. NICHOLAS INST. FOR ENV'T POLICY SOLUTIONS, IRON FERTILIZATION IN THE OCEAN FOR CLIMATE MITIGATION: LEGAL, ECONOMIC, AND ENVIRONMENTAL CHALLENGES 3 (2007), http://www.nicholas.duke.edu/institute/ironfertilization.pdf.

8. *Germany Blasts Geo-Engineering Scheme in Atlantic*, TERRADAILY.COM, Jan. 14, 2009, http://www.terradaily.com/reports/Climate_Germany_blasts_geo-engineering_scheme_in_Atlantic_999.html.

9. *See* Press Release, German Fed. Env't Ministry, Federal Environment Ministry Regrets Approval by Federal Research Ministry of Iron Enrichment Experiment (Jan. 26, 2009) (on file with author).

10. Quirin Schiermeier, *Ocean Fertilization: Dead in the Water?*, 457 NATURE 520 (2009), *available at* http://www.nature.com/news/2009/090128/pdf/457520b.pdf.

proceed. Research Minister Annette Schavan declared that "[a]fter a study of expert reports, I am convinced there are no scientific or legal objections against the . . . ocean research experiment LOHAFEX."[11] Shortly thereafter, the German Environment Ministry issued a press release reiterating its objections and voicing its regret over the decision to allow the experiment to proceed.[12]

Private enterprises proposing ocean iron fertilization experiments have also stirred controversy. Planktos, a company based in the United States, announced plans to use similar technology to generate carbon credits that might be sold or traded.[13] When warned by the United States Environmental Protection Agency (EPA) that such research activities might violate the Ocean Dumping Ban Act of 1988,[14] Planktos responded that its activities would no longer be conducted with a U.S.-flagged vessel.[15] Though Planktos later abandoned the project after failing to secure adequate funding, other commercial outfits such as Climos, which recently announced its plans to engage in iron fertilization of up to 40,000 square kilometers of ocean, are attempting to profit using a similar business model.[16]

The dire threats posed by climate change have inspired innovative methods of carbon sequestration, including ocean iron fertilization as one of a variety of tools to mitigate the threat.[17]

11. *German Coalition at Loggerheads Over Global Warming Test*, SPACEDAILY.COM, Jan. 26, 2009, http://www.spacedaily.com/reports/German_ coalition_at_ loggerheads_over_global_warming_test_999.html.

12. Press Release, German Fed. Env't Ministry, *supra* note 9.

13. SAGARIN ET AL., *supra* note 7, at 7-8.

14. *Id*. For information on the Act, *see generally* Ocean Dumping Ban Act of 1988, 33 U.S.C. §§ 1401-45 (2006).

15. SAGARIN ET AL., *supra* note 7, at 7-8.

16. Richard Black, *Setback for Climate Fix*, BBC NEWS, Mar. 23, 2009, http://news.bbc.co.uk/2/hi/science/nature/7959570.stm. For information on a company seeking to profit from fertilization techniques that use nitrogen instead of iron, *see* Ocean Nourishment Corporation, http://www.oceannourishment.com (last visited Apr. 14, 2010).

17. For a summary of climate change and the threats it poses, *see* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC FOURTH ASSESSMENT REPORT, CLIMATE CHANGE 2007: SYNTHESIS REPORT (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf. For a broad overview of the role of carbon cycle management as a means to mitigate climate change, *see* Lisa Dilling et al., *The Role of Carbon Cycle Observations and Knowledge in Carbon Management*, 28 ANN. REV. ENVTL. RES. 521-58 (2003).

However, there is little concrete data available about the environmental consequences of ocean iron fertilization or the efficacy of ocean iron fertilization as a method of carbon sequestration.[18] Moreover, because ocean iron fertilization activities generally take place on the high seas, beyond the jurisdiction of domestic legal regimes, it is unclear which sources of international law should regulate the two categories of ocean iron fertilization projects: (1) the small-scale research activities that have taken place to date, and (2) the large-scale, and potentially more dangerous, ventures contemplated by private companies.[19]

This article explores the promise and perils of ocean iron fertilization and the intricacies of its regulation under international environmental law. Part I examines the science of ocean iron fertilization and its strengths and limitations as a strategy to mitigate climate change. Part II reviews the overlapping international legal regimes that govern ocean fertilization—the United Nations Convention on the Law of the Sea (UNCLOS),[20] the CBD,[21] and the London Convention and Protocol[22]—and the applicability of those regimes to ocean iron

18. Ken O. Buesseler et al., *Ocean Iron Fertilization—Moving Forward in a Sea of Uncertainty*, 319 SCIENCE 162 (2008), *available at* http://academics2.vmi.edu/biol/humstonr/GCC/Buesseler%20et%20al%202008.pdf. "Although these [twelve] experiments greatly improved our understanding of the role of iron in regulating ocean ecosystems and carbon dynamics, they were not designed to characterize OIF as a carbon mitigation strategy . . . [and] we do not understand the intended and unintended biogeochemical and ecological impacts." *Id.*

19. For an international legal regime that distinguishes between small-scale and large-scale research activities, *see* Convention on Biological Diversity, June 5, 1992, 1760 U.N.T.S. 79 [hereinafter CBD]; *see also* Convention on Biological Diversity, COP 9 Decision IX/16, Biodiversity and Climate Change, http://www.cbd.int/decision/cop/?id=11659 (last visited Apr. 16, 2010). For a commercial enterprise proposing to use emerging environmental markets to help fund research on ocean iron fertilization and fertilize up to 40,000 square kilometers of ocean, *see* What is Climos' Funding/business Model?, http://www.climos.com/faq.php#8 (last visited Apr. 16, 2010); Black, *Setback for Climate Fix*, *supra* note 16.

20. U.N. Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS].

21. CBD, *supra* note 19.

22. 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. 138 [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, S. TREATY DOC. NO. 110-5, 36 I.L.M. 1 [hereinafter London Protocol].

fertilization projects. Part III addresses the controversy and conflicting legal obligations at issue in the LOHAFEX project to illustrate the need for a new legal framework to govern ocean iron fertilization. Part IV proposes a new international regulatory framework to govern ocean iron fertilization. This framework would harmonize incongruous treaty obligations by bringing all classes of activity under UNCLOS with permitting and arbitration authority delegated to the International Maritime Organization (IMO).[23] It would also seek to harness the capital and innovation of private enterprise by allowing those entities that can prove that their carbon sequestration efforts are effective and benign to conduct ocean iron fertilization projects and sell carbon credits.

However, the framework would also require measures to protect the environment. Any proposed experiment, regardless of the scale, would have to conduct a rigorous environmental assessment prior to approval. In addition, the framework would require state sponsorship for any project and would distinguish between small-scale and large-scale projects, with the latter subject to more stringent permitting requirements, a higher degree of potential liability, and monitoring through on-board observers or satellite imaging. This two-tiered regulatory approach would promote environmentally responsible experiments by private and public actors, thereby expanding the body of information available to policy makers seeking to evaluate ocean iron fertilization as a tool to mitigate global climate change. It would also retain flexibility so that the international regulatory regime could respond quickly to any relevant scientific advancement.

I. THE SCIENCE OF OCEAN IRON FERTILIZATION

Ocean iron fertilization involves adding iron to the sea to artificially stimulate the rapid growth of phytoplankton, whose

23. The International Maritime Organization (IMO), a specialized agency within the United Nations that maintains a comprehensive framework for shipping and its remit, already plays a significant role in the implementation of regulations pursuant to UNCLOS. For additional information on the interaction between UNCLOS and IMO, *see generally* Agustín Blanco-Bazán, *IMO interface with the Law of the Sea Convention*, IMO, Jan. 6-9, 2000, http://www.imo.org/home.asp?topic_id=194 (scroll down to No. 2 to access).

photosynthetic activity could potentially absorb enough heat-trapping carbon dioxide to help cool the atmosphere of the Earth.[24] In practice, this strategy requires spreading iron particles in ocean areas where iron exists in such low concentrations that its absence limits phytoplankton growth.[25] These waters include the Southern Ocean and the equatorial and northern regions of the Pacific Ocean.[26]

Proponents emphasize the vast potential of ocean iron fertilization as a way to rapidly deploy "carbon sinks" that could draw large amounts of carbon dioxide from the atmosphere.[27] The addition of relatively small amounts of iron offers the possibility of large increases in carbon sequestration and rapid mitigation of climate change at a relatively low financial cost.[28] A pioneer of this method, the late John Martin, famously quipped, "[g]ive me half a tanker of iron, and I'll give you an ice age."[29] Yet critics point to three major flaws with this strategy: (1) it may be less efficient than it seems;[30] (2) it could raise a host of foreseeable and unforeseeable adverse environmental consequences;[31] and (3) its effectiveness is difficult to measure.[32] This part of the article examines the promise of this geoengineering technique as well as its pitfalls.

24. Buesseler et al., *supra* note 18.

25. SAGARIN ET AL., *supra* note 7, at 3-4.

26. *Id.* at 4.

27. *See, e.g.*, V. Smetacek & S.W.A. Naqvi, *The Next Generation of Iron Fertilization Experiments in the Southern Ocean*, 366 PHIL. TRANS.R. SOC'Y A 3947, 3947-67 (2008), *available at* http://rsta.royalsocietypublishing.org/content/366/1882/3947.full.pdf+html. Interestingly, Smetacek, who was one of the lead scientists on the LOHAFEX expedition, lost much of his enthusiasm for iron fertilization as a mitigation strategy following the modest results of that experiment, *see* Black, *Setback for Climate Fix*, *supra* note 16.

28. Ken O. Buesseler & Phillip W. Boyd, *Will Ocean Fertilization Work?*, 300 SCIENCE 67 (2003).

29. Hugh Powell, *Fertilizing the Ocean with Iron: Is this a Viable Way to Help Reduce Carbon Dioxide Levels in the Atmosphere?*, 46 OCEANUS 4 (2008), *available at* http://www.whoi.edu/cms/files/OceanusIron_Fertilizing_ 30749.pdf.

30. *See, e.g.*, Buesseler & Boyd, *supra* note 28.

31. *See, e.g.*, ALLSOPP ET AL., GREENPEACE RESEARCH LAB., A SCIENTIFIC CRITIQUE OF OCEANIC IRON FERTILIZATION AS A CLIMATE CHANGE MITIGATION STRATEGY 3-4 (2007), *available at* http://www.greenpeace.to/publications/iron_ fertilisation_ critique.pdf.

32. *See, e.g.*, *id.* at 13.

