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A Tale of Two Carbon Sinks: Can Forest Carbon Management Serve as a Framework to Implement Ocean Iron Fertilization as a Climate Change Treaty Compliance Mechanism?

Randall S. Abate[†]

Any post-Kyoto climate change treaty regime must seek to fully engage the use of carbon sinks to complement emissions reduction measures in order to comply with the treaty's mandates. The Kyoto Protocol did not include avoided deforestation as a mechanism for earning emission reduction credits. However, reducing emissions from deforestation and degradation (REDD) quickly gained popularity as a viable climate change compliance strategy in the period immediately preceding the negotiations at the Fifteenth Conference of the Parties (COP 15) in Copenhagen in 2009. The Copenhagen Accord is replete with references to REDD as a focus for the international community's progression toward a binding successor agreement to the Kyoto Protocol.

Ocean iron fertilization (OIF) is an emerging and controversial strategy to promote climate change treaty compliance, and may be the next step in engaging the creative use of carbon sinks to fulfill carbon reduction mandates. Both REDD and OIF must overcome challenges such as developing effective monitoring techniques, ensuring the "permanence" of emission reductions, and avoiding "leakage" of such reductions. Like REDD, OIF could promote a global carbon trading market that may help ensure the success of a post-Kyoto climate change treaty. Unlike REDD, however, OIF is hampered by "moral hazard" and "unintended consequences" concerns associated with its techniques. In addition, to ensure effective regulation of the research and implementation of OIF projects, OIF must overcome significant international law governance challenges.

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Nevertheless, OIF has the potential to build on REDD's success and become incorporated as another important dimension of a post-Kyoto carbon market system.

I. INTRODUCTION

Climate change is the most daunting and divisive environmental governance issue that humanity has ever faced. Traditional treaty negotiation and implementation efforts remain relevant to combat this crisis; however, these channels of governance and diplomacy have fallen short of expectations in significant respects in the past two decades. For example, the refusal of the United States to become a member of the Kyoto Protocol¹ has severely undermined the effectiveness of this global greenhouse gas emissions reduction agreement. In addition, the Copenhagen Accord² does not commit nations to binding emission reduction goals and is a merely aspirational, non-binding international law agreement. Therefore, the much-anticipated Fifteenth Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 15), held in Copenhagen in 2009, was widely regarded as a failure.³

Relying exclusively on traditional domestic emission reduction strategies will not suffice to meet the ambitious and urgent goals of climate change treaty compliance in the post-Kyoto era. The parties to the Kyoto Protocol recognized the need for flexible compliance strategies and implemented one such mechanism to fulfill this objective in the form of the Clean Development Mechanism (CDM).⁴ This creative compliance mechanism provides an opportunity for partnerships between developed and developing countries to promote clean energy projects that enable the participating countries to earn credits for emission reductions.⁵

The international community now has a valuable opportunity to expand the scope of the CDM model and employ market-based mechan-

1. Kyoto Protocol to the United Nations Framework Convention on Climate Change, *opened for signature* Dec. 11, 1997, 2303 U.N.T.S. 162 (*entered into force* Feb. 16, 2005) [hereinafter Kyoto Protocol].

2. U.N. Framework Convention on Climate Change Conference of the Parties, Copenhagen, Den., Dec. 7-19, 2009, *Copenhagen Accord*, art. 6, U.N. Doc. FCCC/CP/2009/L.7 (Dec. 18, 2009), available at <http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf#page=4> [hereinafter Copenhagen Accord].

3. Given the recent failures in international climate change negotiations, some commentators have questioned whether the U.N. Conference of the Parties model is the best approach to address the international climate change crisis. See, e.g., John M. Broder, *The Last U.N. Climate Extravaganza?*, N.Y. TIMES, Oct. 8, 2010, <http://green.blogs.nytimes.com/2010/10/08/the-last-u-n-climate-extravaganza/>.

4. Kyoto Protocol, *supra* note 1, art. 12.

5. See *id.*

isms, consequently providing more flexibility in responding to the climate change crisis. Carbon markets have developed rapidly since the Kyoto Protocol's emissions reduction commitments entered into force in 2005. Mandatory and voluntary carbon markets have been established.⁶ The mandatory carbon markets, such as the EU Emissions Trading System, have not drawn on avoided deforestation credits.⁷ However, within the past few years, voluntary carbon markets based on reducing emissions from deforestation and degradation (REDD) have emerged and are working effectively.⁸ These developments offer some hope that an international carbon market, bolstered by the authorized use of avoided deforestation credits, could evolve as part of a post-Kyoto climate change compliance regime.

If and when REDD becomes more institutionalized, ocean iron fertilization (OIF) projects may then be able to capitalize on REDD's successes and become the next step forward in the use of market-based climate change regulation mechanisms. Tradable credits generated from the carbon dioxide sequestered from OIF projects could be part of a climate change compliance regime in much the same manner as avoided deforestation credits in REDD. However, several social, scientific, and legal uncertainties impede OIF's succession of REDD.

II. REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION (REDD)

The Kyoto Protocol's exclusion of two significant contributing sources to climate change—deforestation and forest degradation—from its regulatory framework is one reason it failed to produce an adequate international response to climate change.⁹ Reducing emissions of greenhouse gases from traditional industrial sources, while failing to address emissions from other significant sources, created a situation of winning the battle but losing the war against climate change. Deforestation and forest degradation release up to eighteen percent of annual global carbon

6. CLÉMENT CHENOST et al., *Bringing Forest Carbon Projects to the Market*, UNEP 24, (2010), available at http://www.unep.fr/energy/activities/forest_carbon/pdf/Guidebook%20English%20Final%2019-5-2010%20high%20res.pdf.

7. *Id.* at 32.

8. *Id.* at 35.

