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Removing Carbon Dioxide Through Ocean Fertilization: Legal Challenges and Opportunities

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EXECUTIVE SUMMARY

Carbon dioxide removal ("CDR") will be needed, alongside deep emissions cuts, to achieve global temperature goals. According to a 2022 report by the Intergovernmental Panel on Climate Change ("IPCC"), to keep global average temperatures within 1.5°C above pre-industrial levels, carbon dioxide and other greenhouse gas emissions must reach net-zero by mid-century. The report concluded that "the deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero . . . emissions are to be achieved." The extent of CDR required will depend on the pace of emissions reductions, with the IPCC warning that, if reductions are delayed, large scale CDR may be needed to reduce the atmospheric concentration of carbon dioxide to limit warming to 1.5°C.

Scientists have proposed a number of land- and ocean-based CDR techniques. This paper focuses on ocean fertilization, which involves adding iron or other nutrients to the ocean to stimulate the growth of phytoplankton that uptake carbon dioxide and convert it into organic carbon. The hope is that the organic carbon will end up sequestered in the deep ocean when the phytoplankton die and sink.

Scientists have conducted a number of in-ocean fertilization experiments, which suggest that adding iron does stimulate phytoplankton blooms, leading to increased uptake of carbon dioxide. However, further study is needed to evaluate whether ocean fertilization leads to long-term carbon storage and evaluate its potential co-benefits and risks, including the potential for nutrient-diversion from other ocean areas.

This paper explores the application of existing international and domestic (U.S.) law to ocean fertilization research and deployment. (Subsequent work will examine relevant domestic laws in selected other coastal countries.) The legal framework for ocean fertilization, both at the international level and domestically in the U.S., is complex. This is, in part, due to the shared nature of the ocean. Generally speaking, under international law, the U.S. and other coastal countries have primary jurisdiction over ocean areas within 200 nautical miles of their coastlines. U.S. states and the federal government share authority over the 200 nautical mile zone. Ocean waters located more than 200 nautical miles from the coast of any country form part of the so-called "high seas" and are open to use by all countries in accordance with international law.

There are currently no legally binding international treaties dealing specifically with ocean fertilization. However, in recent years, three international treaty bodies have taken initial steps to develop rules for ocean fertilization research and deployment. Most notably, the parties to the Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter ("London Protocol") have adopted an amendment which, if and when it enters into force, will create a specific permitting regime for ocean fertilization projects. To date, however, only six of the fifty-three parties to the London Protocol have ratified the amendment and it is yet to enter into force. Nevertheless, ocean fertilization projects may be subject to permitting or similar requirements under other international agreements, which

establish general rules for ocean-based activities. There is some uncertainty as to when and how those general agreements will apply to ocean fertilization projects.

At the domestic level, the Marine Protection, Research, and Sanctuaries Act ("MPRSA") regulates the discharge of material into ocean waters within twelve nautical miles of the U.S. coast and further offshore in some cases. Ocean fertilization projects are likely to require a permit from the U.S. Environmental Protection Agency under the MPRSA. Additional permitting and other legal requirements could apply to the mining and processing of iron and other materials for use in ocean fertilization. Projects may also be subject to environmental review requirements under U.S. federal and state law. A full list of permitting and environmental review requirements for the discharge of materials is included in Appendix A to this paper.

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ACRONYMS

ACE	Army Corps of Engineers
BOEM	Bureau of Ocean Energy Management
CAA	Clean Air Act
CBD	Convention on Biological Diversity
CDR	Carbon Dioxide Removal
CZMA	Coastal Zone Management Act
DOI	Department of the Interior
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ENMOD	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques
ESA	Endangered Species Act
FWS	Fish and Wildlife Service
GHG	Greenhouse gas
ICJ	International Court of Justice
IPCC	Intergovernmental Panel on Climate Change
MARPOL	International Convention for the Prevention of Pollution from Ships
MPRSA	Marine Protection, Research, and Sanctuaries Act
MSR	Marine Scientific Research
NASEM	National Academies of Sciences, Engineering, and Medicine
NEPA	National Environmental Policy Act
n.m.	nautical mile
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
RCRA	Resource Conservation and Recovery Act
SLA	Submerged Lands Act
UNCLOS	United Nations Convention on the Law of the Sea
U.S.	United States

1. INTRODUCTION

In the 2015 Paris Agreement, countries around the world committed to combat climate change by "[h]olding the increase in global average temperatures to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels."[1] Since the Paris Agreement's adoption, numerous reports by the Intergovernmental Panel on Climate Change ("IPCC") and others have emphasized that achieving these temperature goals will require rapid and significant cuts in carbon dioxide and other greenhouse gas ("GHG") emissions, but many countries have been slow to act.[2] As a result, atmospheric carbon dioxide levels now exceed 420 parts per million[3]—higher than at any other point in the last two million years[4]—and global average temperatures are already 1.09°C above pre-industrial levels.[5]

A 2022 IPCC report found that, to limit future warming to 1.5°C above pre-industrial levels, carbon dioxide emissions must reach net-zero by the early 2050s.[6] Emissions must reach net-zero by the early 2070s to keep global warming to 2°C.[7] According to the IPCC, in both cases, achieving net-zero emissions will require the removal of carbon dioxide from the atmosphere "to counterbalance hard-to-abate residual emissions" from "agriculture, aviation, shipping, [and] industrial processes."[8] Carbon dioxide removal ("CDR") could also be used to "lower[] net . . . emissions in the near-term," and to achieve "net negative . . . emissions in the long-term if deployed at levels exceeding annual residual emissions."[9]

Scientists have proposed a number of CDR techniques, all of which aim to take carbon dioxide out of the atmosphere, and store or utilize it in some way. In recent years, scientists have focused primarily on land-based CDR techniques, such as reforestation and afforestation (i.e., wherein trees and other plants are used to absorb and store carbon dioxide) and direct air capture and sequestration (i.e., wherein carbon dioxide is removed through a mechanical process and injected underground for long-term storage).[10] While each of these techniques has been shown to be technically feasible, deployment at scale will require large amounts of land, energy, water, and/or other resources, which could lead to conflicts with other users.[11] The potential for conflicts may be reduced where CDR is performed in the ocean.

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1 Paris Agreement, Dec. 12, 2015, Art. 2(1).
2 *See e.g.,* Hans-O. Pörtner et al., *Summary for Policymakers* in Climate Change 2022: Impacts, Adaptation and Vulnerability (Hans-O. Pörtner et al. eds, 2022).
3 UC San Diego, Scripps Institution of Oceanography, *The Keeling Curve*, https://keelingcurve.ucsd.edu/ (last visited June 13, 2022).
4 Richard P. Allan et al., *Summary for Policymakers in* Climate Change 2021: The Physical Science Basis 5 (Valerie Masson-Delmotte et al. eds., 2021).
5 *Id*. at 8.
6 Jim Skea et al., *Summary for Policymakers in* Climate Change 2022: Mitigation of Climate Change SPM-30 (2022).
7 *Id*.
8 *Id*. at SPM-47 – SPM-48.
9 *Id*. at SPM-48.
10 *See generally*, National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda (2019), https://perma.cc/TV94-7BK6.
11 *Id*. at 9-13.

The ocean already removes approximately ten gigatonnes of carbon dioxide from the atmosphere annually through natural processes.[12] A 2022 report by the National Academies of Sciences, Engineering, and Medicine ("NASEM") found that the "ocean holds great potential for [additional] uptake and longer-term sequestration" of carbon dioxide and recommended research to advance understanding of six key ocean-based CDR techniques.[13] This paper focuses on one of those techniques—ocean fertilization—which aims to enhance uptake of carbon dioxide by phytoplankton by adding nutrients (e.g., iron, nitrogen, or phosphorous) to surface waters in ocean areas where those nutrients are in short supply.[14] The goal is to stimulate the growth of phytoplankton that uptake carbon dioxide from the atmosphere and convert it into organic carbon, which will (hopefully) end up sequestered for long periods in the deep ocean.[15]

The 2022 NASEM Report noted that, while several ocean fertilization experiments have already been conducted, further research is needed to fully evaluate its CDR potential, co-benefits, and risks.[16] In addition to this scientific research, the 2022 NASEM Report also emphasized the need for research into the legal framework for ocean fertilization, both internationally and domestically in the U.S.[17] This paper provides the first comprehensive analysis of how existing international and U.S. laws would apply to ocean fertilization research and deployment. The remainder of the paper is structured as follows: Part 2 introduces ocean fertilization, its potential benefits, and risks. Part 3 then discusses key principles of international and U.S. law defining jurisdiction over the ocean. In Part 4, we explore key international agreements and principles of customary international law that could apply to ocean fertilization projects, while Part 5 discusses applicable U.S. law. Part 6 concludes.

12 Wil Burns & Charles R. Corbett, *Antacids for the Sea? Artificial Ocean Alkalinization and Climate Change*, 3 One Earth 154, 154 (2020).

13 National Academies of Sciences, Engineering, and Medicine, A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration 2 (2022), https://perma.cc/UTK2-DSP3 [hereinafter "2022 NASEM Report"]. One of the authors of this paper – Romany M. Webb – served on the ad hoc committee appointed by NASEM to draft the report.