A. The Promise of the Iron Hypothesis

The conceptual foundation for ocean iron fertilization traces its origins to a scientific article published in 1988.[33] The author, John Martin, recognized that wind-swept atmospheric dust from land formed an important source of iron for ocean waters, and that iron-deficient regions of the ocean received minimal amounts of that dust.[34] Martin also observed that there is an inverse correlation between ice core records of carbon dioxide in the atmosphere and dust concentrations in the past 180,000 years: when atmospheric carbon dioxide was low, high concentrations of dust were present.[35] Martin hypothesized that during dry glacial periods, a greater amount of iron reached then iron-deficient waters and activated a "biological pump" that absorbed carbon dioxide from the atmosphere and affected global climate patterns.[36] This "iron hypothesis" generated a tremendous amount of interest in ocean iron fertilization.

After Martin's original findings, scientists have utilized ice-core records to suggest that in past glacial periods natural ocean iron fertilization repeatedly absorbed as much as sixty-billion tons of carbon from the atmosphere.[37] Early climate models likewise indicated that intentional iron fertilization could absorb between one to two billion tons of carbon from the air, which would offset ten to twenty-five percent of the world's annual total emissions of carbon dioxide.[38] Given that iron fertilization occurs naturally and has arguably withdrawn significant amounts of carbon dioxide from the atmosphere in the past, proponents assert that it could play a considerable role as a mitigation tool.[39] Some scientists and private companies have also claimed that ocean iron fertilization projects would have the secondary

33. John H. Martin & S.E. Fitzwater, *Iron Deficiency Limits Phytoplankton Growth in the North-East Pacific Subarctic,* 331 NATURE 341, 341-43 (1988).

34. John H. Martin, *Glacial-Interglacial CO_2 Change: The Iron Hypothesis*, 5 PALEOCEANOGRAPHY 1, 10 (1990).

35. *Id.* at 10.

36. *Id.* at 2.

37. Powell, *Fertilizing the Ocean with Iron*, *supra* note 29, at 4.

38. *Id.*

39. *See* Kenneth S. Johnson & David M. Karl, *Is Ocean Fertilization Credible or Creditable?*, 296 SCIENCE 467, 467-68 (2002).

advantage of stimulating the base of the food chain and promoting marine productivity.[40]

To some degree, the thirteen open-water experiments that have taken place to date have verified the potential of ocean iron fertilization to draw carbon dioxide from the atmosphere. In a review of the first twelve experiments, one study concluded that the results have "unequivocally shown that iron supply limits production in [more than one-third] of the global ocean, where surface macronutrient concentrations are perennially high."[41] This finding demonstrates the vast expanse of water amenable to fertilization activities: in approximately one-third of the ocean, the only missing ingredient is iron.[42] The initial twelve experiments also all reported up to fifteen-fold increases in surface-water chlorophyll content, a measure of carbon-drawing photosynthetic activity used in lieu of actual plankton counts.[43] The experiments all produced the predicted algae blooms, and one experiment demonstrated a twenty- to thirty-fold increase in phytoplankton biomass, a result that underscores the potential of this method to withdraw carbon dioxide from the atmosphere.[44]

Perhaps the most important factor in the success of ocean iron fertilization projects is the location of such efforts. The experiments up to this point have largely focused on high-nutrient, low chlorophyll (HNLC) regions, such as the northern

40. Smetacek & Naqvi, *supra* note 27, at 1 (noting the possibility that increases in krill populations could lead to recovery of great whale populations); Ocean Nourishment Corporation, The Benefits, http://www.oceannourishment.com/technology.asp (last visited Apr. 16, 2010) (claiming that "for every tonne of nitrogen infused into the ocean, 1.1 tonnes of fish (wet weight) may be produced").

41. Nielsdottir et al., *Iron Limitation of the Postbloom Phytoplankton Communities in the Iceland Basin*, 23 GLOBAL BIOGEOCHEM. CYCLES 1, 12 (2009).

42. *See id.*

43. Hugh Powell, *Will Ocean Fertilization Work?*, 46 OCEANUS 10 (2008), *available at* http://www.whoi.edu/cms/files/OceanusIron_Will_It_Work_30747.pdf.

44. Sallie W. Chisholm et al., *Dis-Crediting Ocean Fertilization*, 294 SCIENCE 309 (2001) (nevertheless, the author concludes that the environmental risks do not warrant commercial ocean iron fertilization activities). The most recent experiment, the LOHAFEX expedition, produced an algae bloom as expected, but one which did not last long and was less successful than anticipated in transporting carbon dioxide to the ocean floor, a problem examined more fully below, *see infra* notes 79-88 and accompanying text. For a helpful overview of the results of the LOHAFEX expedition, *see* Black, *Setback for Climate Fix*, *supra* note 16.

and equatorial Pacific Ocean and the Southern Ocean, because these areas already have high levels of other nutrients, such as nitrate, phosphate, and silicic acid, which are required for the growth of plankton present in the waters.[45] The warmth of the equatorial waters promotes rapid plankton growth, but these regions already have some plankton growth.[46] Consequently, some scientists have predicted that additional plankton would deplete the nutrient supply too quickly and produce blooms that are too concentrated to have more than a negligible effect on atmospheric carbon absorption.[47]

The potential for fertilization is far greater in the Southern Ocean, which is due in part to the larger HNLC area of roughly twenty-million square miles.[48] The waters of the area also contain far more nutrients than other iron-deficient areas.[49] Indeed, without the addition of iron, the nutrients of this region often sink to the bottom before they can be utilized.[50] Some scientists have claimed that if the full expanse of these waters alone were artificially fertilized with iron, the ocean could remove one-eighth of the annual emissions from burning oil, gas, and coal.[51]

In addition to these two principal regions for potential future ocean iron fertilization experiments, there are other areas that might support artificially induced phytoplankton growth. Anthony Michaels of the University of Southern California has investigated the possibility of fertilizing low-nutrient, low-chlorophyll (LNLC) waters at the middle latitudes.[52] One three-week experiment in the North Atlantic showed that adding iron and phosphorus can stimulate the growth of the photosynthetic

45. Powell, *Will Ocean Fertilization Work?*, *supra* note 43, at 12.

46. *Id.*

47. *Id.*

48. Gerald Traufetter, *Slowing Warming with Antarctic Iron*, SPIEGEL ONLINE INTERNATIONAL, Jan. 2, 2009, http://www.spiegel.de/international/world/0,1518,599213,00.html.

49. Powell, *Will Ocean Fertilization Work?*, *supra* note 43, at 12.

50. *Id.*

51. Traufetter, *supra* note 48.

52. Powell, *Will Ocean Fertilization Work?*, *supra* note 43, at 12 (citing Anthony Michaels, Address at the Ocean Iron Fertilization Symposium: Nitrogen Fixation and Carbon Sequestration (Sept. 26, 2007) (on file with author)).

bacteria *Trichodesmium*.[53] This species has the potential to convert dissolved nitrogen gas into a usable form and thereby produce blooms similar to the naturally occurring blooms found in HNLC regions.[54] In addition, these blooms theoretically could add their own nutrients rather than deplete those nutrients from the surface water, a common criticism of HNLC iron experiments.[55] However, these blooms have a tendency to deplete the phosphorus added to the water and die more quickly than HNLC blooms.[56]

Another factor that plays a significant role in the success of carbon dioxide sequestration is the interplay between phytoplankton produced by the fertilization and the species that feed on them. One study noted that the experiments that produced phytoplankton blooms containing larger diatom phytoplankton survive longer and, therefore, can draw more carbon dioxide from the atmosphere.[57] This dynamic occurs because diatom phytoplankton has a protective silica casing that allows it to survive comparatively longer than other species of phytoplankton that do not have this casing.[58] However, diatom phytoplankton tends to deplete the surrounding waters of the silica needed to form their casing, and the blooms tend to expire shortly thereafter.[59] The lack of silica in the water was a limiting factor for the algal growth in the recent LOHAFEX experiment.[60]

The type of creatures that feed on the blooms also matters with respect to the efficiency of carbon sequestration. Scientists have suggested that the presence of salps, which excrete phytoplankton in heavier pellets, could lead to greater carbon

53. *Id.* For a robust scientific examination of LNLC fertilization and interesting hypothesis about efficacy of controlled upwelling techniques (pumping nutrient-rich deep water towards the surface), *see* David M. Karl & Ricardo M. Letelier, *Nitrogen-Fixation Enhanced Carbon Sequestration in Low-Nitrate, Low-Chlorophyll Seascapes*, 364 MAR. ECOL. PROG. SER. 257 (2008).

54. Powell, *Will Ocean Fertilization Work?*, *supra* note 43, at 12.

55. *Id.*

56. *Id.*

57. Boyd et al., *Mesoscale Iron Enrichment Experiments 1993-2005: Synthesis and Future Directions*, 315 SCIENCE 612, 613, 615 (2007).

58. Black, *Setback for Climate Fix*, *supra* note 16.

59. Powell, *Will Ocean Fertilization Work?*, *supra* note 43, at 13.

60. Black, *Setback for Climate Fix*, *supra* note 16.

dioxide export efficiency.[61] These heavier excretions make it more likely that the carbon dioxide withdrawn from the atmosphere will actually make it to the ocean floor, instead of returning to the surface and thereafter reintroducing the carbon dioxide into the atmosphere.[62]

B. The Potential Pitfalls of Ocean Iron Fertilization

Human intervention in any ecological system can trigger a chain reaction of foreseeable and unforeseeable consequences, the results of which are complex and difficult to monitor. Ocean iron fertilization is no different. Therefore, although ocean iron fertilization has the potential to serve as a potent tool in combating climate change, opponents have raised concerns about the potentially devastating ecological and geophysical impacts of this climate change mitigation strategy.[63] While conceding that the addition of iron would draw carbon dioxide from the atmosphere, other critics do not believe that enough of this carbon would actually make it to the ocean floor to justify such potentially damaging measures.[64]

Perhaps the most common criticism lodged against ocean iron fertilization is that it would, by design, significantly change the composition of the phytoplankton community.[65] Studies undertaken on artificial and natural blooms have revealed dramatic changes in the species that make up the two lowest links in the marine food chain: phytoplankton and the bacteria that feed on them.[66] Larger diatom phytoplankton generally

61. R. Perissinotto & E.A. Pakhomov, *Contribution of Salps to Carbon Flux of Marginal Ice Zone of the Lazarev Sea, Southern Ocean*, 131 MAR. BIOL. 25, 29 (1998).

62. *Id.*

63. *See, e.g.,* ALLSOPP ET AL., *supra* note 31.

64. *See*, *e.g.*, Chisolm et al., *supra* note 44.

65. *Id.* at 310.