9. During the Kyoto Protocol negotiations, REDD was considered and ultimately rejected for inclusion as one of the flexibility mechanisms in the Protocol. See Crystal Davis, *Protecting Forests to Save the Climate: REDD Challenges and Opportunities*, World Resources Institute, Apr. 23, 2010, <http://earthtrends.wri.org/updates/node/303>; See also Randall S. Abate & Todd A. Wright, *A Green Solution to Climate Change: The Hybrid Approach to Crediting Reductions in Tropical Deforestation*, 20 DUKE ENVTL. L. & POL'Y F. 87, 100 (2010) (more than a decade after the exclusion of REDD from Kyoto, "developing countries remain ineligible to earn tradable carbon credits under the Kyoto Protocol for curbing deforestation.").

dioxide emissions.¹⁰ Forestry projects under the CDM do not include avoided deforestation but rather are limited to afforestation and reforestation.¹¹ Moreover, CDM forestry projects comprise only 0.4% of all registered CDM projects.¹² The CDM also has failed to provide developing countries with a meaningful role in addressing global climate change because it is too narrow and administratively stringent to achieve broad-based participation.¹³

REDD offers an opportunity to build on the CDM's basic premise of cultivating partnerships between developed and developing nations in meeting climate change commitments, while operating in a more flexible and inclusive manner. REDD represents a critically important partnership between developed and developing countries. It involves developed countries paying developing countries to protect their tropical forests as an international climate change mitigation strategy.¹⁴ REDD seeks to establish a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forested lands.¹⁵

Even though the international community was well aware of the important role that REDD could play in climate change treaty compliance, the parties to the Kyoto Protocol rejected the inclusion of this mechanism within the regime's regulatory framework, citing concerns relating to monitoring and verification of reductions from REDD projects.¹⁶ Conceptually, environmental groups opposed REDD on the

10. SIR NICHOLAS STERN, THE STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE 171 (2006), available at http://www.hm-treasury.gov.uk/stern_review_report.htm.

11. See Bernard Schlamadinger et al., *Should We Include Avoidance of Deforestation in the International Response to Climate Change?*, in TROPICAL DEFORESTATION AND CLIMATE CHANGE 53, 53 (Paulo Moutinho & Stephan Schwartzman eds., 2005). "Afforestation and deforestation both refer to anthropogenic conversion of non-forested areas into forested land. The difference is that afforestation refers to projects on land that has not been forested for at least fifty years, while reforestation refers to the conversion of non-forested areas that have not been forested since December 31, 1989." Abate & Wright, *supra* note 9, at 94 (internal citations omitted). REDD's system of generating credits for avoided deforestation provides a more effective response to limiting anthropogenic greenhouse gas emissions from deforestation and forest degradation as compared to the CDM's limited framework.

12. CHENOST, *supra* note 6, at 8.

13. Abate & Wright, *supra* note 9, at 95-97; see generally Ann E. Prouty, *The Clean Development Mechanism and its Implications for Climate Justice*, 34 COLUM. J. ENVTL. L. 513 (2009); Michael Wara, *Measuring the Clean Development Mechanism's Performance and Potential*, 55 UCLA L. REV. 1759 (2008) (discussion of the CDM and some of the criticisms that have been lodged against it).

14. See UN-REDD Programme: The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (2009), <http://www.un-redd.org/AboutREDD/tabid/582/language/en-US/Default.aspx>

15. *Id.*

16. Abate & Wright, *supra* note 9, at 98.

basis that industrialized nations should not be permitted to circumvent their greenhouse gas emission reduction requirements by investing in REDD projects.¹⁷ Another major concern is that funds generated from REDD activities could work to the detriment of indigenous forest communities by falling into the hands of corrupt local government officials.¹⁸

Several years after being considered and rejected as a Kyoto compliance mechanism, REDD's role as a potentially valuable tool in the fight against climate change gained popularity at the Eleventh Conference of the Parties of the United Nations Framework Convention on Climate Change (COP 11) in Montreal in 2005.¹⁹ "Spearheaded by the Coalition of Rainforest Nations, a group of developing nations with a high percentage of tropical rainforests that support the use of carbon credits to curb tropical deforestation, REDD was proposed as a way to enhance developing nations' contribution to climate change compliance."²⁰ REDD also was expressly included as part of the Bali Action Plan at COP 13 in Bali in December 2007,²¹ which called for "policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries."²² From 2005 to the present, REDD has become a focus of the developing world's negotiation strategy for a post-Kyoto regime.²³

Prior to the linking of forest conservation and climate change compliance through REDD projects, global forest conservation efforts had been limited to non-binding international environmental agreements such as the forest conservation principles developed at the United Nations

17. Erin Myers Madeira, *Reduced Emissions from Deforestation and Degradation (REDD) in Developing Countries: An Examination of the Issues Facing the Incorporation of REDD into Market-Based Climate Change Policies* 29 (2008), available at http://www.rff.org/RFF/Documents/RFF-Rpt-REDD_final.2.20.09.pdf.

18. *Id.*

19. Rhett Butler, *Forest Conservation in U.S. Climate Policy: An Interview with Jeff Horowitz*, Mongabay.com, Feb. 5, 2010, available at http://print.news.mongabay.com/2010/0205-adp_forests_redd.html?print.

20. Randall S. Abate, *REDD, White, and Blue: Is Proposed U.S. Climate Legislation Adequate to Promote a Global Carbon Credits System for Avoided Deforestation in a Post-Kyoto Regime?*, 19 *Tul. J. Int'l & Comp. L.* 95, 99 (2010) (internal citations omitted).

21. See Bali Action Plan, Decision -/C.P. 13, available at http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf.

22. *Id.* at art. 1(b)(iii).