14 *Id*. at 77. Note that the NASEM report refers to ocean fertilization as nutrient fertilization.

15 *Id*.

16 *Id*. at 95.

17 *Id*. at 94.

2. OVERVIEW OF OCEAN FERTILIZATION

In many parts of the ocean, phytoplankton growth is impeded by limited availability of nutrients. Phytoplankton require macronutrients (i.e., nutrients needed in large amounts), such as nitrogen and phosphorus, to grow and divide.[18] They also require trace amounts of iron, a micronutrient (i.e., needed in very small amounts), to process nitrogen and phosphorus.[19] Scientists have, therefore, posited that adding one or more of those nutrients to ocean waters could stimulate phytoplankton growth and lead to carbon dioxide sequestration.

Phytoplankton uptake carbon dioxide through photosynthesis and convert it into organic carbon. Through biological processes, some of the organic carbon is sunk to the deep sea, where it may be sequestered for hundreds to thousands of years.[20]

Most ocean fertilization research to date has focused on adding iron to ocean waters. The idea to fertilize the ocean with iron stemmed from analogues in the natural world. Phytoplankton blooms occur in ocean areas that are close to tropical arid regions and receive iron naturally from land.[21] Further, iron was abundant in the world's ocean during the last ice age, suggesting that high ocean iron levels may be associated with decreased atmospheric carbon dioxide and cooled global temperatures.[22]

The nutrients used in ocean fertilization would be produced and processed onshore, before being loaded onto vessels for discharge into the ocean. Iron fertilization would likely occur in the Southern Ocean, subarctic North Pacific, and Eastern Equatorial Pacific due to iron limitations in those regions.[23] Modeling suggests deployment would need to occur over multiple years to multiple decades.[24]

Nitrogen fertilization may be done on its own or together with phosphate; phosphate fertilization would likely only be done in combination with nitrogen.[25] Proposed locations for nitrogen and phosphate fertilization include much of the global ocean in the low latitudes—the tropics and sub-tropics—where either nitrogen or phosphorous limit primary productivity.[26] Scientists have proposed both one-off and continuous, multi-year deployments.[27]

18 Ian Jones, Engineering Strategies for Greenhouse Gas Mitigation 72-105 (2011).
19 *Id*.
20 *Id*. at 70.
21 Matthew Hubbard, *Barometer Rising: The Cartagena Protocol on Biosafety as a Model For Holistic International Regulation of Ocean Fertilization Projects and Other Forms of Geoengineering*, 40 Wm. & Mary Envtl. L. & Pol'y Rev. 591 (2016), https://scholarship.law.wm.edu/wmelpr/vol40/iss2/9.
22 *Id*.
23 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques 43 (2019), https://perma.cc/TE22-9QLC.
24 *Id*. at 44.
25 *Id*. at 45.
26 *Id*. 45
27 *Id*.

2.1 Past Ocean Fertilization Research

Scientists conducted at least 13 real world ocean iron fertilization experiments between 1993 and 2009. There was also one commercial effort to use iron fertilization to increase fish yields in 2012 by the Haida Salmon Restoration Corporation. The latter project was highly controversial, with some environmental groups raising questions about its legality and others expressing concern that the corporation did not adequately consult or share data with the public.[28]

The ocean fertilization experiments produced varied results and did not clearly demonstrate reliable long-term carbon dioxide sequestration in the deep ocean following the addition of iron to ocean waters.[29] While the experiments did establish that iron fertilization leads to an increase in photosynthesis by marine phytoplankton, and thus enhanced uptake of carbon dioxide, the ultimate fate of the carbon dioxide remains uncertain.[30] The experiments were typically of short duration and, in most cases, the fate of the carbon after enhanced growth was not studied.[31]

Two early experiments near the Galapagos Islands showed increases in biomass, plant growth, and carbon dioxide uptake as a result of iron fertilization, but also showed the need to fertilize multiple times to overcome iron sinking without uptake by plankton.[32] A 1999 experiment near Australia showed increased phytoplankton growth but did not confirm an increased downward export of organic carbon to the deep sea.[33] Further experimentation showed that iron fertilization could change the dominant phytoplankton species,[34] and that low silicic acid levels[35] and high grazing rates by zooplankton[36] could limit the effectiveness of iron fertilization. A 2004 study looked at the carbon dioxide sequestration potential in the deep sea. It concluded, with some uncertainty, that around half of organisms in the enriched experiment area sank below 1000 meters, suggesting sequestration for centuries to

28 Martin Lukacs, *World's biggest geoengineering experiment 'violates' UN rules*, The Guardian (Oct. 15, 2012), https://perma.cc/LQ26-94QJ; Nicole Mordant, *Native village defends ocean experiment; Canada launches probe*, Reuters (Oct. 19, 2012), https://perma.cc/BG62-9EKL. Environment and Climate Change Canada conducted an investigation into the incident, but the Public Prosecution Service of Canada subsequently declined to pursue a case against the Haida Salmon Restoration Corporation.

29 Royal Society of Engineering, Greenhouse Gas Removal 43–45 (2018), https://royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf [https://perma.cc/UFH6-MNA2]; 2022 NASEM Report, *supra* note 13, at 70-72.

30 2022 NASEM Report, *supra* note 13, at 70 & 72.

31 *Id*. at 73.

32 John H. Martin et al., *Testing the iron hypothesis in ecosystems of the equatorial Pacific Ocean*, 371 Nature 123-129 (1994); Coale et al., *A massive phytoplankton bloom induced by an ecosystem-scale iron fertilization experiment in the equatorial Pacific Ocean*, 383 Nature 495-501 (1996).

33 Philip W. Boyd et al., *A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization*, Nature, 407, 695-702, 2000.

34 Atsushi Tsuda et al., *A Mesoscale Iron Enrichment in the Western Subarctic Pacific Induces a Large Centric Diatom Bloom*, Science, 300, 958-961, 2003.

35 Mike J. Harvey et al., *The SOLAS air–sea gas exchange experiment (SAGE) 2004*, Deep-Sea Res. Pt. II, 58, 753-763, 2010.

36 Atsushi Tsuda et al., *Evidence for the grazing hypothesis: Grazing reduces phytoplankton responses of the HNLC ecosystem to iron enrichment in the western subarctic pacific (SEEDS II)*, J. Oceanogr., 63, 983-994, 2007.

millennia.[37] However, a 2009 study in the Subantarctic Atlantic Ocean found that limited silicic acid abundance and high zooplankton grazing limited downward flux of organic carbon.[38]

2.2 CDR Potential of Ocean Fertilization

If successful, ocean fertilization projects have the potential to remove large amounts of carbon dioxide from the atmosphere. Initial research suggests that, for each tonne of iron added to the ocean, up to 78,000 tonnes of carbon dioxide could be removed.[39] One study found a maximum theoretical removal potential of 3.7 gigatonnes of carbon dioxide per year for ocean iron fertilization (assuming continuous addition of iron in all suitable ocean areas).[40] Additional carbon dioxide could be removed through nitrogen and phosphorous fertilization. It is estimated that up to 21 tonnes of carbon dioxide could be removed per ton of nitrogen added to the ocean, and up to 150 tonnes of carbon dioxide per ton of phosphorus.[41] In all cases, these figures may be not be realizable due limited understanding of the ocean carbon flux and may be constrained by other factors, like production limitations and cost constraints.

Iron fertilization is likely to be less expensive than fertilization with nitrogen or phosphorous. This is, in part, because the same level of carbon dioxide sequestration can be achieved using significantly less iron than nitrogen or phosphorous.[42] The cost of producing, and thus the market price of, iron is also significantly lower than nitrogen. The 2022 NASEM Report estimated that one tonne of carbon dioxide could be removed using just $0.40 worth of iron or $48 worth of nitrogen, based on current market prices for the materials and excluding the costs of transport and discharge into the ocean.[43] Other studies have estimated the overall cost of iron fertilization (including transport and discharge) at anywhere from less than $10 up to $450 per tonne of carbon dioxide sequestered.[44] Nitrogen fertilization has been estimated as having a lower bound cost of $20 per tonne of carbon dioxide sequestered.[45] Phosphate's finite supply, its essential role in food production, and its location in large quantities in just a few countries may necessitate careful consideration of its use in ocean fertilization.[46]

2.3 Potential Co-Benefits and Risks of Ocean Fertilization

In addition to its CDR benefits, ocean fertilization could also benefit fisheries. In theory, because ocean fertilization stimulates the growth of phytoplankton—i.e., the base of the food

37 Victor Smetacek et al., *Deep carbon export from a Southern Ocean iron-fertilized diatom bloom*, Nature, 487, 313-319, 2012.
38 Patrick Martin et al., *Iron fertilization enhanced net community production but not downward particle flux during the Southern Ocean iron fertilization experiment LOHAFEX*, Global Biogeochem. Cycles, 27, 871-881, 2013.
39 *Id*. at 92.
40 Royal Society of Engineering, *supra* note 29, at 44.
41 2022 NASEM Report, *supra* note 13, at 92.
42 Jones, *supra* note 18, at 72-105. *See also* 2022 NASEM Report, *supra* note 13, at 83.
43 2022 NASEM Report, *supra* note 13, at 84. These figures represent material costs but do not account for upstream carbon dioxide emissions from the production of the materials.
44 *See e.g.,* Philip Boyd, *Implications of large-scale iron fertilization of the oceans*, 364 Marine Ecology Progress Series 213 (2008); National Research Council, Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration 56-63 (2015), https://doi.org/10.17226/18805 [https://perma.cc/A5EF-NYNH].
45 Daniel P Harrison, *Global negative emissions capacity of ocean macronutrient fertilization*, 12 Environmental Research Letters 035001 (2017).
46 *Id*.

chain—it should lead to an increase in fish stocks.[47] As noted above, in 2012, the Haida Salmon Restoration Corporation engaged in ocean fertilization for the express purpose of enhancing salmon stocks. There is, however, no evidence that the project impacted fisheries (either positively or negatively).[48]

Ocean fertilization could also help to combat ocean acidification, at least temporarily.[49] As noted above, the goal of ocean fertilization is to stimulate the growth of phytoplankton, which convert dissolved inorganic carbon in ocean water into organic carbon. The reduction in dissolved inorganic carbon will lead to an increase in ocean water pH (and thus a reduction in acidity). This would only be temporary, however. As more carbon dioxide is taken up by the ocean, the pH of the water would decrease back to its starting point.