66. Hugh Powell, *What are the Potential Side Effects?: The Uncertainties and Unintended Consequences of Manipulating Ecosystems*, 46 OCEANUS 14 (2008), *available at* http://www.whoi.edu/cms/files/OceanusIron_SideEffects_30748.pdf (citing Phillip Boyd, New Zealand Nat'l Inst. for Water, Presentation at the Ocean Iron Fertilization Symposium: What Have We Learned From Past Iron Fertilization Experiments? (Sept. 26, 2007) and Stéphane Blain, CNRS/Université de la Méditerranée, Presentation at the Ocean Iron Fertilization Symposium: What Can We Learn From Natural Iron Sources? (Sept. 27, 2007)).

appear to benefit most from the iron enrichment,[67] and scientists fear that disruption caused by such changes to the base of the food chain may affect populations of larger predators such as copepods, krill, salps, jellyfish, and other fish.[68]

Many experts also have expressed concern that large-scale ocean iron fertilization projects could lead to detrimental reductions of essential nutrients down-current from the bloom.[69] Scientists know that phytoplankton blooms tend to decrease nutrients such as nitrate, phosphorus, and silicate concentrations located forty to fifty meters from the surface of the ocean.[70] Thus, those down-current organisms that depend on these nutrients could suffer adverse impacts, which might result in reduced productivity of marine life and unpredictable changes in the structure of the marine food web. Modeling has also shown that ocean iron fertilization could result in a long-term reduction in marine life productivity in much larger areas of the ocean.[71]

Scientists have raised additional concerns that large-scale ocean iron fertilization projects could reduce oxygen levels in deeper waters.[72] When a plankton bloom begins to die, the organic material sinks to deeper waters, and the decomposition that happens at this point depletes the natural oxygen in the water.[73] This acute oxygen shortage has the potential to cause significant negative impacts on marine life including fish, shellfish, and invertebrates.[74] While not directly attributable to iron fertilization, scientists have linked such outcomes to "toxic"

67. Hein J. W. De Baar et al., *Synthesis of Iron Fertilization Experiments: From the Iron Age in the Age of Enlightenment*, 110 J. GEOPHYSICAL RES. 2, 17 (2005).

68. Powell, *What are the Potential Side Effects?, supra* note 66, at 14 (citing Stéphane Blain, CNRS/Université de la Méditerranée, Presentation at the Ocean Iron Fertilization Symposium (Sept. 26-27, 2007) and ALLSOPP ET AL., *supra* note 31, at 3).

69. *See, e.g.,* ALLSOPP ET AL., *supra* note 31, at 3.

70. Buesseler et al., *The Effects of Iron Fertilization on Carbon Sequestration in the Southern Ocean*, 304 SCIENCE 414 (2004); Kenneth H. Coale et al., *Southern Ocean Iron Enrichment Experiment: Carbon Cycling in High-and Low-Si Waters*, 304 SCIENCE 408, 413 (2004).

71. ALLSOPP ET AL., *supra* note 31, at 10 (citing Anand Gnanadesikan et al., *Effects of Patchy Ocean Fertilization on Atmospheric Biological Production*, 17 GLOBAL BIOGEOCHEM. CYCLES 19.1 (2003)).

72. ALLSOPP ET AL., *supra* note 31, at 10.

73. Powell, *What are the Potential Side Effects?, supra* note 66, at 14-15.

74. *Id.* at 15.

algal blooms off the coast of Oregon[75] and in the Gulf of Mexico.[76] In studies conducted off the West Florida coast, these harmful blooms, also known as "red tides," were linked to iron supplied by wind-blown dust from the Sahara and to localized phosphorus input.[77] While no ocean iron fertilization study has yet linked the addition of iron to the creation of toxic blooms, many worry that large-scale projects run the risk of creating massive red tides.

In a related concern, recent scientific research suggests that the cultivation of iron-enhanced diatom communities of the *Pseudonitzschia* genus could have damaging unintended consequences to surface-dwelling organisms.[78] Coastal species of *Pseudonitzschia* have been known to produce the potent neurotoxin domoic acid, which has led to massive toxic harmful algal blooms in coastal waters.[79] According to one scientist, domoic acid poisoning is becoming a regular occurrence in some parts of the world, leading to mass mortality and seizures in sea lions off the west coast of the United States.[80] The recent research has linked oceanic varieties of *Pseudonitzschia*, previously perceived to be nontoxic, with the production of domoic acid.[81] The findings demonstrate that toxin production can occur with ocean iron fertilization and indicates that large-scale fertilization projects could produce ecologically harmful levels of domoic acid.[82]

Scientists also fear potentially damaging geophysical impacts. The most troubling of these is the possibility of

75. *Id.*

76. ALLSOPP ET AL., *supra* note 31, at 11-12 (citing J.J. Walsh et al., *Red Tides in the Gulf of Mexico: Where, When, and Why?*, 11 J. GEOPHYSICAL RES. 111 (2006) and NAT'L AERONAUTICS & SPACE ADMIN., AFRICAN DUST LEADS TO LARGE TOXIC ALGAL BLOOM (2001), http://eospso.gsfc.nasa.gov/ftp_docs/African_Dust.pdf).

77. *Id.*

78. CHARLES G. TRICK ET AL., PROCEEDINGS OF THE NAT'L ACAD. OF SCI., IRON ENRICHMENT STIMULATES TOXIC DIATOM PRODUCTION IN HIGH-NITRATE, LOW-CHLOROPHYLL AREAS 1 (2010), http://www.pnas.org/content/early/2010/02/24/0910579107.full.pdf+html?sid=86200a60-9c23-4339-9c6c-a174d7aa8ffe.

79. *Id.*

80. Richard Black, *Toxic Troubles for Climate 'Fix'*, BBC NEWS, Mar. 16, 2010, *available at* http://news.bbc.co.uk/2/low/science/nature/8569351.stm (quoting Ailsa Hall, Deputy Dir., Sea Mammal Research Inst. at St. Andrews Univ. Scotland).

81. TRICK ET AL., *supra* note 78, at 1.

82. *Id.*

increased production of nitrous oxide and methane, both far more potent greenhouse gases than carbon dioxide.[83] Phytoplankton requires certain nutrients to grow. After they die, the nutrients in their remains are believed to move into deeper waters many miles away from the site of the original iron fertilization.[84] "The depletion of oxygen in these waters that has been attributed to algae blooms, coupled with the breakdown of inorganic nitrogen when organic matter is remineralized in the interior of the ocean, has the potential to produce nitrous oxide and methane."[85] One ocean iron fertilization experiment detected a small increase in nitrous oxide at the bottom of a mixed layer, and computer modeling predicted releases of nitrous oxide and methane that could more than counteract any benefits of carbon sequestration.[86]

Another troubling geophysical outcome is the potential for the release of dimethylsulfide (DMS), a gas capable of producing clouds which could have an unpredictable impact on the climate.[87] Some classes of phytoplankton produce dimethylsulphonio-propionate (DMSP), which degrades to DMS; thereby causing some scientists to fear that the resulting increase in DMS could increase the amount of clouds in the atmosphere and thus cool the planet in a highly unpredictable manner.[88] Interestingly, others cite this outcome as a potential benefit of ocean iron fertilization.[89]

Apart from these ecological and geophysical concerns, the experiments conducted thus far have not conclusively shown how

83. ALLSOPP ET AL., *supra* note 31, at 12; Powell, *What are the Potential Side Effects?, supra* note 66, at 4.

84. *Id.*

85. ALLSOPP ET AL., *supra* note 31, at 12.

86. *Id.*

87. Peter Liss et al., *Ocean Fertilization with Iron: Effects on Climate and Air Quality*, 57B TELLUS 269 (2005).

88. ALLSOPP ET AL., *supra* note 31, at 4; *see also* Liss et al., *supra* note 87, at 270.

89. Liss et al., *supra* note 87, at 270 (noting that the authors stop short of endorsing iron fertilization, however, due to concerns about uncertainties that inhere in the technique and the potential countervailing effects of other gaseous bi-products such as nitrous oxide); *see also* Wingenter et al., *Changing Concentrations of CO, CH4, C5H8, CH3Br, CH3I, and Dimethyl Sulfide During the Southern Ocean Iron Enrichment Experiments*, 101 PROC. NAT'L ACAD. SCI. 8537, 8540 (2004).

much carbon actually gets transferred to the ocean floor or sufficiently deep waters. To assess whether ocean iron fertilization has potential as an effective carbon sequestration method, it is necessary to compare the ratio of iron added to the amount of carbon sequestered.[90] Laboratory experiments have shown comparatively high carbon export ratios, and proponents have used extrapolations from this data to support iron fertilization as a potential sequestration strategy.[91] Scientists have not yet replicated these results in experiments in the ocean, however.

The four open-ocean experiments that have taken place in the Southern Ocean—the most promising location for iron fertilization—have shown notable increases in biomass and promising decreases in inorganic carbon.[92] However, the experiments provided limited evidence of sinking particles of the particulate organic carbon required for successful sequestration, which implies that carbon export efficiency might be far less than suggested by proponents when applied in actual ocean conditions.[93] In summarizing the data collected in the first three experiments, Hugh Powell estimated that only five to fifty percent of the total carbon reaches 100 meters; about two to twenty percent sinks between 100 to 500 meters; and perhaps only one to fifteen percent of the original carbon falls below 500 meters.[94] The recent LOHAFEX experiment provided even less promising results, as increasing grazing pressure of small crustacean zooplankton prevented sustained growth of the phytoplankton bloom and limited carbon export to only "minor" amounts as compared to prior experiments.[95]

Leading scientists caution against drawing conclusions from this data, however, because the ocean iron fertilization experiments have not yet been conducted over sufficiently long

90. Buesseler & Boyd, *supra* note 28.

91. *Id.* at 68 (concluding that, in light of the natural history of carbon absorption and subsequent tests, "exploring regulation of the ocean's biological pump by iron supply is strongly warranted.").

92. *Id.*

93. Powell, *Will Ocean Fertilization Work?*, *supra* note 43, at 10.

94. *Id.* at 11.

95. Press Release, Alfred Wegener Inst., Lohafex Provides New Insights on Plankton Ecology—Only Small Amounts of Atmospheric Carbon Dioxide Fixed (Mar. 23, 2009).

periods to observe the termination of the blooms in the Southern Ocean.[96] They further note that large-scale or long-term experiments might come closer to approximating past climatic shifts towards lower atmospheric carbon dioxide concentrations associated with iron dust influx, as evidenced in ice records.[97] Indeed, a recent study conducted on a natural phytoplankton bloom over the Kerguelen plateau in the Southern Ocean that was sustained by natural sources of iron and nutrients in surface waters showed carbon sequestration efficiency between 10 and 150 times greater than in artificial fertilization experiments.[98] Though the bloom was sustained by continuous input of major nutrients other than iron and resulted from an upwelling of nutrients rather than input from below,[99] it could be argued that methods of enrichment need only mirror more closely such natural processes to provide for effective and efficient carbon sequestration.