23. For a comprehensive summary of the evolution of REDD from Kyoto to Copenhagen, see generally CARBON PLANET WHITE PAPER: THE HISTORY OF REDD POLICY (Dec. 4, 2009), available at http://www.carbonplanet.com/protected_downloads/white_papers/The_History_of_REDD.pdf.

Conference on Environment and Development in 1992.²⁴ Consequently, the win-win scenario that REDD offers to achieve two desirable goals simultaneously—conserving forests and addressing the climate change problem—has a compelling appeal if incorporated into a mandatory climate change regime. However, the international community’s confidence in the reliability of this alternative compliance mechanism has developed slowly and reluctantly.

The implementation challenges that critics have raised about REDD led to the creation of “REDD+” as a potentially more effective and flexible form of REDD for the future. “REDD’s evolution into REDD+ at the Poznan negotiations in December 2008, and the Bonn negotiations in March 2009, helped propel the hope that REDD would be instrumental at Copenhagen.”²⁵ REDD+ was developed as a way to preserve what was compelling about REDD as a climate change compliance strategy and transform it into an approach to promote sustainable development in forestry management practices in developing nations. REDD+ involved a transition to an enhanced, broad-based approach that includes conservation, sustainable forest management, and forest carbon stock enhancement.²⁶ “REDD+ goes further than just rewarding actions that ‘do less harm’ (e.g. less forest clearance and unsustainable management). It will also reward practices that ‘do more good’ such as those that create new, and improve existing, carbon sinks.”²⁷ In May 2010, fifty-two nations gathered in Oslo, Norway for a climate change and forests conference.²⁸ The meeting was regarded as an important step forward to help REDD+ gain momentum in the months leading up to COP 16 in Cancún, Mexico in December 2010.²⁹

One of the greatest successes of the Copenhagen Accord is the inclusion of references to REDD and REDD+ that appear throughout the

24. See Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests, June 13, 1992, 31 I.L.M. 881.

25. Abate, *supra* note 20, at 100.

26. Food and Agriculture Organization (FAO) and the Center for People and Forests, *Forests and Climate Change After Copenhagen: An Asia-Pacific Perspective* 6 (2010), available at http://recoftc.org/site/fileadmin/docs/publications/The_Grey_Zone/2010/FCC-after-Copenhagen_3.pdf [hereinafter *FAO Report*].

27. *Id.*

28. *Climate Change Commission Joins 52 Countries in REDD+ Partnership* — Alvarez, BAYANIHAN, May 30, 2010, <http://bayanihan.org/2010/05/30/climate-change-commission-joins-52-countries-in-redd-partnership-alvarez>.

29. *Id.* See also, *Oslo Climate Change Conference Report – May Feature*, COOL EARTH, May 2010, <http://www.coolearth.org/371/news-32/features-147/oslo-climate-change-conference-report-may-feature-1400.html> (Robert Zoellick, chief of the World Bank, remarked that the outcome of the Oslo meeting may “be the first comprehensive component for a future international agreement on climate change.”).

agreement.³⁰ For example, Article 6 acknowledges the critical role of reducing emissions from deforestation and forest degradation to “enable the mobilization of financial resources from developed countries” to reduce global greenhouse gas emissions.³¹ Article 8 seeks to implement this objective by providing that developed countries will contribute 30 million dollars in adaptation funding between 2010-2012 to the “most vulnerable developing countries, such as the least developed countries, small island developing states and Africa.”³² Despite these positive steps forward, the Copenhagen Accord contains little guidance regarding how to implement the REDD provisions in the agreement.

Not surprisingly, funding is one of the most significant unanswered questions regarding the implementation of REDD projects. Financing for REDD activities could be fund-based, market-based, or a combination of these approaches. REDD activities are likely to be fund-based initially with market-based support factoring in slowly over time.³³ Market-based support will likely evolve into mandatory compliance schemes as confidence in the carbon market system grows.³⁴

COP 15 represents the first significant step forward for REDD as a component of a post-2012 climate change regime because the Copenhagen Accord negotiated at the meeting contains important references to REDD and REDD+.³⁵ Despite the failure to forge a binding climate change agreement in Copenhagen, there is a sense of cautious optimism that the negotiations and outcomes addressing REDD from the Copenhagen meeting have established a framework for continued progress on this issue in future COP meetings.³⁶ Nevertheless, while its popularity has continued to grow in the international community, REDD has been slow to take hold in carbon markets because of implementation concerns regarding monitoring, additionality, permanence, and leakage of REDD activities.³⁷ OIF also faces these challenges, which will be discussed below.

30. Commentators who considered the negotiations at Copenhagen to be at least partially successful referred to the inclusion of REDD as the foundation for that conclusion. *See, e.g.*, Tensie Whelan, *REDD in Copenhagen: Picking the Low-Hanging Fruit vs. Saving the Tree*, ENV'T L LEADER, Dec. 16, 2009, <http://www.environmentalleader.com/2009/12/16/redd-in-copenhagen-picking-the-low-hanging-fruit-vs-saving-the-tree/>; and Butler, *supra* note 19.

31. *See* Copenhagen Accord, *supra* note 2, art. 6.

32. *Id.* art. 8.

33. FAO Report, *supra* note 26, at 7.

34. *See id.*

35. *See* Copenhagen Accord, *supra* note 2, arts. 6, 8.

36. FAO Report, *supra* note 26, at 5. COP 16, which is taking place as of this writing in Cancun, Mexico in December 2010, will be an important gauge of the significance of REDD's role in negotiating a post-Kyoto agreement.