Large scale ocean fertilization would require the addition of large amounts of iron, nitrogen, and/or phosphorous to the ocean. The production and transportation of those materials could have a range of negative environmental and social impacts.[50] For example, the mining of iron ore, and the production of iron therefrom, are energy-intensive processes that can result in pollution and other environmental harms. Nitrogen and phosphorous production present similar risks.[51] Moreover, because phosphate is a finite resource that is currently widely used in agriculture, ocean fertilization could have implications for food production.[52]

There is also a risk that phytoplankton growth associated with iron fertilization could divert macronutrients from other ocean regions and thus limit photosynthesis in those regions.[53] Ocean fertilization could additionally cause harmful algae blooms that are known to be toxic to humans and wildlife.[54] It is also possible that the increase in cellular respiration could cause anoxic conditions and lead to increased methane and nitrous oxide emissions.[55]

47 2022 NASEM Report, supra note 13, at 90.
48 *Id*.
49 *Id*. at 91.
50 *See* Romany M. Webb et al., Removing Carbon Dioxide Through Ocean Alkalinity Enhancement: Legal Challenges and Opportunities (2021), https://perma.cc/QMJ2-VDZH for a discussion of those impacts.
51 Jones, *supra* note 18, at 72-105.
52 Harrison, *supra* note 45.
53 Jones, *supra* note 18, at 72-105.
54 National Research Council, *supra* note 44, at 56-63.
55 Royal Society of Engineering, *supra* note 29, at 43-45.

3. JURISDICTION OVER OCEANS

Regulatory jurisdiction over the ocean is governed by international law. The relevant principles of international law and their application in the U.S. are discussed in this Part.

3.1 International Legal Framework

The United Nations Convention on the Law of the Sea ("UNCLOS") defines the extent of countries' jurisdiction over ocean waters and submerged land. UNCLOS had been ratified or otherwise adopted by 167 countries and the European Union.[56] The U.S. has not ratified UNCLOS, but recognizes many of its provisions, including those discussed in this Part, as forming part of customary international law.[57]

Under UNCLOS, non-landlocked countries ("Coastal Countries") have jurisdiction over ocean areas within 200 nautical miles ("n.m.") of the low water line along their coasts (the "baseline") and further in some circumstances.[58] The 200 n.m. zone is generally divided into four key parts (see Figure 2), each of which has a different legal status as follows:

- The territorial sea, which comprises the waters and submerged land extending twelve n.m. from the baseline, and forms part of the sovereign territory of Coastal Countries.[59] Within its territorial sea, the coastal country has full sovereign rights over the water and submerged land and the airspace above.

- The contiguous zone, which extends twelve to twenty-four nautical miles from the baseline.[60] Unlike the territorial sea, the contiguous zone does not form part of Coastal Countries' sovereign territory. However, within the contiguous zone, Coastal Countries can exercise the control necessary to prevent and punish infringements of customs, fiscal, immigration, and sanitary laws within their territory.[61]

- The exclusive economic zone ("EEZ"), which overlaps with, but extends beyond, the contiguous zone up to 200 n.m. from the baseline.[62] Again, the EEZ does not form part of Coastal Countries' sovereign territory, but countries do have sovereign rights to explore, exploit, conserve, and manage natural resources and undertake other activities for the economic exploitation of the zone. Coastal Countries also have jurisdiction over artificial islands, installations, structures, marine scientific research, and marine protection in their EEZs.[63]

56 United Nations, *Law of the Sea*, https://perma.cc/AZ7L-APX4 (last updated Jan. 19, 2021).
57 *Id. See also* U.S. Dept. of State, *Law of the Sea Convention*, https://perma.cc/A8A5-QA98 (last updated Mar. 7, 2019).
58 United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter "UNCLOS"].
59 *Id.* Art. 2-3.
60 *Id.* Art. 33.
61 *Id.*
62 *Id.* Art. 55 & 57.
63 *Id.* Art. 56.

- The continental shelf, which comprises the submerged land extending beyond the territorial sea to the farthest of 200 n.m. from the baseline or the outer edge of the continental margin,[64] up to sixty n.m. from the foot of the continental slope or the point where sediment thickness is one percent of the distance thereto.[65] Each Coastal Country has sovereign rights over its continental shelf for the purpose of exploring and exploiting natural resources.[66]

Coastal Countries do not have jurisdiction over ocean waters more than 200 n.m. from shore. Those waters, known as the "high seas," are open to use by all coastal and landlocked countries in accordance with international law.[67] UNCLOS provides for "freedom of the high seas," which is defined to include, "for both coastal and land-locked [countries]: (a) freedom of navigation; freedom of overflight; freedom to lay submarine cables and pipelines . . . ; freedom to construct artificial islands and other installations . . . ; freedom of fishing . . . ; [and] (f) freedom of scientific research."[68] The seabed underlying the high seas (known as the "Area") is similarly open to use by all countries.[69] Activities in the Area must, however, be conducted "exclusively for peaceful purposes" and "for the benefit of mankind as a whole."[70]

A country's domestic laws will apply to activities on the high seas if they are performed by individuals subject to that country's jurisdiction (e.g., because the individual is a national of the country) or using vessels that are registered or flagged in the country.

3.2 U.S. Jurisdictional Areas

Consistent with international law the U.S. has claimed jurisdiction over all waters up to 200 n.m. from its coast ("U.S. waters").[71] Jurisdiction is shared among the coastal states, which have primary authority over areas within three n.m. of shore (and further in some cases) ("state waters"), and the federal government, which has authority over areas lying beyond state waters within U.S. territory ("federal waters").

3.2.1 State Waters

Under the Submerged Lands Act of 1953 ("SLA"), the boundaries of each coastal state extend three n.m. from its coastline, except in the Gulf of Mexico, where the boundaries of Texas and

64 The "continental margin" refers to the submerged prolongation of the land mass of the Coastal State. *See id.* Art. 76(1).
65 *Id.* Art. 76(5). The continental shelf cannot extend more than 100 n.m. from the 2,500 meter isobath or 350 n.m. from the baseline. *See id.*
66 *Id.* Art. 77.
67 *Id.* Art. 86-87.
68 *Id.* Art. 87.
69 *Id.* Art. 1 & 136-149.
70 *Id.* Art. 140-141.
71 Proclamation No. 5030, 48 Fed. Reg. 10605 (Mar. 14, 1983).

Florida extend nine n.m. from the coastline.[72] For the purposes of the SLA, a state's "coastline" is defined as "the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters."[73]

Offshore waters within state boundaries fall under the primary jurisdiction of the relevant coastal state. With limited exceptions, coastal states have title to, and ownership of, all lands beneath their state waters and the right to take natural resources (including minerals, marine animals, and plant life) within those lands and waters.[74] The federal government has relinquished all of its property rights to, and interests in, land and resources within state waters.[75] However, the federal government retains authority to regulate state waters "for the constitutional purposes of commerce, navigation, national defense, and international affairs."[76] Local governments also have limited authority in state waters in some areas. For example, in parts of New York, local governments own the submerged land under state waters pursuant to Colonial patents.[77] The New York state government has also ceded title to some submerged lands to local governments through legislative enactments.[78]

3.2.2 Federal Waters

Waters lying beyond state boundaries up to 200 n.m. from shore fall under the exclusive authority of the federal government. The federal government also has exclusive authority over offshore land, comprising the seabed and subsoil of the outer continental shelf ("OCS"). The federal Outer Continental Shelf Lands Act ("OCSLA") defines the OCS as comprising the "submerged lands lying seaward and outside of the area [subject to state jurisdiction] . . . and of which the subsoil and seabed appertain to the U.S."[79] As discussed in Part 3.2.1 above, state jurisdiction typically ends three n.m. from shore (except off Texas and the west coast of Florida, where it ends nine n.m. from shore), at which point the OCS begins. The OCS extends to the seaward limit of U.S. jurisdiction, defined under international law as the farthest of:

- 200 n.m. from the baseline (i.e., normally the low-water line along the coast); or
- if the continental margin exceeds 200 n.m., a line:

72 43 U.S.C. § 1312 (providing that "[t]he seaward boundary of each original coastal State is approved and confirmed as a line three geographic miles distant from its coast line"). *See also id.* § 1301(b) (defining the term "boundaries" and providing that "in no event shall the term boundaries . . . be interpreted as extending from the coast line more than three geographical miles in the Atlantic Ocean or the Pacific Ocean, or more than three marine leagues into the Gulf of Mexico"). A "marine league" is equivalent to three n.m. Thus, in the Gulf of Mexico, the boundaries of Texas and Florida extend nine n.m. from the coastline. *See generally* U.S. v. Louisiana, 100 S.Ct. 1618 (1980), 420 U.S. 529 (1975), 394 U.S. 11 (1969), 389 U.S. 155 (1967), 363 U.S. 1 (1960), 339 U.S. 699 (1950).