A final concern regarding the prospect of ocean iron fertilization is the difficulty in monitoring the carbon sequestration. To enable trading of carbon credits or selling of carbon offsets, independent organizations would have to be able to verify the amount of carbon exported to the ocean floor. Critics have argued that a monitoring program of large-scale experiments would not work because the costs associated with tracing and verifying the amount of carbon sequestered, along with the monitoring of negative impacts such as nitrous oxide formation, de-oxygenation, or other ecological changes, would be prohibitively expensive.[100]

Therefore, the promise of ocean iron fertilization as a climate change mitigation tool is tempered by a range of biological and geophysical concerns. Nevertheless, the potential for this mitigation strategy to help combat climate change merits further research and requires a flexible legal framework that acknowledges the limitations of the current state of the science

96. Buesseler & Boyd, *supra* note 28, at 68.

97. *Id.*

98. Stéphane Blain et al., *Distribution of Dissolved Iron During the Natural Iron-Fertilization Experiment KEOPS (Kerguelen Plateau, Southern Ocean)*, 55 DEEP SEA RES. II 594 (2008).

99. *Id.*

100. *See, e.g.*, ALLSOPP ET AL., *supra* note 31, at 13.

and reconciles the applicability of intersecting sources of international environmental law.

II. THE EXISTING LEGAL FRAMEWORK

A regulatory framework for ocean iron fertilization requires the use of international law because the vast majority of waters best suited for ocean iron fertilization are located in the high seas, beyond the 200-mile jurisdictional boundaries of any coastal nation's exclusive economic zone.[101] Three international environmental law treaties govern ocean iron fertilization: (1) UNCLOS;[102] (2) the CBD;[103] and (3) the London Convention and Protocol.[104] This part of the article addresses the legality of ocean iron fertilization under each of these treaties and considers the initial responses under these treaties to the legal challenges that ocean iron fertilization has presented.

A. The United Nations Convention on the Law of the Sea

UNCLOS provides the basic legal framework for both the protection of the world's oceans and the use of the resources contained therein.[105] UNCLOS is widely regarded as "the constitution for ocean governance."[106] Its provisions codify the customary international law obligation binding on all states, including non-party nations such as the United States, to prevent

101. Hugh Powell, *Dumping Iron and Trading Carbon: Profits, Pollution, and Politics will Play Roles in Ocean Iron Fertilization*, 46 OCEANUS 22 (2008).

102. UNCLOS, *supra* note 20.

103. CBD, *supra* note 19.

104. London Protocol, *supra* note 22. The Protocol entered into force on March 24, 2006 and there are currently thirty seven parties to the Protocol. Although iron fertilization that takes place in the Southern Ocean might also have to comply with the strict laws designed to protect Antarctica, such as the Antarctic Treaty of 1959, its 1991 Madrid Environmental Protocol, and the 1980 Convention for the Conservation of Antarctica, this paper seeks to provide a flexible global framework and analysis of these regional treaties is therefore beyond its scope.

105. David Freestone & Rosemary Rayfuse, *Ocean Iron Fertilization and International Law*, 364 MAR. ECOL. PROG. SER. 227, 228 (2008).

106. DAVID HUNTER, JAMES SALZMAN & DURWOOD ZAELKE, INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 739 (3d ed. 2007).

practices that damage the marine environment of other nations or areas beyond national jurisdiction.[107]

UNCLOS Article 192 expresses the broad general obligation of all states "to protect and preserve the marine environment."[108] Likewise, Article 145 provides in principle that "necessary measures shall be taken . . . with respect to activities in the Area to ensure effective protection for the marine environment from harmful effects which may arise from such activities."[109] While these broad obligations are qualified somewhat by provisions that allow parties the sovereign right to exploit the natural resources in areas within their territorial control,[110] states are nevertheless required to take all necessary measures to: (1) prevent, reduce and control pollution of the marine environment,[111] (2) prohibit the transfer of damage or hazards from one area to another,[112] and (3) protect rare and fragile ecosystems, as well as the habitat of depleted, threatened, or endangered species from pollution.[113]

Under Article 1(1)(4), UNCLOS defines pollution as:

> [T]he 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, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.[114]

Under this definition, it is not the nature of the substance introduced into the environment that brings an activity within its prohibitions, but the potential deleterious effects that its introduction may have.[115] Proponents of ocean iron fertilization might argue that this definition of pollution would not cover their activities because such activity has not "resulted" nor is it "likely

107. Freestone & Rayfuse, *supra* note 105, at 228.
108. UNCLOS, *supra* note 20, art. 192.
109. *Id.* art. 145.
110. *Id.* art. 193.
111. *Id.* art. 194.
112. *Id.* art. 195.
113. *Id.* art. 194(5).
114. UNCLOS, *supra* note 20, art. 1(1)(4).
115. Freestone & Rayfuse, *supra* note 105, at 229.

to result" in the deleterious effects proscribed because this same result occurs naturally and the dire results predicted by some are largely based on modeling that operates under the assumption of worst case scenarios.[116] Alternatively, proponents may argue that ocean iron enrichment could have a net positive effect because the phytoplankton blooms stimulate the base of the food chain.[117]

One way for critics to respond to this line of argument, which emphasizes the uncertainty surrounding ocean iron fertilization, is to invoke the precautionary principle. The precautionary principle provides that "where there are threats of serious or irreversible damage, lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[118] A corollary to this principle is that the burden of proof falls on those who propose to engage in activity that may harm the environment.[119]

Unlike the majority of modern environmental legal and regional seas agreements,[120] however, UNCLOS does not contain an express endorsement of the precautionary principle.[121] However, some scholars have read the pollution provisions of UNCLOS to contain an implicit endorsement of the precautionary principle because the definition of pollution refers to actions that "result or are likely to result" in the proscribed deleterious effects.[122] Under this reading, the obligations to prevent pollution

116. *See* Smetacek & Naqvi, *supra* note 27, at 1.

117. *Id.* (noting the possibility that increases in krill populations could lead to recovery of great whale populations); Ocean Nourishment Corporation, The Benefits, http://www.oceannourishment.com/technology.asp (last visited Apr. 16, 2010) (claiming that "for every tonne of nitrogen infused into the ocean, 1.1 tonnes of fish (wet weight) may be produced.").

118. The Rio Declaration on Environment and Development, Princ. 15, U.N. Doc A/CONF/151/26 (vol.1) (June 13, 1992), *available at* http://www.unep.org/Documents.Multilingual/Default.asp?documentid=78&articleid=1163.

119. David Kriebel et al., *The Precautionary Principle in Environmental Science*, 109 ENVTL. HEALTH PERSPECT. 871 (2001).

120. U.N. Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, July 24-Aug. 4, 1995, *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1992 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*, art. 6, U.N. Doc. A/CONF.164/37 (Sept. 8, 1995).

121. Karen Scott, *The Day After Tomorrow: Ocean CO_2 Sequestration and the Future of Climate Change*, 18 GEO. INT'L ENVTL. L. REV. 57, 69 (2005).

122. *Id.*

are triggered even when no direct causal link has been established, so long as environmental harm is likely.[123] Even assuming that the probability of harm does not rise to the level of likelihood, the party advocating the action should nevertheless bear the burden of proof that the action is benign.

The problem with the precautionary principle in this context, however, is that the action proposed seeks to address the catastrophic environmental consequences of *inaction* in the face of climate change. In other words, when the threat of environmental degradation posed by mitigation measures such as ocean iron fertilization is considered in the context of the more significant threat of large-scale environmental degradation from global warming, concerns regarding the risks of ocean iron fertilization become less compelling. Advocates for ocean iron fertilization could argue that this climate change mitigation strategy is a cost-effective measure that could prevent the serious and irreversible environmental damage caused by climate change, and that lack of scientific certainty should not prevent its evaluation as a potentially critical mitigation tool. This inversion of the logic of the precautionary principle, along with the absence of the principle in the language of UNCLOS, diminishes the applicability of the precautionary principle in the ocean iron fertilization context.

There is, however, another way to bring ocean iron fertilization activities within the regulatory ambit of UNCLOS. Article 194 provides that states must act to prevent, reduce, and control pollution from all sources, which includes "dumping."[124] Dumping is defined as "any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea."[125] Article 210 of UNCLOS requires states to adopt laws and regulations to prevent and regulate dumping that must be no less effective than internationally agreed global rules and standards.[126] UNCLOS delegates the promulgation of global rules and standards regarding "dumping" to other international treaties, and endorses the recently enacted rules and standards under the CBD and the London Protocol, which specifically

123. *Id.*
124. UNCLOS, *supra* note 20, art. 194(3)(a).
125. *Id.* art. 1, para. 1(5)(a).
126. *Id.* art. 210(1-6).

address iron fertilization on the high seas. It is to these two treaty regimes that the analysis now turns.

B. The Convention on Biological Diversity

The 1992 Convention on Biological Diversity (CBD) seeks to conserve biodiversity and encourage the sustainable use of its components, including genetic resources.[127] The protection of marine and coastal areas within the framework of the CBD emerged as an important agenda item in the mid-1990s following the conclusion of the Jakarta Mandate in 1995 and the adoption of a program of related works in 1998.[128]

Parties to the CBD directly addressed ocean iron fertilization at the May 2008 Ninth Meeting of the Conference of the Parties in Bonn. Section C of Decision IX/16 urged States to use the utmost caution when considering proposals for large-scale ocean iron fertilization and declared that such large-scale operations were not justified.[129] Decision IX/16 further recommended that parties and governments act in accordance with the precautionary principle to ensure that ocean iron fertilization activities do not take place until there is: (1) an adequate scientific basis on which to justify such activities, including assessing associated risks; and a (2) global, transparent, and effective regulatory mechanism for these activities.[130]

Decision IX/16 established an exception for "small-scale" scientific research studies undertaken within "coastal waters."[131] It qualified the exception by authorizing only those experiments justified by the need to gather specific scientific data, provided

127. CBD, *supra* note 19, art. 1.

128. *See id. See also* Scott, *supra* note 121, at 105; 4th Meeting of the Conference of the Parties to the Convention on Biological Diversity, *Decision IV/5* (May 1998). At the Fourth Meeting of the Conference of the Parties in 1998, the parties adopted Decision IV/5, which contained a program of work arising from the Jakarta Mandate on Marine and Coastal Biological Diversity. The program of work, contained in the annex to the decision, identified five "key elements" that required further attention: (1) integrated marine and coastal area management, (2) marine and coastal living resources, (3) marine and coastal protected areas, (4) mariculture, and (5) alien species and genotypes.

129. 9th Meeting of the Conference of the Parties to the Convention on Biological Diversity, *Decision IX/16, Section C* (May 2008).