37. Abate & Wright, *supra* note 9, at 102-05.

III. OCEAN IRON FERTILIZATION (OIF)

Deforestation and forest degradation are significant components of the climate change crisis³⁸ and must be regulated regardless of whether such controls are implemented through REDD or some other mechanism. Like REDD, ocean iron fertilization (OIF) is a market-based method of reducing the amount of atmospheric carbon dioxide. OIF differs from REDD in that while REDD seeks to prevent anthropogenic emissions from deforestation, OIF involves the capture of carbon through direct or indirect addition of iron to surface waters.³⁹ OIF is designed to “enhance microscopic marine plant growth, on a scale large enough not only to significantly increase the uptake of atmospheric carbon by the ocean, but also to remove it from the atmosphere for long enough to provide global climatic benefit.”⁴⁰ Notwithstanding the conceptual difference between REDD and OIF, many of the challenges and opportunities for success associated with adopting REDD as a climate change compliance mechanism also apply to employing OIF techniques.

OIF involves dispersing iron particles into ocean areas where iron exists in low concentrations such that its absence limits phytoplankton growth.⁴¹ The addition of iron is designed to “stimulate the rapid growth of phytoplankton whose photosynthetic activity could potentially absorb heat trapping carbon.”⁴² The ultimate objective of OIF is to absorb carbon dioxide and store it in the ocean interior for an adequate duration and in a sufficient quantity so as “to make a significant reduction in the increase of atmospheric CO₂ in a verifiable manner, without deleterious unintended side effects.”⁴³

There are two primary categories of climate geoengineering techniques: solar radiation management and carbon dioxide removal.⁴⁴ OIF is a method of carbon dioxide removal. Implementing geoengineering projects such as OIF involves the threat of transboundary impacts.⁴⁵ The

38. See STERN, *supra* note 10 and accompanying text.

39. U.N. Educ. Scientific & Cultural Org. (UNESCO), Intergovernmental Oceanographic Commission, *Ocean Fertilization: A Scientific Summary for Policy Maker*, IOC/2010/BRO/2 (forthcoming 2010) (prepared by Doug Wallace et al.) [hereinafter Intergovernmental Oceanographic Commission].

40. *Id.*

41. Randall S. Abate & Andrew B. Greenlee, *Sowing Seeds Uncertain: Ocean Iron Fertilization, Climate Change, and the International Environmental Law Framework*, 27 PACE ENVTL. L. REV. 555, 561 (2010).

42. *Id.* at 560-561.

43. Intergovernmental Oceanographic Commission, *supra* note 39.

44. Kelsi Bracmort, et al., Cong. Research Serv., R41371, *Geoengineering: Governance and Technology* 2 (2010), available at <http://www.fas.org/sgp/crs/misc/R41371.pdf>.

45. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-546T, CLIMATE CHANGE: PRELIMINARY OBSERVATIONS ON GEOENGINEERING SCIENCE, FEDERAL EFFORTS, AND GOVERNANCE ISSUES:

U.S. Government Accountability Office has recommended that, where transboundary impacts are involved, transparency and international cooperation are key factors for pursuing geoengineering research.⁴⁶

A. Obstacles to OIF Implementation

OIF faces several critical challenges that currently limit its ability to be implemented as a viable climate change compliance mechanism in a mandatory or voluntary regulatory scheme. These challenges can be grouped into two general categories: 1) social and moral concerns, including concerns regarding unintended consequences, and 2) international and domestic law governance issues.

1. “Moral Hazard” and “Unintended Consequences” Concerns

The “moral hazard” concern associated with climate geoengineering tactics, including OIF, is that these techniques represent a short cut or substitute for continuing with aggressive targets and timetables for greenhouse gas emission reductions for all nations.⁴⁷ Advocates of climate geoengineering techniques disagree with this characterization and maintain that these techniques would supplement, not supplant, existing climate change mitigation mandates.⁴⁸ Regardless of whether the moral hazard concern is well grounded, climate geoengineering tactics remain highly controversial because of this issue.

In addition to the moral hazard obstacle, concerns abound regarding the unintended consequences of climate geoengineering techniques. The international community has previously confronted unintended consequences concerns regarding such deliberate alteration of the “natural order of things” in other contexts. One example is the release of genetically modified organisms under the Biosafety Protocol to the Convention on Biological Diversity (CBD).⁴⁹ The Earth’s climate system is so complex, and our understanding of it so incomplete, that OIF could cause dangerous unintended consequences that ultimately risk doing more harm than the alternative of inaction. Critics of OIF are concerned that a chain reaction of geoengineering responses to the intended and unintended conse-

TESTIMONY BEFORE THE COMMITTEE ON SCIENCE AND TECHNOLOGY 5 (2010) [hereinafter GAO Report] (statement of Frank Rusco, Director, Natural Resources and Environment), available at <http://www.gao.gov/new.items/d10546t.pdf>.

46. *Id.* at 10.

47. See Laura Helmuth, *Riled up About Geoengineering*, SMITHSONIAN.COM, Feb. 23, 2010, <http://blogs.smithsonianmag.com/science/2010/02/23/riled-up-about-geoengineering/>.

48. See Josh Horton, *What Moral Hazard?*, GEOENGINEERING POLITICS, Sept. 17, 2010, <http://geoengineeringpolitics.blogspot.com/2010/09/what-moral-hazard.html>.