73 43 U.S.C. § 1301(c).

74 *Id.* § 1311(a)(1).

75 *Id.* § 1311(b).

76 *Id.* § 1314.

77 *See e.g.*, Town of Oyster Bay v. Commander Oil Corp., 96 N.Y.2d 566, 572 (N.Y., 2001) (holding that the Town of Oyster Bay "owns the underwater land beneath Oyster Bay by virtue of a colonial patent").

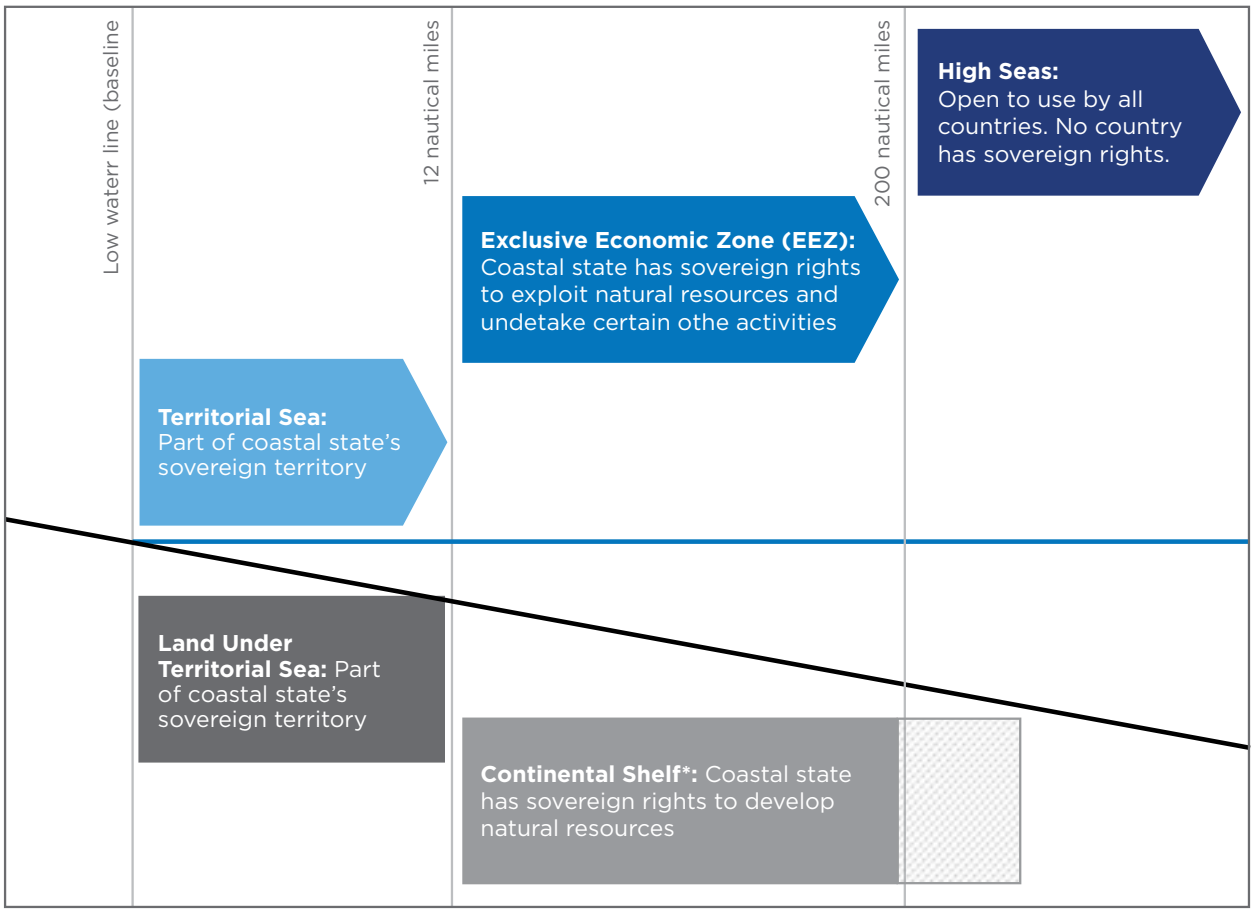
78 *See e.g.,* N.Y. Envtl. Conservation Law § 13-0302 (stating that "all the right, title and interest in which the people of the state of New York have in and to the lands under water of Gardiner's and Peconic bays in the county of Suffolk, except underwater lands within one thousand feet of the high water market is hereby ceded to such county, for the purposes of shellfish cultivation").

79 43 U.S.C. § 1331.

- sixty n.m. from the foot of the continental shelf; or
- beyond the shelf foot where the sediment thickness is one percent of the distance thereto.[80]

The OCS cannot, however, extend more than 350 n.m. from the baseline or 100 n.m. from the 2,500 meter isobath (i.e., a line connecting the depth of 2,500 meters).[81]

Figure 1: Offshore Zones Identified in UNCLOS



** The continental shelf typically extends 200 n.m. from shore. However, in some circumstances, it may extend beyond this point to the farthest of 100 n.m. from the 2,500 meter isobath or 350 n.m. from the baseline.*

80 UNCLOS, *supra* note 58, Art. 76(1) & (4).
81 *Id*. Art. 76(5).

4. INTERNATIONAL LEGAL FRAMEWORK FOR OCEAN FERTILIZATION

This Part discusses key international agreements and principles of customary international law that could apply to ocean fertilization projects. At the outset, it is important to note that international agreements are only binding on countries that have consented to them, whereas customary international law comprises universal standards that are binding on all countries. Additionally, international agreements and customary international law typically only impose binding obligations on countries and not on private actors (e.g., individuals and corporations). However, countries may implement their international legal obligations by enacting domestic laws, which are binding on private actors.

As explained further below, there are currently no international agreements with legally binding provisions specific to ocean fertilization. There are, however, a number of agreements governing ocean-based activities generally that could apply to ocean fertilization projects in some circumstances. The parties to three of those agreements—i.e., the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter ("London Convention"), the Protocol to that Convention ("London Protocol"), and the Convention on Biological Diversity ("CBD")—have adopted several non-binding decisions and resolutions recommending that countries avoid certain ocean fertilization projects. The parties to the London Protocol have also adopted an amendment which, if and when it enters into force, will establish a specific permitting regime for ocean fertilization. However, at the time of writing, the amendment had only been ratified by six countries and had yet to enter into force.

4.1 Relevant International Agreements

4.1.1 London Convention and Protocol

The London Convention was adopted in November 1972 and entered into force in August 1975. The London Convention aims to "promote the effective control of all sources of pollution of the marine environment," particularly those resulting from the "dumping" of "waste or other matter" at sea.[82] In November 1996, the parties to the London Convention adopted a new protocol, which is intended to update the Convention and will replace it if ratified by all contracting parties.[83] The London Protocol sets more ambitious goals than the London Convention, aiming to "protect and preserve the marine environment from all sources of pollution," and to "prevent, reduce and where practicable eliminate pollution caused by dumping" of "waste or other matter."[84]

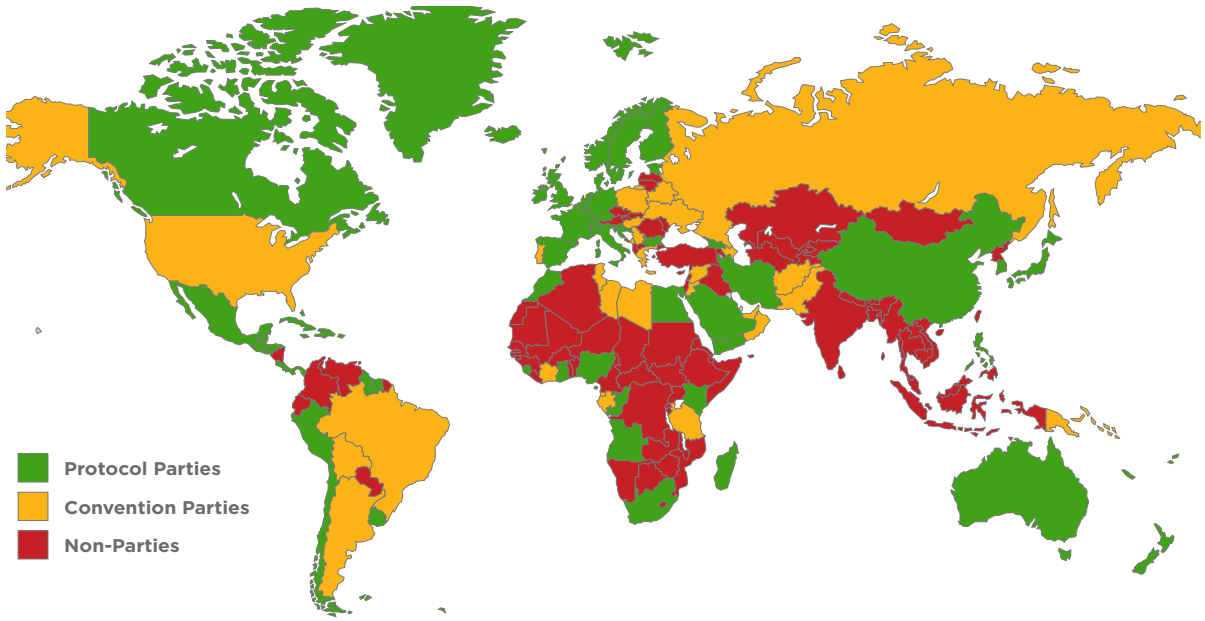
82 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972 [hereinafter "London Convention"], Art. I-II.