130. *Id.*

131. *Id.*

that the studies were subject to a thorough prior assessment of the potential impacts of the research studies on the marine environment.[132] Finally, Decision IX/16 distinguished between research conducted for scientific purposes and research conducted for generating and selling carbon offsets or any other commercial purposes, and forbade ocean iron fertilization activities designed to promote research in the latter category.[133]

Interpreting the effect of Decision IX/16 has raised some important questions. First, Decision IX/16 fails to define "small-scale" activities that would fit within the scientific research exception of the framework. When compared to the vast expanse of the oceans, one thousand square miles might be considered to be "small scale." Yet such an experiment would far exceed the scope of any experiments yet undertaken. Second, Decision IX/16 calls for the restriction of research activities to "coastal waters." Yet this limitation deprives scientists of the most useful regions for experimentation – the iron-deficient high seas of the Southern Ocean. This language was likely included in an attempt to internalize the externalities perceived to be present on the high seas.[134] However, Decision IX/16 essentially imposes a moratorium on ocean iron fertilization experiments, particularly since the international system has not yet framed a global, transparent, and effective regulatory mechanism as required under this CBD decision.

132. *Id.*

133. *Id.*

134. If the high seas are common property, available for anyone to exploit, then economic theory indicates that the high seas could suffer from a tragedy of the commons and the externality of over-exploitation. *See, e.g.*, Bernard H. Oxman, *The Territorial Temptation: A Siren Song at Sea*, 100 AM. J. INT'L L. 830, 833 (2006) (discussing the failure of the 1958 Convention on Fishing and Conservation of the Living Resources of the High Seas to provide an effective means for avoiding the tragedy of the commons). A response to this problem was for coastal states to claim to control the sea out to 200 miles. One way to avoid this problem in the ocean iron fertilization context would be to restrict any operations to coastal waters, where countries have an interest in protecting the resources within their jurisdiction. This approach eliminates the externality by making those coastal countries internalize the environmental costs associated with ocean iron fertilization.

C. The London Convention and Protocol

Both the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter[135] and its more recent incarnation, the 1996 London Protocol, provide rules and standards that pertain generally to marine pollution and, more specifically, to ocean iron fertilization. Parties to the London Convention cannot dump any prohibited substances without first undergoing an environmental impact assessment, obtaining a permit, and complying with the monitoring requirements of Annex 2 of the London Protocol.[136]

By contrast, under the stricter London Protocol, dumping of any waste or other matter is prohibited, except for five categories of substances listed in Annex 1.[137] Parties to the London Protocol must additionally abide by the precautionary principle under Article 3 of the Protocol. Article 3 requires the adoption of "appropriate preventative measures" whenever an activity is "likely to cause harm" even when there is "no conclusive evidence to prove a causal relation between inputs and their effects."[138] However, both the London Convention[139] and the London Protocol[140] provide an exception to these restrictions whereby the "placement of matter for a purpose other than the mere disposal thereof does not qualify as dumping," provided that such placement is not contrary to the aims of the Convention or Protocol.[141]

On May 8, 2007, the Scientific Group of the London Convention and the Scientific Group of the London Protocol

135. *See* London Convention, *supra* note 22. The Convention, which entered into force in 1975, has provided a framework for international control and prevention of marine pollution. A special meeting of the Contracting Parties produced the "1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972," which was designed to replace the 1972 Convention. For an overview of recent developments respecting these two instruments, *see generally* Alan B. Sielen, *The New International Rules on Ocean Dumping: Promise and Performance*, 21 GEO. INT'L ENVTL. L. REV. 495 (2009).

136. Freestone & Rayfuse, *supra* note 105, at 229.

137. *Id.*

138. London Protocol, *supra* note 22, art. 3.

139. London Convention, *supra* note 22, art. 3(b)(ii).

140. London Protocol, *supra* note 22, at 1.4.2.2.

141. London Convention, *supra* note 22; London Protocol, *supra* note 22, at 1.4.2.2.

released a joint Statement of Concern about Ocean Fertilization.[142] This document stated that the current knowledge about the practice was insufficient to justify large-scale projects and characterized iron fertilization as largely a speculative endeavor.[143] It also noted the risk of negative impacts that large-scale projects posed to the marine environment. Ultimately, the joint statement recommended that any operations be carefully evaluated to ensure that activities were not contrary to the aims of the London Convention and the London Protocol.[144]

The parties to the London Convention and Protocol revisited this topic in London in October 2008 and agreed to adopt Annex Six Resolution LC-LP.1 on the Regulation of Ocean Fertilization (Annex Six Resolution).[145] This resolution stated that the scope of the London Convention and Protocol includes ocean iron fertilization activities, which it defined as any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans.[146] The resolution further stated that "legitimate scientific research" should be regarded as "placement of matter for a purpose other than mere disposal" under both the London Convention and the London Protocol.[147] As such, this resolution exempted from the prohibitions of both treaties ocean iron fertilization projects that qualify as "legitimate scientific research."

The Annex Six Resolution does not specify what activities constitute "legitimate scientific research." The resolution merely provides that proposals should be assessed on a case-by-case basis using an assessment framework to be developed by the Scientific Groups under the London Convention and Protocol, which should include tools for determining whether the proposed

142. *See* SCI. GROUP OF THE LONDON PROTOCOL & SCI. GROUP OF THE LONDON CONVENTION, STATEMENT OF CONCERN REGARDING IRON FERTILIZATION OF THE OCEANS TO SEQUESTER CO*2* (2007), *available at* http://www.whoi.edu/cms/files/London_Convention_statement_24743_29324.pdf.

143. *Id.*

144. *Id.*

145. *See* ANNEX SIX RESOLUTION LC-LP.1 ON THE REGULATION OF OCEAN FERTILIZATION,http://www.imo.org/includes/blastDataOnly.asp/data_id%3D24337/LC-LP1(30).pdf [hereinafter ANNEX SIX RESOLUTION]; London Protocol, *supra* note 22; London Convention, *supra* note 22.

146. ANNEX SIX RESOLUTION, *supra* note 145.

147. *Id.*

activity is contrary to the aims of the Convention and Protocol.[148] Until such guidance is available, the resolution urges contracting parties to use utmost caution and the "best available guidance"[149] to evaluate whether the proposal will ensure protection of the marine environment consistent with the Convention and Protocol.[150] Finally, the resolution expressly forbids any ocean iron fertilization activities other than legitimate scientific research and states that such projects cannot qualify for any exemption from the definition of dumping.

The Intersessional Technical Working Group on Ocean Fertilization had its first meeting from February 9-13, 2009 under the Chairmanship of Dr. Chris Vivian.[151] Delegations from eighteen Contracting Parties to the London Convention attended, as did delegations from fifteen members of the Contracting Parties to the London Protocol.[152] Several non-governmental organizations, including Greenpeace International, as well as an intergovernmental organization, the North Pacific Marine Science Organization, also attended the meeting.[153] The group convened to develop an assessment framework on ocean fertilization and compile information for the contracting parties on ocean iron fertilization and its impacts on the marine environment.[154]

148. *Id.*

149. The resolution directs parties to consult the following sources for guidance: (1) previous agreements of the Consultative Meetings/Meetings of the Contracting Parties; (2) Annex III of the London Convention; (3) Annex 2 of the London Protocol; (4) the considerations for evaluating ocean fertilization proposals developed by the scientific groups; and (5) the Revised Generic Waste Assessment Guidance. *Id.* n.4.

150. IMO, FIRST MEETING OF THE INTERSESSIONAL TECHNICAL WORKING GROUP ON OCEAN FERTILIZATION, PROVISIONAL AGENDA (2009), *available at* http://www.imo.org/includes/blastDataOnly.asp/data_id%3D24375/1.pdf (in December 2008, the IMO announced the First Meeting of the Intersessional Technical Working Group on Ocean Fertilization to take place February 9-13, 2009). The Agenda calls for the "[d]evelopment of an assessment framework on ocean fertilization." *Id.*

151. IMO, INTERSESSIONAL TECHNICAL WORKING GROUP ON OCEAN FERTILIZATION, REPORT OF THE FIRST MEETING OF THE INTERSESSIONAL TECHNICAL WORKING GROUP ON OCEAN FERTILIZATION § 1.1 (2009), [hereinafter IMO REPORT], *available at* http://www.imo.org/includes/blastDataOnly.asp/data_id%3D25080/5.pdf.

152. *Id.* §§ 1.2, 1.3.

153. *Id.* §§ 1.6, 1.7.

154. *Id.* §§ 1.9.1, 1.9.2.

The Group agreed to draft a Risk Assessment and Management Framework for Scientific Research involving Ocean Fertilization. The parties agreed this would be a "work in progress," and would serve as a preliminary model for a final framework that the governing bodies would adopt in October 2009.[155] The South African delegation suggested that the project not monetize any carbon offsets generated nor use such offsets for meeting targets of the Kyoto Protocol.[156] However, the Group decided that such a policy matter should be considered at a meeting of the governing bodies.[157] Finally, the delegations of Brazil and Argentina expressed concern about the LOHAFEX experiment and requested a report from the German and Indian sponsors on how the experiment might impact their coastal areas and EEZs.[158]

The draft framework proposed at the meeting was designed to serve as a tool to assess scientific research proposals on a case-by-case basis to determine if a proposed activity would comport with the London Convention or Protocol.[159] This guidance would also help "determine whether a project is legitimate scientific research," characterize the risks to the marine environment on a "project-specific basis," and "collect the necessary information to develop a management strategy."[160] The elements of the assessment, which the sponsor of the proposed project would present to a national regulator,[161] would include: (1) problem formulation and initial assessment that would define the parameters of the experiment; (2) site selection and description; (3) exposure assessment that would describe the movement and fate of the added substances; (4) an effects assessment; (5) a risk characterization that would estimate the likelihood for adverse impacts and the magnitude of those impacts; and (6) a list of risk management procedures.[162]

155. *Id.* § 2.11.
156. *Id.* § 2.12.
157. IMO REPORT, *supra* note 151 § 1.1.
158. *Id.* § 4.
159. *Id.* at Annex 2, § 1.2.1.
160. *Id.* §§ 1.2.2, 1.2.2.1 to .3.
161. *See id.* § 1.4.
162. *Id.* §§ 1.4.1 to1.4.6.

The framework further requires that the sponsor of a project provide evidentiary support for key assumptions and explain the potential impacts to countries that might be affected.[163] The approval for projects would only be issued for defined periods of time and within defined areas, and sponsors would also have to report on the conduct of the experiment, as well as compliance with the conditions set forth by the Secretariat.[164] Finally, the assessment and approval documentation would be made publicly available.[165]

Interestingly, neither the language of the Annex Six Resolution nor the subsequent draft framework includes any reference to the language of the CBD Decision IX/16, which limits research to "small-scale" experiments in "coastal waters" in its criteria for permitted ocean fertilization research.[166] Since the resolution and framework came after the CBD Decision and refer to the CBD Decision in their text, it is reasonable to conclude that the parties to the London Convention and Protocol considered and rejected these limitations.