49. See Cartagena Protocol on Biosafety to the Convention on Biological Diversity, adopted Jan. 29, 2000, 39 I.L.M. 1027, 2226 U.N.T.S. 208.

quences of the deliberate alteration of the climate system could continue indefinitely.⁵⁰ One critic cautioned that, “[e]nvironmental impacts associated with ocean fertilization schemes could dwarf the current Gulf oil spill disaster.”⁵¹

Two important issues demonstrate the potential for more harm than good from OIF projects. First, OIF has been proposed as a potential strategy to mitigate ocean acidification.⁵² Ocean acidification is caused by increased carbon deposition in the oceans as a result of increased atmospheric carbon dioxide.⁵³ A 2010 study concluded, however, that OIF “can only slightly mitigate surface ocean acidification caused by anthropogenic [carbon dioxide] emissions, and at the expense of accelerated acidification of the deep ocean.”⁵⁴ Second, in 2008, a moratorium on OIF was implemented under the CBD because of the need for more research on the unsettled science of OIF and because of the potential for unintended consequences that could ensue from deploying OIF techniques.⁵⁵ Two years later, the value of this precautionary measure became evident when a study revealed that OIF could produce toxic algae blooms and cause neurological disorders in marine mammals.⁵⁶

Research on OIF within the past two years has concluded that OIF’s carbon sequestration potential comes at a high ecological price.⁵⁷ OIF has the potential to negatively impact the oceans by disturbing and destroying marine ecological systems. One recognized side effect of OIF is that it can significantly increase the chances of neurotoxin production.⁵⁸ The neurotoxins, in turn, can ascend the food chain and contami-

50. Adam Corner & Nick Pidgeon, *Geoengineering the Climate: The Social and Ethical Implications*, ENV’T., Jan.-Feb. 2010, at 24, 31.

51. *Iron Fertilization Dead in the Water? Controversial Geoengineering Proposal Banned in US Climate Legislation*, UNDERWATER TIMES.COM NEWS SERVICE, (2010), http://www.underwatertimes.com/news.php?article_id=20716358491.

52. Long Cao & Ken Caldeira, *Can Ocean Iron Fertilization Mitigate Ocean Acidification?*, A Letter, 99 CLIMATIC CHANGE, 303, 303 (2010), available at [http://www.stanford.edu/~longcao/Cao&Caldeira\(2010\).pdf](http://www.stanford.edu/~longcao/Cao&Caldeira(2010).pdf).

53. See Robin Kundis Craig, *Climate Change Comes to the Clean Water Act: Now What?*, 1 WASH. & LEE J. ENERGY CLIMATE & ENV’T 5, 9 (2010).

54. Cao & Caldeira, *supra* note 52.

55. Abate & Greenlee, *supra* note 41, at 576.

56. Charles Trick, et al., *Iron Enrichment Stimulates Toxic Diatom Production in High-Nitrate, Low Chlorophyll Areas*, 107 PNAS 5587, 5891 (2010).

57. Jessica Marshall, *Ocean Geoengineering Scheme May Prove Lethal: Seeding the oceans with iron could result in the production of a potent neurotoxin, putting the lives of birds, fish and even humans at risk*, DISCOVERY NEWS, Mar. 15, 2010, <http://news.discovery.com/earth/geoengineering-carbon-sequestration-phytoplankton.html>.

58. *Ocean Geo-Engineering Produces Toxic Blooms of Plankton*, PHYSORG.COM, Mar. 15, 2010, <http://www.physorg.com/print187896509.html> [hereinafter PHYSORG.COM].

nate food webs on which marine life feed,⁵⁹ which can lead to illness and mortality of thousands of marine mammals and birds along the coast of North America.⁶⁰ Human mortality also may ensue from consuming seafood that contains the toxin. In addition, OIF also is likely to cause a lack of oxygen in non-surface waters resulting from the burgeoning growth of phytoplankton. The increased phytoplankton growth also prevents sunlight from reaching deep waters, which causes increased mortality rates of different organisms that may serve as a foundation for many ecosystems.⁶¹ In large-scale OIF projects, the changes in ecosystems can potentially cause local extinctions of certain species.⁶² At the same time, OIF may also facilitate the introduction of invasive species because artificially introduced iron may contain unidentified microscopic organisms that can disrupt the marine ecosystems.⁶³

While the moral hazard and unintended consequences concerns have merit, the precautionary principle counterbalances these fears. The precautionary principle counsels that “where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”⁶⁴ Domestic and international protections against species extinction operate on this basis, as did the aggressive regulation of the stratospheric ozone depletion under the Montreal Protocol regime.⁶⁵ Similarly, scientists have posited a tipping point for climate change at which intervention strategies will be futile.⁶⁶ OIF and other geoengineering strategies arguably need to be researched and potentially deployed well in advance of reaching such a tipping point. The converse

59. Marshall, *supra* note 57. However, at least one expert questions the degree of harm posed by this alleged concern. “Harmful algal blooms (HABs) are blooms of algae that produce toxic substances that can affect other organisms. They are predominantly a coastal phenomenon and there is no evidence of such blooms arising from iron fertilization experiments. The algae associated with most coastal HABs are rare in the open ocean and are not associated with natural or iron fertilized blooms there.” Dr. Margaret Leinen, et. al., *Why Ocean Iron Fertilization?*, CLIMOS, Mar. 12, 2009, http://www.climos.com/pubs/2009/Climos_Why_OIF-2009-03-12.pdf.

60. PHYSORG.COM 2010, *supra* note 58.

61. Jennie Dean, *Iron Fertilization: A Scientific Review with International Policy Recommendations*, 32 ENVIRONS ENVTL. L. & POL’Y J. 321, 330 (2009).

62. *Id.* at 330-331.

63. *Id.* at 331. *But see* Leinen et al., *supra* note 59 (noting that many of the feared effects of OIF are limited to coastal waters and OIF experiments would be conducted in open ocean waters beyond national jurisdiction).

64. Rio Declaration on Environment and Development, princ. 15, *adopted* June 14, 1992, 31 I.L.M. 874.

65. *See* The Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, 1522 U.N.T.S. 3 (*entered into force* Jan. 1, 1989).

66. *See* Juliet Eilperin, *Debate on Climate Shifts to Issue of Irreparable Change; Some Experts on Global Warming Foresee ‘Tipping Point’ When It Is Too Late to Act*, THE WASHINGTON POST, Jan. 29, 2006, at A01.

may be equally compelling, however. The precautionary principle could be used to support the conclusion that the potentially severe unintended consequences of OIF would weigh against immediate implementation of large-scale OIF.