83 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters, Nov. 7, 1996 [hereinafter "London Protocol"], Art. III.

84 *Id.*

At the time of writing, there were eighty-seven parties to the London Convention, and fifty-three parties to the London Protocol (see Figure 2 and Table 1).[85] For countries that are parties to both instruments, the London Protocol supersedes the London Convention. The U.S. has only ratified the London Convention and is, therefore, bound only by its terms.[86]

Figure 2: Parties to the London Convention and London Protocol[87]



See Appendix A for a list, by country, of the parties to the London Convention and Protocol

Both the London Convention and London Protocol require parties to adopt domestic laws to regulate the dumping of waste and other matter within offshore areas under their jurisdiction (i.e., the territorial sea and EEZ) and, outside of those areas, by vessels or aircraft that are registered, or were loaded, within their territory.[88] Parties to the London Convention must prohibit the dumping of eight substances listed in Annex I to the Convention ("prohibited substances"),[89] but can permit the dumping of other (non-prohibited) substances.[90] The London Protocol is more restrictive, requiring parties to prohibit the dumping of all substances, except the eight listed in Annex I to the Protocol ("allowed substances").[91]

Table 1: Prohibited Substances Listed in Annex I to the London Convention and Allowed

85 International Maritime Organization, *Map of Parties to the London Convention/Protocol*, https://perma.cc/QQG4-DY7H (last updated Feb. 22, 2019).
86 Envtl. Prot. Agency, *Ocean Dumping: International Treaties*, https://perma.cc/9KSU-756N (last updated Feb. 28, 2019).
87 *Id.*
88 London Convention, *supra* note 82, Art. VII; London Protocol, *supra* note 83, Art. 10.
89 *Id.*
90 London Convention, *supra* note 82, Art. IV.
91 London Protocol, *supra* note 83, Art. 4, Annex 1.

Substances Listed in Annex I to the London Protocol

Prohibited Substances under the London Convention[92]	Allowed Substances under the London Protocol[93]
(1) Organohalogen compounds (2) Mercury and mercury compounds (3) Cadmium and cadmium compounds (4) Persistent plastics and other persistent synthetic material (5) Crude oil and petroleum products and wastes (6) Radioactive wastes or matter (7) Materials produced for biological or chemical warfare (8) Industrial waste	(1) Dredged material (2) Sewage sludge (3) Fish waste and material from industrial fish processing operations (4) Vessels, platforms, and other man-made structures at sea (5) Inert, inorganic geological material (6) Organic material of natural origin (7) Certain bulk items primarily comprising iron, steel, concrete, and similarly unharmful materials (8) Carbon dioxide streams from carbon dioxide capture processes for sequestration

Both the London Convention and London Protocol define "waste or other matter" broadly to include "material of any kind, form or description."[94] In both instruments, "dumping" is defined to mean the "deliberate disposal of waste or other matter at sea from vessels, aircraft, platforms, or other man-made structures."[95] Notably, however, the definition expressly excludes the "placement of matter for a purpose other than mere disposal thereof, provided that such placement is not contrary to the aims of" the London Convention or Protocol (the "dumping exemption").[96]

(A) Treatment of Ocean Fertilization Projects under the London Convention and Protocol

The parties to the London Convention and Protocol have concluded that ocean fertilization projects may involve "dumping," at least in some circumstances (see Part 4.1.1(B) below). Ocean fertilization projects involve the discharge of materials—i.e., iron and/or other nutrients—into ocean waters from vessels. Arguably, however, the discharge is not for the purposes of disposal. While the term disposal is not defined in the London Convention or Protocol, in ordinary parlance, it generally refers to the act of getting rid of something that is no longer useful. In contrast, in ocean fertilization, materials are discharged for the purpose of sequestering carbon dioxide (i.e., not to get rid of them). However, while the discharge is for a purpose other than disposal, it may be considered contrary to the aims of the London

92 Materials containing substances (1) through (5) as "trace contaminants" are not prohibited. Materials containing substances (1) through (5) or (7) through (8) are also not prohibited if they "are rapidly rendered harmless by the physical, chemical or biological processes in the sea" and do not "make edible marine organisms unpalatable" or "endanger human health or that of domestic animals."
93 Materials containing more than "de minimis concentrations" of radioactivity are not allowed.
94 London Convention, *supra* note 82, Art. III; London Protocol, *supra* note 83, Art. I.
95 London Convention, *supra* note 82, Art. III; London Protocol, *supra* note 83, Art. I.
96 London Convention, *supra* note 82, Art. III; London Protocol, *supra* note 83, Art. I

Convention and Protocol. Both instruments aim to protect the marine environment from pollution.[97] As discussed further below, the parties have previously agreed that certain ocean fertilization activities should be regarded as contrary to the aims of the London Convention and Protocol, including because there is insufficient information about their "effectiveness and potential environmental impacts."[98]

Under the terms of the London Convention and Protocol, where ocean fertilization projects are found to involve dumping, those projects would need to be permitted by the country under whose jurisdiction they occur. A country is considered to have jurisdiction over a project if it involves the dumping of materials within that country's territorial sea or in other areas if the materials are dumped from a vessel that was loaded or is registered or "flagged" in the country. Thus, a country-issued permit will be needed under the London Convention or Protocol if (1) dumping will occur within the territorial sea of a country that is party to the Convention or Protocol, (2) the materials to be dumped will be loaded onto a vessel in the territory of a country that is party to the London Convention or Protocol, or (3) the dumping will occur from a vessel that is registered in a country that is a party to the Convention or Protocol. Under both the Convention and Protocol, the country in whose jurisdiction the loading occurs is responsible for permitting, as long as it is a party to the Convention or Protocol.[99] If the loading country is not a party, then the flag state of the vessel is responsible for permitting.[100]

Parties to the London Convention likely could permit ocean fertilization projects because the materials used therein—e.g., iron, nitrogen, and phosphate—do not appear on the list of prohibited substances in the Convention. Permits likely could not be issued by parties to the London Protocol, however. As noted above, parties to the London Protocol can only permit the dumping of allowed substances, listed in Annex I to the Protocol. The Annex I list does not include iron, nitrogen, or phosphate.

97 London Convention, *supra* note 82, Art I; London Protocol, *supra* note 83, Art. 2.
98 Report of the Thirtieth Meeting of the Scientific Group of the London Convention and the First Meeting of the Scientific Group of the London Protocol, LC/SG 30/14 (July 25, 2007).
99 London Convention, *supra* note 82, Art. VI(2); London Protocol, *supra* note 83, Art. 9(2).
100 *Id*.

Table 2: Party Status of Top 10 Ship Registry Countries[101]

Country	London Convention	London Protocol
Panama	X	
Liberia		
Marshall Islands		X
Hong Kong (China)	X	X
Singapore		
Bahamas		
Malta	X	
Greece	X	
China	X	X
Cyprus	X	

(B) London Convention / Protocol Resolutions on Ocean Fertilization

The scientific groups[102] of, and the parties to, the London Convention and Protocol have adopted a series of non-binding resolutions dealing specifically with ocean fertilization. Since the resolutions are non-binding, parties are not legally required to comply with them. However, some argue that the resolutions must be consulted in the context of interpreting the provisions of the two agreements.[103] Thus, for instance, the resolutions can aid parties in determining whether ocean fertilization projects will be viewed as contrary to the aims of the London Convention and Protocol, and thus whether such projects will be considered "dumping" within the terms of those instruments.