The omission of this language perhaps reflects the findings of the UNESCO Intergovernmental Oceanographic Commission ad hoc Consultative Group on Ocean Fertilization (IOC ad hoc group), a group of five leading scientists on ocean iron fertilization that was formed at the request of the Scientific Groups of the IMO in advance of the Resolution of the London Convention and Protocol. In a statement released by the IOC ad hoc group in June 2008, the group sharply criticized the limitations imposed by the CBD decision.[167] It railed against the "arbitrary" and "new" limitation of scientific research to "coastal waters" as "counterproductive" given that the most useful scientific experiments to date have taken place on the open ocean.[168]

163. IMO REPORT, *supra* note 151, §§ 1.7, 1.8.

164. *Id.* § 1.9.

165. *Id.*

166. *See supra* notes 118-123 and accompanying text.

167. UNESCO INTERGOVERNMENTAL OCEANOGRAPHIC COMM'N, STATEMENT OF THE IOC AD HOC CONSULTATIVE GROUP ON OCEAN FERTILIZATION (2008), http://ioc3.unesco.org/oanet/OAdocs/IOC_LCSGStatement.pdf.

168. *Id.*

The IOC ad hoc group statement also stressed that the size of the activity should not be determinative, noting that ocean iron fertilization projects conducted only over one square kilometer might be damaging if undertaken over a coral reef, while ocean fertilization undertaken over thousands of square kilometers might be benign.[169] The statement further maintained that "small-scale" was a relative term and it expressly approved of larger experiments as a means to diminish the dilution of iron near the center of smaller experiments and obtaining better data relating to vertical transport of carbon dioxide.[170] It endorsed experiments as large as 200 kilometers by 200 kilometers as clearly justified.[171]

The IOC ad hoc group conceded that it lacked expertise in international law or policy, but it nevertheless offered two alternatives to policy makers of the London Convention and Protocol.[172] The first called for an independent committee composed of scientists and representatives from the policy, legal, and industry sectors that would assess each proposed fertilization activity on the basis of the risks posed to the environment.[173] This committee would have veto power over those projects it considered to fall below a clearly defined threshold of damage to the environment.[174] The second suggestion would allow "legitimate scientific experiments"—those with defensible scientific goals and public disclosure of methods and results—to proceed, while delaying those activities designed to generate carbon credits or other monetary gain until environmental safeguards can be developed and enacted.[175]

The IMO London Convention and Protocol Working Group on Ocean Fertilization (Working Group), which met in Guayaquil, Ecuador in May 2008, reviewed the IOC ad hoc group input and information from other international organizations with special expertise in ocean iron fertilization issues. The Working Group

169. *Id.* § I.4.
170. *Id.* §§ II.A., II.B.
171. *Id.* § II.B.
172. *Id.* §§ I.6(a), (b).
173. UNESCO INTERGOVERNMENTAL OCEANOGRAPHIC COMM'N, STATEMENT, *supra* note 167.
174. *Id.*
175. *Id.* § I.6(b).

issued three recommendations for the scientific and legal groups: (1) it requested advice from the Legal Intersessional Correspondence Group regarding the appropriateness of the phrase "contrary to the aims of the Convention/Protocol;" (2) it requested that the London Convention and Protocol consolidate new information on scientific research on ocean iron fertilization as it becomes available and make it available for use in assessing proposals; and (3) it recommended that Annex 3 be used as the list of considerations for evaluating ocean iron fertilization activities.[176]

There are some indications that the CBD is retreating from its de facto moratorium on ocean iron fertilization. A draft CBD document entitled "Scientific Synthesis on the Impacts of Ocean Fertilization on Marine Biodiversity" noted the need for international oversight for all ocean iron fertilization activities.[177] In addition, it called for the adoption of an assessment framework to validate side effects and, surprisingly, for legitimate scientific research to advance the collective understanding of biogeochemical processes within the global oceans.[178]

The London Convention and Protocol Correspondence Group reviewed this document and stated that the CBD draft could serve as a background paper for the London Convention and Protocol.[179] However, it noted that the document does not offer an assessment framework for scientific research proposals involving ocean iron fertilization, nor does it provide the level of technical guidance necessary to ensure precautionary protection of the

176. UNESCO INTERGOVERNMENTAL OCEANOGRAPHIC COMM'N, REPORT ON THE IMO LONDON CONVENTION SCIENTIFIC GROUP MEETING ON OCEAN FERTILIZATION (2008), http://ioc3.unesco.org/oanet/OAdocs/INF1247-1.pdf. Annex 3 calls for the consideration of: (1) a description of the project, including the chemicals to be added, the manner and amount of the addition, along with the date, location and purpose; (2) the potential impacts of the activity on the marine environment; (3) the project's contributions to scientific knowledge; and (4) the monitoring of the substance. According to this recommendation, all parties seeking to engage in research activities would have to submit a proposal addressing these considerations. *Id.* at Annex 3.

177. SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, SCIENTIFIC SYNTHESIS OF THE IMPACTS OF OCEAN FERTILIZATION ON MARINE BIODIVERSITY 10 (2009), *available at* http://www.cbd.int/doc/publications/cbd-ts-45-en.pdf.

178. *Id.*

179. CHAIRMAN OF THE SG OCEAN FERTILIZATION CORRESPONDENCE GROUP, INTERIM REPORT ON OCEAN FERTILIZATION SCIENCE OVERVIEWS 3 (2009).

marine environment.[180] The Group further noted that the CBD document "contained gaps" and served a different purpose—to compile and synthesize available scientific information on potential impacts on marine biodiversity—than that of the Correspondence Group.[181]

Based on the text of the Annex Six Resolution released by the London Convention and Protocol, the extent to which the statements of the IOC ad hoc group or the Scientific Working Group were considered is unclear. Nor does the resolution offer any indication as to the applicability of the limitations imposed by the CBD Decision IX/16. However, it is clear that the London Convention and Protocol do not authorize sanctions for violations. While voluntary compliance with the London Convention and Protocol is reported to be high,[182] it is unclear whether the prohibition provides sufficient deterrence for commercial enterprises that might engage in large-scale ocean iron fertilization research to test their methods in advance of expected future carbon trading.

III. THE LOHAFEX PROJECT AND THE NEED FOR A NEW LEGAL FRAMEWORK

If one of the goals of international environmental law is to provide clear guidelines so that states may regulate entities subject to their jurisdiction, then the LOHAFEX project provides an ideal illustration of the shortcomings of the current legal framework governing ocean iron fertilization. This part of the article examines the legality of the LOHAFEX expedition under existing international environmental law and illustrates why a new legal framework is necessary.

The LOHAFEX project fails to comply with the mandate of CBD Decision IX/16, which restricts ocean iron fertilization projects to "small-scale" studies within "coastal waters."[183] Neither the decision, nor Article 2, of CBD defines" small-scale" or "coastal waters," but the proposed site in the Southern Ocean does not appear to qualify as coastal waters.

180. *Id.*
181. *Id.*
182. HUNTER, SALZMAN & ZAELKE, *supra* note 106, at 819.
183. *See supra* notes 118-123 and accompanying text.

The risk assessment prepared by the Alfred Wegener Institute, the German group that co-sponsored the experiment, does not claim that the site falls within coastal waters. Instead, the assessment states that its proposed approach complies with the requirements of the CBD. It first references the recent CBD decision, placing emphasis on the stated need for further research to assess the impact on the ecosystem and the efficacy of iron fertilization.[184] It then asserts that the proposal is based on "intercomparisons . . . of previous iron fertilisation experiments all carried out in the Southern Ocean including *coastal waters* that provide the basis for the assessment of the impact of such experiments on the environment."[185] It later describes the location as "downstream from an extensive land mass" (the Antarctic Peninsula), which "contains waters with *coastal* plankton species."[186] With regard to the "small-scale" requirement, the assessment describes the spatial scale as "small in respect to the surrounding environment" and small "in comparison to natural iron enrichments by coastal waters or icebergs."[187]

According to the assessment, the LOHAFEX experiment: (1) fulfills the need to assess its impact on the ecosystem;[188] (2) fits within the scope of the term "coastal waters" because the subject matter has previously been studied in coastal water and coastal plankton live in the water;[189] and (3) satisfies the "small-scale" requirement if compared to the size of the Southern Ocean and natural iron enrichments.[190] This argument is hardly an ironclad legal defense. Therefore, it is reasonable to conclude, as did the German Environment Ministry, that the experiment would not comply with a strict interpretation of CBD Decision IX/16.

In response to a letter from a non-governmental organization (NGO) that alleged that a violation of the CBD had occurred, the Bureau of the Conference of the Parties to the CBD addressed the

184. ALFRED WEGENER INST., RISK ASSESSMENT OF THE LOHAFEX EXPEDITION 2 (2009).

185. *Id.* at 2 (emphasis added).

186. *Id.* at 3 (emphasis added).

187. *Id.*

188. *Id.* at 4.

189. *Id.* at 5-6.

190. RISK ASSESSMENT OF THE LOHAFEX EXPEDITION, *supra* note 184.

issue of the LOHAFEX expedition in Nairobi, Kenya on February 19, 2009.[191] After the German representative left the room to let the Bureau discuss the course of action, the Executive Secretary noted that the issue of implementation of COP decisions was not addressed in the rules of procedure and that the *responsibility* to implement COP decisions lay with the parties at the national level.[192] Nevertheless, the Bureau members felt compelled to issue a formal response to the NGO.[193] The Bureau concluded that it was up to Germany to respond to the letter from the NGO. The Bureau also indicated that it would send a letter to Germany and India to convey the Bureau's concerns about the LOHAFEX expedition.[194]

This interaction highlights the decentralized nature of international law. Instead of providing a centralized enforcement mechanism, the CBD (and the other treaties discussed above) relies on states to police the activities of nationals within their jurisdiction. While the results might have disappointed the expectations of observers in favor of more concrete action against Germany in response to the LOHAFEX expedition, the CBD Bureau's response demonstrates that its members shared the concerns that the NGO expressed regarding possible violations of the CBD's restrictions on ocean iron fertilization.

By contrast, the legal justification for the LOHAFEX expedition appears somewhat stronger under the London Convention and Protocol Resolution, whose terms do not include the restrictions of the CBD resolution. The project would very likely meet the threshold requirement that it be a scientific research project. However, the Scientific Groups under the London Convention and Protocol have not yet issued an assessment framework. Therefore, as a party to the Convention and Protocol, Germany must "use utmost caution and the best available guidance to evaluate the . . . proposal to ensure "protection of the marine environment consistent with the

191. Bureau of the Conference of the Parties to the Convention on Biological Diversity, Nairobi, Kenya, Feb. 13, 2009, *Minutes of the Meeting of the Bureau of the Conference of the Parties to the Convention on Biological Diversity Held in Nairobi, on 13 February 2009*, *available at* http://www.cbd.int/doc/meetings/cop-bureau/cop-bur-2009/cop-bur-2009-02-13-minutes-en.pdf.