The international community has confronted and overcome moral hazard and unsettled science concerns in other contexts, such as the regulation of genetic engineering under the Biosafety Protocol and the development and oversight of nuclear energy. If society is to advance and confront modern problems, the international community needs to remain flexible and innovative about how best to respond. No solution to climate change will please everyone or be without risk. Some commentators have suggested that the dangers posed by OIF simply require a careful and structured approach to continued research.⁶⁷

2. Governance Issues for OIF at the Domestic and International Levels

Unlike REDD, which is already incorporated into the governance structure for climate change in the Copenhagen Accord,⁶⁸ the methods and framework for OIF governance are highly uncertain at this time. International governance of OIF is necessary for one or both of the following interrelated reasons: 1) OIF projects likely will occur outside any single country's 200-mile exclusive economic zone,⁶⁹ and 2) transboundary impacts are likely to be involved.⁷⁰

OIF is potentially subject to a wide range of international environmental treaty mandates contained in the United Nations Convention on the Law of the Sea (UNCLOS), the London Convention and Protocol, the Convention on Biological Diversity, and the Antarctic Treaty regime. First, under UNCLOS, OIF may qualify as "pollution."⁷¹ Second, under the London Convention and Protocol, OIF could be considered "dumping."⁷² Third, proposed OIF activities have targeted the Southern Ocean as a likely area for large-scale experiments. The Southern Ocean is strictly regulated by the Antarctic Treaty, the Madrid Protocol on Environ-

67. For example, one commentator has called for the creation of a new U.S. agency to lead research initiatives on climate geoengineering techniques. See William Daniel Davis, *What Does Going Green Mean?: Anthropogenic Climate Change, Geoengineering, and International Environmental Law*, 43 GA. L. REV. 901, 938-950 (2009).

68. See Copenhagen Accord, *supra* note 2, arts. 6, 8.

69. Abate & Greenlee, *supra* note 41, at 572.

70. GAO Report, *supra* note 45, at 6.

71. Abate & Greenlee, *supra* note 41, at 573.

72. *Id.* at 578.

mental Protection, and the Convention for the Conservation of Antarctic Marine Living Resources.⁷³

The CBD and the London Convention and Protocol treaty regimes have responded directly to the prospect of OIF regulation;⁷⁴ however, neither has implemented any binding treaty mandates on the issue. The International Maritime Organization (IMO), the implementing body for the London Treaty Convention and Protocol, held a meeting on March 5, 2010, that addressed the progress made on OIF science.⁷⁵ The IMO mandated the assembly of a Correspondence Group to review the final text of the CBD report, “Scientific Synthesis on the Impacts of Ocean Fertilization on Marine Biodiversity,” released in January 2010, to assess its adequacy and to provide recommendations.⁷⁶ Members of the Correspondence Group failed to reach consensus on whether this report adequately summarized the current state of scientific knowledge on OIF.⁷⁷

The Correspondence Group identified two gaps in the report. First, the report only focused on the potential impacts OIF may cause to marine diversity, rather than providing a comprehensive summary of the current state of knowledge on OIF.⁷⁸ Second, the Correspondence Group identified that the report lacked sufficient guidance for determining what level of impact to marine diversity is acceptable.⁷⁹ The Correspondence Group recommended that this second gap could be addressed by identifying upper and lower levels of potential impacts in individual sea areas that have been targeted for potential deployment of OIF projects, such as the Southern Ocean.⁸⁰ As of this writing, the Correspondence Group is working on a document that will provide a comprehensive report on the current state of knowledge on OIF, which is scheduled for release in April 2011.⁸¹

73. Hugh Powell, *Dumping Iron and Trading Carbon*, 46 OCEANUS MAG. 22, 23 (2008), available at http://www.whoi.edu/cms/files/OceanusIron_TradingCarbon_30866.pdf.

74. See Convention on Biological Diversity (CBD), *Scientific Synthesis of the Impacts of Ocean Fertilization on Marine Diversity*, CBD Technical Series No. 45 (1981), available at <http://www.cbd.int/doc/publications/cbd-ts-45-en.pdf> (2009); Int’l Maritime Org. (IMO), Scientific Group of the London Convention, *Ocean Fertilization: Development of Science Overviews on Ocean Fertilization*, IMO Doc. LC/SG 33/2/1 (Mar. 5, 2010), available at http://www.imo.org/includes/blastDataOnly.asp/data_id%3D27823/2-1.pdf.

75. IMO, *supra* note 74, at 1.

76. *Id.*

77. *Id.* at 2.

78. *Id.*

79. *Id.*

80. *Id.* at 2-3.

81. IMO, Scientific Group of the London Convention, *Ocean Fertilization: Development of Science Overviews on Ocean Fertilization*, 2, IMO Doc. LC/SG/ES.2/1 (July. 30, 2010), available at http://www.imo.org/includes/blastDataOnly.asp/data_id%3D29393/2-1.pdf.

To capitalize on the treaty regimes' growing awareness of the need to regulate OIF, these overlapping and potentially conflicting treaty mandates need to be reconciled. Precedent for harmonizing treaty objectives exists in international environmental law. For example, in the climate change context, the Kyoto and Montreal Protocol regimes are working together to address the regulation of hydrofluorocarbons (HFCs), an ozone-depleting substance and a potent greenhouse gas.⁸² Similarly, in the OIF context, an inter-treaty body could be established to harmonize UNCLOS, CBD, and the London Convention and Protocol.⁸³ The IMO could serve as the implementing body for such inter-treaty coordination.⁸⁴

In the alternative, a new governance structure could be established in a separate treaty to evaluate new technologies. The Swedish Society for Nature Conservation developed such a proposal, the International Convention for the Evaluation of New Technologies, under which OIF and other new and emerging technologies could be assessed, monitored, and regulated.⁸⁵ The proposal calls for the establishment of scientific committees that would identify and evaluate new technologies and support the diffusion of such new technologies once they are determined to be safe.⁸⁶ A narrower version of this proposal could involve a new treaty focused exclusively on assessing, monitoring, and regulating climate geoengineering strategies.