First, in July 2007, the scientific groups of the London Convention and Protocol issued a "statement of concern" regarding proposals for "[l]arge-scale fertilization of ocean waters using micro-nutrients such as iron to stimulate phytoplankton growth in order to sequester carbon dioxide," and recommended that any such proposals "be evaluated carefully to ensure . . . [they are] not contrary to the aims of the London Convention and Protocol."[104] The statement of concern was endorsed by the parties to the London Convention and Protocol at a meeting in November 2007. At that meeting, the parties also expressed the view that "the scope of work of the London Convention and Protocol included ocean fertilization," and that

101 The top 10 flag of registry countries are drawn from U.S. Department of Transportation Maritime Administration, *Top 25 Flags of Registry* (2018), https://perma.cc/M9XX-Y6UK. The list ranks flags of registry by gross tons carried on oceangoing self-propelled, cargo-carrying, privately-owned vessels of 1,000 gross tons and above.

102 The Scientific Group of the London Convention and the Scientific Group of the London Protocol provide advice to the parties on scientific and technical aspects of ocean dumping.

103 A Proelss, *Law of the Sea and Geoengineering*, *in* Law of the Sea: Normative Context and Interactions with other Legal Regimes (N Matz-Lück et al. eds., 2021), in print.

104 Report of the Thirtieth Meeting of the Scientific Group of the London Convention and the First Meeting of the Scientific Group of the London Protocol, LC/SG 30/14 (July 25, 2007).

those instruments "were competent to address th[e] issue."[105] This view was reiterated in a resolution adopted by the parties to the London Convention and Protocol in October 2008.[106] The resolution further defined when ocean fertilization will constitute "dumping" within the terms of the London Convention and Protocol.

The 2008 resolution defined "ocean fertilization" broadly to mean "any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans."[107] That definition would encompass the addition of iron or other nutrients to the ocean to stimulate phytoplankton growth for the purposes of sequestering carbon dioxide.

The 2008 resolution draws a distinction between ocean fertilization research and deployment. According to the resolution, ocean fertilization activities conducted as part of "legitimate scientific research . . . should be regarded as placement of matter for a purpose other than mere disposal," and thus will qualify for the dumping exemption if they are not contrary to the aims of the London Convention or Protocol.[108] The resolution stated that scientific research proposals should be assessed on a case-by-case basis to determine whether they qualify.[109] An assessment framework was developed by the scientific groups of, and adopted by the parties to, the London Convention and Protocol in 2010.[110]

The 2010 assessment framework provides for a two-stage review of projects by the country under whose jurisdiction they occur.[111] The relevant country must first conduct an "initial assessment" to determine whether the project "has proper scientific attributes" to qualify as "legitimate scientific research."[112] The assessment framework states that only activities meeting the following requirements "should" be viewed as having proper scientific attributes:

- the activity "should be designed to answer questions that will add to the body of scientific knowledge;"
- "economic interests should not influence the design, conduct, and/or outcomes of the . . . activity;"
- the activity "should be subject to scientific peer review at appropriate stages;" and

105 Report of the Twenty-Ninth Consultative Meeting of Contracting Parties to the London Convention and The Second Meeting of Contracting Parties to the London Protocol, LC 29/17 (Dec. 14, 2007).
106 Resolution LC-LP.1(2008) on the Regulation of Ocean Fertilization, Art. 1 (Oct. 31, 2008) [hereinafter "2008 Resolution"].
107 *Id*. Art. 2. The definition excludes "convention aquaculture, or mariculture, or the creation of artificial reefs."
108 *Id*. Art 3.
109 *Id*. Art. 4.
110 Resolution LC-LP.2(2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (Oct. 14, 2010) [hereinafter "2010 Resolution"].
111 *Id*. Annex 6. For the purposes of the London Convention and Protocol, the dumping of materials into ocean waters is considered to occur under a country's jurisdiction if (1) the material is carried on a vessel or aircraft registered in the country's territory or flying its flag, (2) the material was loaded onto a vessel or aircraft within the country's territory; or (3) the material is dumped within areas under the jurisdiction of the country under international law. *See* London Convention, *supra* note 82, at Art. VII; London Protocol, supra note 83, at Art. 10.
112 2010 Resolution, *supra* note 110, at Annex I, cl. 1.3.1.

- data and outcomes should be "made publicly available" and results published "in peer reviewed scientific publications."[113]
- Projects that do not meet these requirements cannot be classed as "research" and thus do not qualify for the dumping exemption.[114]

Under the assessment framework, countries must conduct an "environmental assessment" to evaluate the potential short- and long-term effects of the project on the marine environment, characterize the nature and extent of project-related risks, and identify measures to manage those risks.[115] The assessment framework declares that countries "should" only conclude that a project is not contrary to the aims of the London Convention and Protocol, and thus covered by the dumping exemption, if "conditions are in place to ensure that, as far as practicable, environmental disturbance would be minimized, and the scientific benefits maximized."[116] The assessment framework further provides that, "[i]f the risks and/or uncertainties [associated with a project] are so high as to be deemed unacceptable, with respect to the protection of the marine environment, taking into account the precautionary approach, then a decision should be made to seek revision of or reject the proposal."[117] What constitutes "unacceptable" risk is not specified in the framework, but it is clear that countries must follow the precautionary principle. In this regard, the London Protocol states that countries "shall apply a precautionary approach . . . when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to provide a causal relation between inputs and their effects."[118] However, the precautionary principle could also be interpreted to support the application of carbon dioxide removal techniques such as ocean fertilization, because there could be extremely negative consequences from not using available techniques to lower carbon dioxide levels in the atmosphere.

Whereas the 2008 resolution and 2010 assessment framework envisage that some ocean fertilization research may qualify for the dumping exemption, deployment has been viewed differently. The 2008 resolution declares that that "ocean fertilization activities other than legitimate scientific research" do not qualify for the dumping exemption because they are contrary to the aims of the London Convention and Protocol.[119] Such activities would, therefore, be subject to the terms of the London Convention and Protocol. As noted above, both instruments require activities occurring under the jurisdiction of a party to be permitted by that party, and impose restrictions on when permits can be issued. Parties to the London Convention likely could issue permits for non-research ocean fertilization projects but parties to the London Protocol likely could not.

113 *Id*. Annex I, cl. 2.2.
114 *Id*. Annex I, cl. 2.3.
115 *Id.*, Annex 6.
116 *Id*.
117 *Id*.
118 London Protocol, *supra* note 83, Art. 3(1).
119 2008 Resolution, *supra* note 106, Art. 8.

(C) London Protocol Amendment on Ocean CDR

In 2013, the Parties to the London Protocol agreed to an amendment, which would establish a new permitting regime specific to ocean fertilization.[120] The amendment, which has not yet entered into force, would insert a new Article 6bis into the London Protocol stating:

Contracting Parties shall not allow the placement of matter into the sea from vessels, aircraft, platforms or other man-made structures at sea for marine geoengineering activities listed in annex 4, unless the listing provides that the activity or the subcategory of an activity may be authorized under a permit.[121]

The resolution states that the Parties will "continue to develop guidance for listing additional marine geoengineering activities in annex 4,"[122] and the above language suggests that such listings may set the criteria for permit authorization.

At the time of writing, annex 4 only listed "ocean fertilization."[123] The annex defines "ocean fertilization" to mean "any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans," except "conventional aquaculture or mariculture or the creation of artificial reefs."[124] This definition clearly encompasses ocean fertilization activities involving the addition of iron or other nutrients to ocean waters to stimulate phytoplankton growth. Under annex 4, countries cannot permit ocean fertilization projects, unless they are found to constitute "legitimate scientific research."[125] Before permitting any research project, the responsible country must conduct an assessment consistent with the process set out in the 2010 framework, and ensure that appropriate measures are put in place to manage and monitor any adverse effects.[126]

The 2013 amendment currently has limited practical effect on ocean fertilization projects because it has not yet taken effect and thus is not legally binding. Under the terms of the London Protocol, amendments do not enter into force until ratified by two-thirds of the parties to the Protocol.[127] To date, just six of the fifty-three parties to the London Protocol—Estonia, Finland, Germany, the Netherlands, Norway, and the U.K.—have ratified the 2013 amendment, which is well below the two-thirds threshold required. Even if the threshold is met, the amendment will only take effect for parties to the London Protocol. Parties to the London Convention will continue to be subject only to the 2008 and 2010 resolutions which are not legally binding.

120 Resolution LP .4(8), Amendment to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 to Regulate Marine Geoengineering (Oct. 18, 2013) [hereinafter "2013 LP Amendment"].
121 *Id*. Annex 1, Art. 1.
122 *Id*. Preamble.
123 *Id*. Annex 1, Art. 1.
124 *Id*.
125 *Id*.
126 *Id*.
127 London Protocol, *supra* note 83, Art. 21.