192. *Id.* at 7-8.

193. *Id.* at 8.

194. *Id.*

Convention and Protocol."[195] The risk assessment plausibly maintains that the naturally occurring iron enrichment in the region is much larger in scale than the level of iron to be deposited in the proposed experiment; therefore, it would cause no greater ecological damage than that presently occurring naturally. Accordingly, Germany could reasonably conclude that this experiment fits within the scientific research exception to the resolution.

As demonstrated by the foregoing analysis, these two overlapping treaties impose different levels of obligations for scientific research projects that seek to conduct ocean iron fertilization, with the CBD imposing several highly restrictive terms that are conspicuously absent in the London Convention and Protocol. Yet the German Ministry of Research still allowed the project to move forward, despite the uncertainty regarding its compliance with the CBD and over the objections of the Ministry of the Environment. The rationale for this decision is unclear, but press releases from both the Alfred Wegener Institute and the Indian National Institute of Oceanography used the ambiguity and incongruity in international legal instruments to justify the LOHAFEX expedition.[196]

IV. FOUNDATIONS FOR A NEW LEGAL FRAMEWORK

The unclear and conflicting mandates in the existing legal framework governing the LOHAFEX project illustrate the need for a new legal framework to regulate scientific research on ocean iron fertilization. First, and most importantly, the new legal framework would harmonize the incongruous treaty obligations in the existing framework to ensure that states understand whether actors subject to their jurisdiction are in compliance with international law. Second, the framework would address ground rules for those parties seeking to capitalize on ocean iron

195. ANNEX SIX RESOLUTION, *supra* note 145, at 6.

196. *See, e.g.*, INDIAN NAT'L OCEANOGRAPHY INST, SCIENTIFIC AIMS AND DESCRIPTION OF LOHAFEX: AN INDO-GERMAN IRON FERTILIZATION EXPERIMENT IN THE SOUTHERN OCEAN (2009), http://www.nio.org/projects/narvekar/Statement%20_on_LOHAFEX.pdf (citing the approval by London Convention and Protocol Annex Six Resolution of scientific research projects, while failing to mention restrictions on such experiments in the CBD); RISK ASSESSMENT OF THE LOHAFEX EXPEDITION, *supra* note 184.

fertilization through the trade of carbon credits, as well as for those parties that wish to engage in scientific research. In lieu of an artificial distinction based on the motivation of those looking to explore ocean iron fertilization, the new framework would treat all parties equally and distinguish proposed activities on the basis of the scope of the project. Third, the proposed legal framework would include differentiated standards for small-scale and large-scale ocean iron fertilization projects.

A. Harmonize Incongruous Treaty Obligations

The most important element of any framework that seeks to regulate ocean iron fertilization is to consolidate the incongruous treaty obligations under UNCLOS, the CBD, and the London Convention and Protocol. As noted above, UNCLOS requires that member states abide by the international rules and standards regarding pollution, including "dumping.".[197] Thus, the international rules and standards agreed to by parties to the CBD and the London Convention and Protocol could have a binding effect on any party to UNCLOS. Moreover, to the extent that UNCLOS codifies customary international law, such rules and standards could arguably have a binding effect on any state whose flagged vessels engage in ocean iron fertilization.[198]

However, the requirements of the CBD and the London Convention and Protocol need better coordination.[199] This

197. UNCLOS, *supra* note 20, arts. 194, 210.

198*. See generally* Bradford C. Mank, *Can Plaintiffs Use Multinational Environmental Treaties as Customary International Law to Sue Under the Alien Tort Statute?*, 2007 UTAH L. REV. 1085 (2007).

199. Other treaties have successfully entered into cooperative arrangements in the Southern Ocean to regulate the behavior of non-state actors. For example, parties to Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Commission of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) passed a resolution regarding cooperation in trade in toothfish that encouraged a "permanent flow of information." Resolution 12.4, Cooperation Between CITES and the Commission for the Conservation of Antarctic Marine Living Resources Regarding Trade in Toothfish, CITES Doc. Conf. 12.4 (2002). In addition, the two treaties have extended observer status to one another at their respective meetings. Report of the Twenty-First Meeting. For an overview on cooperation between the two treaties on the prevention of overfishing Patagonian Toothfish, *see generally* Laura Little & Marcos A. Orellana, *Can CITES Play a Role in Solving the Problem of IUU Fishing?: The Trouble with Patagonian Toothfish*, 16 COLO. J. INT'L ENVTL. L. & POL'Y 21 (2005). In the context of ocean iron

regulatory gap requires an independent body comprised of delegates from the treaties discussed here and any relevant regional treaties, along with scientific analysts who could provide relevant guidance for any actions. The organization should also obtain input from those entities seeking to engage in commercial ocean iron fertilization whose interests would be regulated by this body. This body should implement regulations that put interested parties, and the states that must govern their actions, on notice of what is required in order to be in compliance with international law.

The international regime best equipped to house such a body is the IMO, a specialized agency within the United Nations primarily tasked with developing and maintaining a comprehensive regulatory framework for maritime shipping.[200] The IMO already oversees a number of international treaties, including the London Convention and Protocol.[201] With 169 Member States and three Associate Members, the IMO has the authority necessary to implement such regulations.[202]

The IMO should implement regulations that allow for interested parties to apply for permits to conduct ocean iron fertilization experiments. Applicants for these permits should be segregated into two classes: (1) those seeking to engage in large-scale activities, and (2) those seeking to conduct small-scale research activities. This distinction was already recognized in

fertilization, such inter-treaty cooperation has similarly begun to coalesce. For example, in May 2009, the Scientific Groups of the London Convention and Protocol established a Correspondence Group on Ocean Fertilization to collate the views of contracting parties on this issue and identify disparities in these views. This group consisted of a number of countries, the CBD Secretariat, the UNESCO-IOC Secretariat, Advisory Committee on Protection of the Sea, Greenpeace International, and International Emissions Trading Association.

200. IMO, The Origins of the International Maritime Organization, http://www.imo.org/home.asp?topic_id=1726 (last visited Apr. 16, 2010). *See generally* Alexandra Ritucci-Chinni, *The Solution to International Cruise Ship Pollution: How Harmonizing the International Legal Regime Can Help Save the Seas*, 7 DARTMOUTH L.J. 27 (2009) (arguing that the IMO could serve as an implementing agency for enhanced integration of UNCLOS and MARPOL mandates to address international cruise ship pollution).

201. London Protocol, *supra* note 22, art. 1.2. For an extensive list of treaties implemented by IMO, *see* IMO, International Maritime Organization Complete List, http://www.imo.org/home.asp?topic_id=1726 (last visited Apr. 16, 2010).

202. IMO, Membership, http://www.imo.org (last visited Apr. 16, 2010) (scroll down to "Member States").

the CBD Decision and the London Convention and Protocol Resolution.

Contrary to the statement of the IOC ad hoc group, the distinction between large-scale projects and small-scale projects is valid and important in considering the regulation of ocean iron fertilization projects. While the ad hoc group's suggestion that a small algae bloom over a reef could cause more damage than a far larger bloom on the open ocean is true, this concern is misplaced. No scientist has yet proposed to engage in ocean iron fertilization over reefs, and there is consensus that these activities are best undertaken in the iron-deficient expanse of the Southern Ocean. Moreover, any activity that would threaten a reef would presumably take place in coastal waters and be subject to the regulations of the state whose territorial seas are threatened.

The IOC ad hoc group suggests, instead, that the line should be drawn between those activities that harm the environment and those that do not. However, this uncontroversial proposition does not exclude distinctions based on the size of the project. Indeed, any regulation has to distinguish between the proposed spatial scope of the project, as well as the proposed amount of iron to be added, because these factors are likely to be the best indicators of the environmental damage that might occur. Therefore, the distinction between large-scale and small-scale projects should be preserved.

However, contrary to the CBD Decision and the Annex Six Resolution of the London Convention and Protocol, the distinction between commercial and scientific activities is artificial and unnecessary. Those parties that seek to profit from ocean iron fertilization have the same capacity to conduct meaningful scientific experiments as any other group. In fact, commercial companies often have access to greater resources that might allow them to conduct longer-term experiments and advance the body of knowledge surrounding ocean iron fertilization. In addition, scientific institutions could cause harm to the environment when conducting reckless experiments in the same manner as profit-driven enterprises could. Therefore, parties that seek to profit should have the same right to apply for a permit as any other research institution, provided that they adhere to the same restrictions that govern the scientific institutions.

B. Capitalize on Cap and Trade

While most commentary on ocean iron fertilization projects vigorously contests the wisdom of allowing such projects for commercial purposes, there are some legitimate reasons, noted above, for allowing these projects to move forward. To understand how these commercial projects could be implemented, however, it is essential to evaluate the international legal mechanisms pursuant to which commercial enterprises seek to profit through the sale of carbon credits.

States can use carbon credits to meet their greenhouse gas emission reduction targets under the Kyoto Protocol, provided that such credits meet the requirements of the Kyoto Protocol and the UNFCCC.[203] While the UNFCCC envisions the use of all types of sequestration techniques, the terms of the Kyoto Protocol do not allow for the use of carbon sinks; strict rules prohibit the use of carbon sinks to generate carbon credits, with the exception of afforestation or reforestation projects.[204] The European Emission Trading Scheme does not accept any sink projects at all.[205]

The Kyoto Protocol does, however, authorize the use of "flexibility mechanisms" to meet emission reduction goals. One of these mechanisms—Joint Implementation—allows two developed countries to collaborate in a project to reduce emissions in one country, with investment from the other that can then claim carbon credits for achieved emission reductions.[206]

The Kyoto Protocol also includes the Clean Development Mechanism (CDM), which allows developed countries to invest in emission reduction projects in developing countries and claim carbon credits for achieved emission reductions.[207] Participation in these projects is open to both public and private actors, provided that they act under the authority of a party to the Kyoto Protocol and act pursuant to the guidance of the CDM Executive Board.[208] While the Conference of the Parties in Bali decided in

203. Freestone & Rayfuse, *supra* note 105, at 228.
204. *Id.*
205. *Id.*
206. *Id.* at 231.
207. *Id.*
208. *Id.*

2007 that it would consider expanding the list of allowable carbon sinks beyond reforestation and afforestation to include avoided deforestation,[209] ocean iron fertilization has not gained sufficient legitimacy to allow for its eligibility as a carbon sink under the CDM anytime in the near future.