However, simply conducting OIF research is controversial.⁸⁷ One proposal emphasizes the establishment of a governance system for geoengineering research, in addition to a subsequent and separate governance system to oversee the deployment of such geoengineering techniques.⁸⁸ Alternatively, geoengineering research could proceed under the direction of international research consortia. This approach was employed in the context of the Human Genome Project and the European

82. ENVIRONMENTAL INVESTIGATION AGENCY, A CLIMATE BRIEFING: THE MONTREAL PROTOCOL MUST WORK IN COLLABORATION WITH THE CLIMATE TALKS TO REGULATE HFCs TO PREVENT EXACERBATION OF GLOBAL CLIMATE CHANGE WHILE RESTORING THE OZONE LAYER 2 (2008), available at <http://www.eia-global.org/PDF/report—Climate—Jan09.pdf>.

83. Abate & Greenlee, *supra* note 41, at 589-91.

84. *Id.* at 590.

85. DIANA BRONSON ET AL., SWEDISH SOCIETY FOR NATURE CONSERVATION, RETOOLING THE PLANET? CLIMATE CHAOS IN THE GEOENGINEERING AGE 40-41 (2009), available at http://www.etcgroup.org/upload/publication/pdf_file/Retooling%20the%20Planet.final_.pdf.

86. *Id.* at 41.

87. See IFM-GEOMAR, *Ocean Iron Fertilization: A Curse or a Blessing?*, RESEARCH IN GERMANY, Dec. 23, 2009, <http://www.research-in-germany.de/37230/2009-12-15-ocean-iron-fertilization-a-curse-or-a-blessing,sourcePageId=12370.html>.

88. GAO Report, *supra* note 45, at 14.

Organization for Nuclear Research.⁸⁹ Proceeding in this manner offers the benefits of precaution in applying emerging technologies while not complicating and constraining the need for expeditious research through a new or revised treaty regime.⁹⁰

In addition to the international governance challenges, any comprehensive federal climate change response in the United States also must address geoengineering regulation. Existing federal laws such as the Marine Protection, Research and Sanctuaries Act (MPRSA)⁹¹ and the National Environmental Policy Act (NEPA)⁹² may apply to OIF projects. These statutes have limited applicability, however, based on the party that is conducting the activity⁹³ and the location where such activities take place.⁹⁴

Within the past two years, however, Congress has undertaken a formal evaluation, and response to the use, of OIF. Beginning in 2009, the Science and Technology Committee of the U.S. House of Representatives conducted hearings to consider the benefits and risks of a variety of climate geoengineering techniques, including OIF.⁹⁵ In May 2010, Senators John Kerry and Joseph Lieberman introduced the American Power Act,⁹⁶ the latest congressional initiative to address climate change, which included a proposed ban on the use of OIF.⁹⁷

B. Generating and Accounting for Carbon Credits in OIF Projects

Another important dimension of OIF governance is whether, and in what manner, to incorporate OIF into a post-Kyoto climate change treaty as a market-based mechanism to generate credits for carbon sequestration. Tradable credits generated from the carbon dioxide sequestered from OIF projects could be part of a climate change compliance regime in much the same manner as avoided deforestation credits in REDD. If OIF is regulated under this market-based approach, the opportunity to draw on the prior successes of REDD could be optimized by allowing two forms of creative climate change compliance mechanisms to work

89. Bracmort, *supra* note 44, at 38.

90. GAO Report, *supra* note 45, at 7.

91. See 33 U.S.C. §§ 1401-1445 (2006).

92. See 42 U.S.C. §§ 4321-4370f (2006).

93. NEPA only applies to “major federal actions.” *Id.* at § 4332(2)(C).

94. MPRSA only governs ocean dumping activities in U.S. territorial waters, which are defined as waters that extend twelve miles from shore. GAO Report, *supra* note 45, at 11-12.

95. Bracmort, *supra* note 44, at 2.

96. See American Power Act (discussion draft), 111th Cong. (2010), available at <http://kerry.senate.gov/imo/media/doc/APAbill3.pdf>.

97. See UNDERWATER TIMES, *supra* note 51; Steven J. Lutz, *Iron Fertilization Out, Blue Carbon In*, BLUE CARBON BLOG, May 27, 2010, <http://bluecarbonblog.blogspot.com/2010/05/iron-fertilization-out-blue-carbon-in.html>.

together within the same treaty regime. This arrangement would build on the menu of flexible mechanisms to achieve compliance that are already available under the Kyoto Protocol: emissions trading, joint implementation, and the CDM.

Although some commentators have argued that forest conservation credits would not provide an adequate foundation for OIF credits under a post-Kyoto scheme,⁹⁸ these conclusions were premised on the application of the CDM compliance model to OIF.⁹⁹ REDD serves as an effective bridge between the CDM and OIF in that it is more flexible than the CDM and enables broad-based participation through the use of avoided deforestation and forest degradation as a means to earn carbon credits. Unlike the CDM, REDD credits are not encumbered by requirements such as securing host party approval or promoting a host country's sustainable development.¹⁰⁰ Like REDD, OIF-generated carbon credits have the flexibility to be incorporated into a voluntary or mandatory post-Kyoto climate change compliance regime without having to adhere to the CDM requirements. However, OIF will be better positioned to enter these carbon markets after some of the implementation hurdles associated with REDD have been resolved.