Table 3: Treatment of Ocean Fertilization Projects Under the London Convention, London Protocol, 2008 Resolution, and 2013 Amendment

	London Convention	London Protocol	2008 Resolution	2013 Amendment
Legally binding on the U.S.	Yes. The U.S. is a party to, and thus bound by, the London Convention.	No. The U.S. is not a party to, and thus not bound by, the London Protocol.	No. The resolution is not legally binding on any country.	No. The amendment has not yet entered into force. Even when it does, the amendment will only affect the London Protocol, to which the U.S. is not a party.
Applicable to ocean fertilization projects	Likely. While the discharge is for a purpose other than disposal, it is likely to be considered contrary to the aims of the London Convention.	Likely. While the discharge is for a purpose other than disposal, it is likely to be considered contrary to the aims of the London Protocol.	Yes. The 2008 resolution explicitly states that the scope of the London Convention and Protocol includes ocean fertilization activities.	Yes, when it enters into force. Ocean fertilization is specifically listed as a "marine geoengineering activity" in Annex 4.
Requirements for ocean fertilization projects (if applicable)	Must be permitted by national authorities in the country with jurisdiction over the project. Permits could be issued for ocean fertilization projects, provided they do not involve the dumping of any prohibited substances.	Must be permitted by national authorities in the country with jurisdiction over the project. Permits could not be issued for ocean fertilization projects.	Subject to review by relevant national authorities in the country with jurisdiction over the project under the 2010 assessment framework. May need to be permitted (depending on findings of review).	Must be permitted by relevant national authorities in the country with jurisdiction over the project. Permits can only be issued for "legitimate scientific research."

4.1.2 Convention on Biological Diversity

Adopted in June 1992, the CBD aims to promote "the conservation of biological diversity, [and] the sustainable use of its components."[128] The CBD entered into force in December 1993 and, at the time of writing, had been ratified or otherwise accepted by 195 countries and the

128 Convention on Biological Diversity, May 22, 1992 [hereinafter "CBD"].

European Union.[129] The U.S. had signed, but not ratified, the CBD at the time of writing.[130]

Article 3 of the CBD recognizes that countries have "the sovereign right to exploit their own resources pursuant to their own environmental policies" but must "ensure that activities within their jurisdiction or control do not cause damage to the environment of other [countries] or of areas beyond the limits of national jurisdiction.[131] Article 7 of the CBD requires parties to, "as far as possible and as appropriate," identify projects "which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects."[132] Under Article 14 of the CBD, parties must require environmental impact assessments of the projects, "with a view to avoiding or minimizing [their] adverse effects."[133] For projects that could have transboundary effects, parties must "[p]romote . . . notification, exchange of information and consultation" with potentially affected countries.[134] In the case of "imminent or grave" transboundary damage, parties must "notify immediately the potentially affected" countries, and "initiate action to prevent or minimize" any damage.[135] Parties should also have in place "national arrangements for emergency responses" to projects that represent a "grave and imminent danger to biological diversity."[136]

Ocean fertilization projects could affect biodiversity in various ways. For example, phytoplankton and algal bloom growth caused by ocean fertilization could divert macronutrients and oxygen from other ocean life, leading to changes in ocean ecosystems.[137] Nevertheless, provided the above requirements are met, the CBD would not prevent countries from undertaking or authorizing ocean fertilization projects.[138] The parties to the CBD have, however, adopted a series of non-binding decisions recommending that countries avoid "ocean fertilization" and other "climate-related geo-engineering activities."

129 Convention on Biological Diversity, *List of Parties*, https://perma.cc/ZY3W-9PC3 (last visited Jan. 19, 2021).

130 *Id*. Article 18 of the Vienna Convention on the Law of Treaties provides that a country that has signed, but not ratified, a treaty is "obliged to refrain from acts which would defeat the object and purpose of a treaty . . . until it shall have made its intent clear not to become a party to the treaty." This has been interpreted as requiring signatories to avoid acts that would make it more difficult or impossible for other parties to comply with the relevant agreement. Some researchers have argued that this requirement forms part of customary international law and thus applies to countries that are not party to the Vienna Convention (including the U.S.). However, even if this is the case, the obligation only applies until the country has signaled "its intent . . . not to become a party to the treaty." The U.S. has arguably done this by failing to ratify the CBD for nearly thirty years (despite having signed it in 1993). *See generally*, Curtis A. Bradley, *Treaty Signature, in* The Oxford Guide to Treaties 208 (Duncan B. Hollis ed., 2012).

131 CBD, *supra* note 128, Art. 3.

132 *Id*. Art. 7(c).

133 *Id*. Art. 14(1)(a).

134 *Id*. Art. 14(1)(c).

135 *Id*. Art. 14(1)(d).

136 *Id*. Art. 14(1)(e).

137 Jones, *supra* note 18.

138 The CBD applies to all activities carried out under the jurisdiction or control of a party thereto, regardless of whether they occur within or beyond the area under the party's national jurisdiction. *See* CBD, *supra* note 128, Art. 4(b).

(A) CBD Decisions on Ocean Fertilization and Marine Geoengineering

In a 2008 decision, the Conference of the Parties to the CBD:

> request[ed] Parties and urge[d] other Governments, in accordance with the precautionary approach, to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities . . . and a global, transparent and effective control and regulatory mechanism is in place for these activities.[139]

The 2008 decision did not define what constitutes "ocean fertilization." Within the scientific community, ocean fertilization is typically defined as the "[a]ddition of micronutrients (e.g., iron) and/or macronutrients (e.g., phosphorus or nitrogen) to the ocean . . . [to] increase photosynthesis by marine phytoplankton."[140]

The 2008 decision includes an exemption for "small scale research studies within coastal waters," which may be "authorized if justified by the need to gather specific scientific data . . . [and] subject to a thorough prior assessment of the potential impacts of the research studies on the marine environment."[141] According to the 2008 decision, authorized research projects should "be strictly controlled," and not undertaken for any "commercial purpose" (e.g., to sell carbon credits or offsets).[142]

A second decision was adopted by the CBD Conference of the Parties in 2010 to regulate "geoengineering activities" more broadly.[143] The 2010 decision defined geoengineering to mean "any technologies that deliberately reduce solar insolation or increase carbon sequestration on a large scale that may affect biodiversity."[144] The Secretariat to the CBD subsequently determined, and the Conference of the Parties agreed, that geoengineering should be defined more broadly to include any "[d]eliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and its impacts."[145] That definition would likely encompass the full-scale deployment of ocean fertilization, at least where it is deployed for the purpose of mitigating climate change or ocean acidification. It could be argued that ocean fertilization deployed for other purposes—e.g., to enhance fisheries—does not qualify as "geoengineering" within the terms of the CBD definition. Ocean fertilization research projects may or may not fall within the definition of "geoengineering," depending on their nature, extent, and objectives.

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139 Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Ninth Meeting, Decision IX/16, Art. C(4) (2008) [hereinafter "2008 CBD Decision"].

140 2022 NASEM Report, *supra* note 13, at 2.

141 *Id*.

142 *Id*.

143 Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Tenth Meeting, Decision X/33, Art. 8 (2010) [hereinafter "2010 CBD Decision"].

144 *Id.* at footnote 3.

145 Secretariat to the Convention on Biological Diversity, CDB Technical Series No. 66, Geoengineering in Relation to the Convention on Biological Diversity: Technical and Regulatory Matters 23 (2012), https://perma.cc/LFU6-5RAU; Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Eleventh Meeting, Decision XI/20 (2012) [hereinafter "2012 CBD Decision"].

The 2010 decision "invite[d] Parties and other Governments" to consider specified guidelines "on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate change mitigation and adaptation."[146] The guidelines recommended that countries:

> [e]nsure . . . in the absence of science based, global, transparent and effective control and regulatory mechanisms for geo-engineering, and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geo-engineering activities that may affect biodiversity take place, until there is in place an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts. (Internal citations omitted.)[147]

Again, the decision provided an exception for "small scale scientific research studies that could be conducted in a controlled setting," but did not define what constitutes such a setting.[148] It could be argued that only research conducted in a laboratory or mesocosm (i.e., an enclosed outdoor experimentation system that enables an examination of the natural environment under controlled conditions) occurs in a "controlled setting." On this view, the exception would not apply to other types of field research, including projects conducted in the open ocean. The 2010 decision further states that research should only occur if "justified by the need to gather specific scientific data and . . . subject to a thorough prior assessment of the potential impacts on the environment."[149]

The 2010 decision was reaffirmed by the Conference of the Parties to the CBD in 2012[150] and again in 2016.[151] None of those decisions are legally binding. Moreover, the 2010 decision uses soft language, merely "invit[ing]" countries to "consider" the guidelines provided. It does, however, provide an indication of how many in the international community view geoengineering activities and the controls that should be imposed on those activities.[152] As one scholar has argued, the CBD has been ratified by 195 countries and the European Union, and thus decisions of the Conference of the Parties "represent the political will of almost all States worldwide."[153]

146 2010 CBD Decision, *supra* note 143, Art. 8.
147 *Id*. Art. 8(w).
148 *Id*.
149 *Id*.
150 2012 CBD Decision, *supra* note 145, at Art. 6-9.
151 Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Thirteen Meeting, Decision XIII/4, Art. 14 (2016).
152 The International Law Commission has suggested that decisions of the conference of the parties to an international agreement should be taken into account in interpreting that agreement. *See* Report of the International Law Commission on the Work of its Seventieth Session, UN Doc A/73/10, 85-88 (2018), https://docs.google.com/file/d/0BxLMteFpPQ08bkYzT1dWaV9iT1U/edit?resourcekey=0-cneRU9Xcx_Jh9LyfK642WA.
153 Harald Ginzky, *Marine Geo-Engineering*, *in* Handbook on Marine Environment Protection: Science, Impacts and Sustainable Management 997, 1008 (Markus Salomon & Till Markus, eds. 2018).