Nevertheless, the uncertainty in the existing legal mechanisms has not prevented companies from positioning themselves to capitalize on this potential market. Companies such as Ocean Nourishment and Climos, among others, have already invested in technology that might one day be used pursuant to the Kyoto Protocol and its post-2012 successor agreement. The parties to the Kyoto Protocol met in Copenhagen in December 2009 in the much-anticipated Fifteenth Conference of the Parties to the Kyoto Protocol. The meeting fell short of expectations and only produced a non-binding agreement, the Copenhagen Accord.[210]

There is room for optimism, however, regarding the future of ocean iron fertilization as a mitigation strategy because the Copenhagen Accord included several provisions addressing reducing emissions from deforestation and degradation (REDD). For example, Article 6 recognizes the crucial role of REDD to "enable the mobilization of financial resources from developed countries" to reduce global GHG emissions.[211] REDD embraces the notion that paying developing countries to preserve tropical forests' capacity to absorb carbon from the atmosphere is an extremely potent regulatory tool. The Copenhagen Accord lays a foundation for REDD to be an integral component of post-Kyoto climate treaty. Such a focus on the importance of sinks in climate change mitigation could open the door for ocean iron fertilization

209. Freestone & Rayfuse, *supra* note 105, at 231.

210. Conference of the Parties, Fifteenth Session, Copenhagen, Denmark, Dec. 7-18, 2009, *Draft Decision: Proposal by the President, Copenhagen Accord,* U.N. Doc. FCCC/CP/2009/L.7 (Dec. 18, 2009), *available at* http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf.

211. *Id.* art. 6. For a critique of the adequacy of the REDD language in the Copenhagen Accord, *see* Chris Lang, *What Came out of Copenhagen on REDD?*, REDD-MONITOR, Dec. 22, 2009, http://www.redd-monitor.org/2009/12/22/what-came-out-of-copenhagen-on-redd/; *see also REDD May Yet Survive Copenhagen Failures*, CARBON POSITIVE, Dec. 21, 2009, http://www.carbonpositive.net/viewarticle.aspx?articleID=1786.

to be added as an acceptable component of climate change mitigation in a post-Kyoto regime.

Moving forward from Copenhagen and its acceptance of REDD, the regulatory framework for ocean iron fertilization should be expanded to allow for pilot projects for more radical carbon sinks such as ocean iron fertilization, provided that the companies are subject to rigorous permitting requirements even stricter than those that would govern REDD projects. This approach could help spur innovation and expand the funding available to scientific researchers who have expressed the need to study ocean iron fertilization on a longer-term basis and on a larger scale.[212] However, these private actors should have to comply with the requirements of a two-tiered permitting scheme that accommodates small-scale and large-scale projects.

C. Identify Requirements for Small-Scale and Large-Scale Projects

To promote environmentally sensitive implementation of ocean iron fertilization projects, both small-scale and large-scale projects should be subject to strict requirements. One such requirement is government sponsorship, which would increase accountability for any experiment as states are unlikely to sponsor an environmentally reckless endeavor that might damage their reputation in the international community. Applicants should also have to share any meaningful scientific data with the community through the publication of peer-reviewed reports upon completion of the experiment. While proprietary techniques and trade secrets could possibly be afforded some protection, the underlying methodology would have to be subject to examination.

In addition, the number of permits to conduct small-scale activities would need to be capped at a number to reflect the understanding of the scientific community as to the carrying capacity of the oceans. This requirement would ensure that the permitting body consider the experiments in the aggregate, and not engage in piecemeal destruction of the marine environment. Finally, applicants should be required to prepare extensive risk assessments, similar to the impact assessments required under

212. *See* Smetacek & Naqvi, *supra* note 27.

the National Environmental Policy Act (NEPA),[213] which would address, at a minimum, the risks inherent in the experiment, the hypothesis to be tested, and the contribution to scientific understanding that the experiment seeks to make. This requirement would force both the applicant and the state sponsor to fully consider the potential environmental impacts of its decisions and enhance the overall understanding of the process of ocean iron fertilization. This list of requirements for small-scale applicants is suggestive, not exhaustive, of the types of restrictions that might limit the environmental impact of any applicant, commercial or public, that seeks to engage in ocean iron fertilization activities.

The foregoing restrictions would apply to both large-scale and small-scale applications. However, large-scale ocean iron fertilization proposals would be subject to greater scrutiny. These experiments would be subject to enhanced oversight, and the adverse consequences of such experiments would potentially trigger liability under certain circumstances.

As with small-scale experiments, applicants for large-scale projects would have to prepare environmental risk statements outlining the potential damage that their activities would pose. The regulatory body responsible for processing the permit applications would have to exercise a greater degree of scrutiny with these applications because the stakes presumably would be higher. In addition, as these large-scale projects would allow for greater potential to test the commercial viability of an enterprise and demonstrate greater ability to sequester carbon, the permits for these activities would likely be worth more to the applicants. Accordingly, these permits should be auctioned to allow the market to determine their worth.

These large-scale experiments would also be subject to a greater degree of oversight. As the number of experiments would be extremely limited, it might be possible for independent observers to travel with the research team to verify that the experiment is conducted properly. This requirement would have the additional benefit of allowing the independent observers to verify the findings of the research team and discourage any exaggeration by commercial enterprises as to the effectiveness of

213. National Environmental Policy Act, 42 U.S.C. §§ 4321-4370f (2006).

their methods. If the body finds that independent observers would not be a feasible way to monitor these projects, an alternative would be to monitor the activities using satellite imaging. This technology exists and algae blooms have already been observed via satellite.[214] Thus, the technology would simply be applied to the research activity in question.

Finally, these large-scale experiments should be subject to a greater degree of liability for any consequences that might arise. For example, if an algae bloom from a large-scale project creates a toxic bloom or low-oxygen environments that produce cognizable damage to the territorial seas of a state, then the permit terms would require assessment of the damages. This assigning of responsibility would be governed by the strict liability standard.[215] Such an approach is reasonable because the risk assessment creates a presumption that the actor has the intent to cause the damages that flow from his actions. In addition, this activity is an abnormally dangerous activity and thus merits the application of strict liability.[216] This approach would not, however, require the actor to compensate the party harmed for every fish taken, as this would require prohibitively expensive environmental analysis. Instead, it would require some form of simplified damage assessment that would use a formula based on degree of harm produced (the type of damage) multiplied by the

214. Powell, *Fertilizing the Ocean with Iron*, *supra* note 29, at 7.

215. *See generally* Alexandre Kiss & Dinah Shelton, *Strict Liability in International Environmental Law*, *in* LAW OF THE SEA, ENVIRONMENTAL LAW AND SETTLEMENT DISPUTES: LIBER AMICORUM JUDGE THOMAS A. MENSAH (Tafsir Malick Ndiaye & Rudiger Wolfrum eds., 2007), *available at* http://ssrn.com/abstract=1010478. For international environmental law treaties imposing some form of strict liability, *see* Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, art. 9, May 5, 1992, 28 I.L.M. 657; International Convention for the Prevention of Pollution from Ships, Nov. 2, 1973, 12 I.L.M. 1319 (1973), *as modified by* Protocol Relating to the International Convention for the Prevention of Pollution from Ships, Oct. 2, 1983, 17 I.L.M.546 (1978); Cartagena Protocol on Biosafety to the Convention on Biological Diversity, art. 27, Sept. 11, 2003, 39 I.L.M. 1027.

216. For a foundational example of strict liability in tort that applies the principle of abnormally dangerous activity, *see generally*, Rylands v. Fletcher, L.R. 3 HL 330 (1868); *see also* Rio Declaration on Environment and Development, pr. 13, June 13, 1992, 31 I.L.M. 874, *available at* http://www.unep.org/Documents.Multilingual/Default.asp?documentid=78&articleid=1163 (noting that Principle 13 is commonly referenced as the Polluter Pays Principle).

number of square kilometers affected. This formula would yield a dollar amount that represents the damages incurred by the party.

In addition, UNCLOS contains a dispute resolution mechanism[217] that allows parties to refer disputes to the International Tribunal for the Law of the Sea, the International Court of Justice, or another ad-hoc arbitral tribunal.[218] Thus, any party harmed by an ocean iron fertilization project may bring suit under this provision, which would promote further disincentives for reckless behavior and a remedy for parties harmed by permitted ocean iron fertilization projects.

CONCLUSION

Ocean iron fertilization is a flashpoint of controversy as well as a source of hope in confronting the challenges posed by global climate change. Although disagreement continues over whether ocean iron fertilization is a safe and effective strategy to absorb carbon, the more significant controversy centers on what form a fair, cohesive, and environmentally sensitive international legal regime to govern these undertakings should take, regardless of whether such undertakings are conducted to advance scientific research or profit-driven motives. The unclear and conflicting mandates in the existing legal framework governing the LOHAFEX project underscore the need for a new legal framework to regulate scientific research on ocean iron fertilization.

This article has proposed a legal framework to address this regulatory gap that would harmonize the overlapping and conflicting regulatory mandates of UNCLOS, the CBD, and the London Convention and Protocol in the context of ocean iron fertilization. The framework would seek to reward proactive

217. UNCLOS, *supra* note 20, art. 297(1)(c). This section provides for binding dispute resolution,

> [w]hen it is alleged that a coastal State has acted in contravention of specified international rules and standards for the protection and preservation of the marine environment which are applicable to the coastal State and which have been established by this Convention or through a competent international organization or diplomatic conference in accordance with this Convention.

Id.

218. Andrew Guzman & Jennifer Landsidle, *The Myth of International Delegation*, 96 CAL. L. REV. 1693, 1717 (2008).

innovation within a broader context of promoting short-term and long-term accountability for the effects of this experimental strategy on the integrity of the marine environment and the global environment as a whole. The IMO would be the lead agency to coordinate and monitor this revised framework. The proposal also would enable parties to capitalize on ocean iron fertilization through the trade of carbon credits in the post-Kyoto era given the Copenhagen Accord's acceptance of the importance of the role of carbon sinks in climate change mitigation. The new framework would treat all parties equally and distinguish proposed activities on the basis of the scope of the project. Finally, the proposed legal framework also would include differentiated standards for small-scale and large-scale ocean iron fertilization projects.

While the proposed framework would provide some foundational principles, any regulatory structure that governs ocean iron fertilization should remain flexible. Technological improvements in ocean iron fertilization tactics could lead to improved efficacy of this technique as a carbon sink, or, alternatively, a consensus may emerge in the scientific community in the near future that such a radical technique has no place as a climate change mitigation strategy. However, as the dire consequences of climate change become ever more real, policy makers need to retain a broad range of options. Most scientists agree that ocean iron fertilization withdrew massive amounts of carbon dioxide in prior periods of climate fluctuation. Therefore, the international community should strive to learn as much as possible about this rapidly deployable mitigation technique that offers tremendous promise as a potent weapon in the fight against climate change.