Like REDD credits, OIF-generated carbon credits will be subject to the same basic requirements as other projects in the existing carbon markets under the Kyoto Protocol and the EU Emissions Trading System (EU-ETS).¹⁰¹ Such projects must meet the following requirements: 1) monitoring and verification, 2) additionality, 3) permanence, and 4) avoiding leakage.¹⁰²

First, OIF projects face the challenge of adequate monitoring and verification. Monitoring of phytoplankton blooms is conducted with satellite technology.¹⁰³ However, according to scientists who have been involved in past iron fertilization experiments, "adequate verification cannot yet be achieved with currently available observing capabilities."¹⁰⁴ Moreover, "satellites are unable to detect the amount of carbon that is re-released back into the atmosphere through phytoplankton respiration."¹⁰⁵ Even if OIF carbon sequestration can be effectively monitored

98. See, e.g., Christine Bertram, *Ocean Iron Fertilization in the Context of the Kyoto Protocol and the Post-Kyoto Process*, 38 ENERGY POL'Y 1130 (2010).

99. *Id.* at 1138.

100. *Id.*

101. See European Commission Climate Action, EU Emissions Trading System (EU ETS), http://ec.europa.eu/clima/policies/ets/index_en.htm (last visited Dec. 9, 2010) [hereinafter EU Emissions Trading System].

102. See Powell, *supra* note 73.

103. Intergovernmental Oceanographic Commission, *supra* note 39, at 4.

104. *Id.* at 8.

105. Dean, *supra* note 61, at 328.

and verified, the costs of doing so could be prohibitive. Such financial barriers could make a viable market in OIF-generated carbon credits more difficult to achieve.

Next, assuming OIF project proponents will be able to overcome the challenges associated with monitoring and verification, these projects will probably satisfy the three remaining requirements. Additionality refers to the fact that OIF-generated carbon credits cannot derive from carbon reductions that would have occurred anyway in the absence of the financed project.¹⁰⁶ This requirement is easily met in the OIF context because carbon mitigation is the reason why OIF projects are undertaken.¹⁰⁷ Carbon credits also must be permanent. That is, the carbon reductions must last for at least one hundred years in the forestry context. However, this standard may be modified for OIF projects.¹⁰⁸ Avoidance of leakage¹⁰⁹ may pose more of a challenge for OIF project proponents in that they would have to account for fuel used to reach the site and any greenhouse gases generated as a result of the OIF project.¹¹⁰

Additionally, voluntary markets are available.¹¹¹ However, OIF credits are less likely to fare well in these markets, because voluntary markets are not subject to strict regulations like the Kyoto and EU-ETS markets.¹¹² Consequently, OIF-generated carbon credits could face a perception of illegitimacy in these markets because they are new and their accounting is more complicated than avoided deforestation credits.¹¹³

IV. CONCLUSION

OIF offers significant promise to follow REDD as a potential component of carbon markets in a post-Kyoto climate change regime. However, international governance challenges to regulate OIF in a consistent and effective manner must be addressed. Additionally, the use of OIF for

106. Dr. Margaret Leinen, *Building Relationships Between Scientists and Business in Ocean Iron Fertilization*, 364 MARINE ECOLOGY PROGRESS SERIES 251, 252 (2008).

107. Christine Bertram, *Ocean Iron Fertilization: An Option for Mitigating Climate Change?*, 5 (Kiel Inst., Kiel Policy Brief No. 3, 2009), available at http://www.ifw-kiel.de/wirtschaftspolitik/politikberatung/kiel-policy-brief/kiel_policy_brief_3.pdf.

108. Leinen, *Building Relationships*, *supra* note 106, at 252-53.

109. "Leakage is the concept that if deforestation is halted in one project area, the market demands will simply shift deforestation to another unregulated area, thus nullifying the benefit of emissions reductions in the project area." Abate & Wright, *supra* note 9, at 103.

110. Leinen, *Building Relationships*, *supra* note 106, at 253.

111. These voluntary markets now exist concurrently with mandatory markets, but in different regions of the world. Ideally, there will be a mandatory global carbon market that would be developed as an indispensable component of a post-Kyoto climate change treaty, which could include carbon credits generated from both REDD and OIF projects.

112. See EU Emissions Trading System, *supra* note 101.

113. See Powell, *supra* note 73, at 24-25.

private gain also needs to be more fully researched and accepted in the international community. While a contentious path is ahead, OIF offers the international community one piece of a solution to the carbon crisis that is worth exploring.

If the international community is governed by a mere patchwork of regional agreements employing voluntary or mandatory carbon markets in the post-Kyoto era, the absence of a coordinated international governance framework to manage OIF projects could be catastrophic to the marine environment because potentially dangerous OIF experiments could proceed without oversight. Therefore, if the international community fails to implement a post-Kyoto treaty, a new international treaty should be negotiated to regulate OIF and similar emerging technologies to ensure adequate protection of the environment. At a minimum, existing treaty obligations should be harmonized to govern OIF in an effective and consistent manner.

The use of OIF for private gain to generate carbon credits is unlikely to be viable in the near future, but it is a goal that will come closer to fruition if and when a global carbon credit system is in place for REDD activities. Even the most optimistic of outcomes for OIF will likely involve a period of postponed commercialization of the field until significant additional research can be conducted to assess the effectiveness and risks of OIF and the verifiability of OIF-generated carbon credits. REDD has already confronted some of these challenges and is making progress in overcoming them.

If the implementation obstacles to OIF can be overcome, the international community stands to gain a great deal from the carbon credits that can be generated from OIF, much like those generated from REDD. Such credits promote environmental protection benefits by sequestering carbon from the atmosphere. These credits also offer the flexibility to address global climate change regulation in a way that is more flexible and potentially effective to promote broad-based participation from both developed and developing nations in a post-Kyoto climate change regime.