4.1.3 United Nations Convention on the Law of the Sea

Often described as the "constitution of the oceans," UNCLOS defines countries' rights and responsibilities with respect to the management and use of offshore areas. UNCLOS was first adopted in December 1982 and entered into force in November 1994.[154] In the following years, two separate agreements dealing with implementation of specific provisions of UNCLOS were adopted—(1) the Seabed Mining Agreement, adopted in July 1994,[155] and (2) the Straddling Fish Stocks Agreement, adopted in August 1995.[156] In June 2015, the United Nations General Assembly agreed to develop a new agreement under UNCLOS on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction (commonly referred to as the "Biodiversity Beyond National Jurisdiction Agreement").[157] However, at the time of writing, the text of that agreement had not been finalized.

UNCLOS has been ratified or otherwise adopted by 167 countries and the European Union, but even countries that are not parties to UNCLOS recognize many of its provisions as forming part of customary international law and thus abide by them.[158] The Seabed Mining Agreement and Straddling Fish Stocks Agreement do not have the same universal acceptance. At the time of writing, there were 150 parties to the Seabed Mining Agreement,[159] and 91 parties to the Straddling Fish Stocks Agreement.[160] The U.S. is a party to the Straddling Fish Stocks Agreement only.

Various provisions of UNCLOS could apply to ocean fertilization projects.[161] Most notably, projects that are conducted for the purposes of research could be subject to Part XIII of UNCLOS, which establishes rules for "marine scientific research" ("MSR").

UNCLOS does not include a definition of MSR. However, the term is commonly understood to encompass any scientific investigation of the marine environment, including studies of

154 United Nations Division for Ocean Affairs and Law of the Sea, *United Nations Convention on the Law of the Sea of 10 December 1982: Overview and Full Text*, https://perma.cc/NYS6-RXZR (last updated Feb. 2, 2020).

155 Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, 1836 U.N.T.S. 3. The Agreement entered into force in July 1996.

156 United Nations Agreement for the Implementation of the Provisions of UNCLOS Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 4 Dec. 1995, 2167 U.N.T.S. 3 [hereinafter, "Straddling Fish Stocks Agreement"]. The agreement entered into force in November 2001.

157 United Nations, *Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction*, https://perma.cc/5WHG-KRCR (last visited Aug. 17, 2021).

158 *See generally*, Angelle C. Smith, *Frozen Assets: Ownership if Arctic Mineral Rights Must be Resolved to Prevent the Really Cold War*, 41 Geo. Wash. Int'l L. Rev. 651, 657 (2011).

159 United Nations, *supra* note 56.

160 *Id*.

161 For a discussion of the application of UNCLOS to other ocean CDR techniques, *see* Romany M. Webb et al., Removing Carbon Dioxide Through Ocean Alkalinity Enhancement: Legal Challenges and Opportunities (2021), https://perma.cc/QMJ2-VDZH; Korey Silverman-Roati et al., Removing Carbon Dioxide Through Seaweed Cultivation: Legal Challenges and Opportunities (2021), https://perma.cc/9ZDH-MSPE; Romany M. Webb et al., Removing Carbon Dioxide Through Artificial Upwelling and Downwelling: Legal Challenges and Opportunities (2022), https://perma.cc/QX9M-YJ8N.

the seabed, water column, and atmosphere above the water.[162] Several legal scholars have concluded that "projects aimed at demonstrating or testing ocean CDR techniques would qualify [as MSR] if conducted "in situ" in the ocean."[163] Thus, for example, projects that test plant growth and carbon sequestration after iron fertilization in the ocean would likely be considered MSR. UNCLOS does not distinguish between basic research, conducted solely for the purpose of increasing scientific knowledge, and more applied research, conducted to inform or facilitate commercial activities.[164]

Part XIII of UNCLOS recognizes that each Coastal Country has "the right to regulate, authorize, and conduct" MSR within its territorial sea and EEZ.[165] Both coastal and landlocked countries also have a right to conduct MSR on the high seas. Countries may only conduct MSR in the territorial sea and EEZ of another country with that country's consent.[166] UNCLOS directs that "coastal [countries] shall, in normal circumstances, grant their consent for" MSR in their territory "in order to increase scientific knowledge of the marine environment for the benefit of all mankind."[167] Notably, however, coastal countries may "withhold their consent" if the project involves "the introduction of harmful substances into the marine environment,"[168] which could apply to the addition of iron, phosphorous, or nitrogen.[169] Coastal countries may also withhold consent if a research project is "of direct significance for the exploration and exploitation of natural resources, whether living or non-living" (among other things).[170] The terms "exploration" and "exploitation" are not defined in UNCLOS, but at least one commentator has argued that recovery of resources, such as fish, for commercial purposes is a form of resource exploitation.[171] Some ocean fertilization projects could impact ocean life by diverting macronutrients away from other ocean regions and thereby impair the recovery of fish, seaweed, and other ocean resources. Where this occurs, a country may view ocean fertilization research as having "direct significance for the . . . exploitation of

162 *See generally*, Patricia Birnie, *Law of the Sea and Ocean Resources: Implications for Marine Scientific Research*, 10 Intl. J. Marine & Coastal L. 229, 241-42 (MSR is "any form of scientific investigation, fundamental or applied, concerned with the marine environment"); Tim Stephens & Donald R. Rothwell, *Marine Scientific Research in* The Oxford Handbook of the Law of the Sea (Donald R. Rothwell et al., eds, 2015) (MSR involves study of the ocean and marine environment as occurs in, for example, "physical oceanography, marine chemistry and biologic, scientific ocean drilling and coring, geological and geophysical research and other activities that have a scientific purpose").

163 2022 NASEM Report, *supra* note 13, at 43.

164 Kerryn Brent, Wil Burns & Jeffrey McGee, Governance of Marine Geoengineering 19 (2019), https://perma.cc/3XTP-D9DQ.

165 UNCLOS, *supra* note 58, Art. 245 & 246.

166 *Id*. Art. 238, 245, 246, 256, & 257.

167 *Id*. Art. 246(3).

168 *Id.* Art. 246(5)(b).

169 UNCLOS does not define "harmful substances" but, as described below, UNCLOS does require parties to take steps to reduce "pollution from the marine environment" defined 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 the sea water and reduction of amenities." *Id*. Art. 1(1)(4). Iron, nitrogen, and phosphorous could cause harm to marine life when used in ocean fertilization if the processdiverts macronutrients from other ocean regions and thus limits photosynthesis in those regions.

170 *Id*. Art. 246(5)(a).

171 *See e.g.,* Chuxiao Yu, *Implications of the UNCLOS Marine Scientific Research Regime for the Current Negotiations on Access and Benefit Sharing of Marine Genetic Resources in Areas Beyond National Jurisdiction*, 51 Ocean Dev. & Int'l L. 1, 6 (2019).

natural resources," and refuse to permit the research in its territory.

Where a country obtains permission to conduct ocean fertilization research in another's territory, it must provide the host country with a description of the nature and objectives of the research, how and where it will be conducted, and the expected start and end dates.[172] The host country has the right to participate or be represented in the research and can request access to research data and results.[173] The research results must also be "made internationally available through appropriate national and international channels."[174] This could help to enhance the transparency of ocean fertilization research. Importantly, however, the requirement to make research results available does not apply where a country conducts ocean fertilization research within its own territory or on the high seas. All MSR, regardless of where it occurs, must be conducted in accordance with "appropriate scientific methods" and in a manner that does not "unjustifiably interfere with other legitimate uses" of the ocean.[175]

Ocean fertilization research projects and commercial-scale operations would also need to comply with Part XII of UNCLOS, which imposes a general obligation on countries to "protect and preserve the marine environment." Under Article 206 of UNCLOS, before undertaking any activity which "may cause . . . significant and harmful changes to the marine environment," countries must "assess the potential effects" of the activity and publish the findings of that assessment.[176] While the need for an assessment must be determined on a case-by-case basis, given the risks associated with ocean fertilization, assessments are likely to be required for many research and commercial-scale operations. Other international agreements (discussed in Part 4.1.4 below) provide further guidance on conducting assessments.

Part XII of UNCLOS further requires countries to "protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life."[177] The Straddling Fish Stocks Agreement similarly directs countries to avoid adverse "impacts on . . . species, in particular endangered species," and to "protect biodiversity in the marine environment."[178] These requirements could have implications for the conduct of ocean fertilization projects. For example, research and commercial-scale operations may need to be conducted outside of sensitive areas to protect rare and fragile ecosystems and minimize species impacts.

Under both UNCLOS and the Straddling Fish Stocks Agreement, countries must also take steps to minimize pollution of the marine environment,[179] which could occur in ocean fertilization projects. UNCLOS defines "pollution" broadly to mean:

172 UNCLOS, *supra* note 58, Art. 248.
173 *Id.* Art. 249.
174 *Id.* Art. 249(1)(e).
175 *Id.* Art. 240.
176 *Id*. Art. 56, Art. 206. *See also id*. Art. 205 (specifying requirements for the publication of assessment reports).
177 *Id*. Art. 194(5).
178 Straddling Fish Stocks Agreement, *supra* note 156, Art. 5(f)-(g).
179 UNCLOS, *supra* note 58, Art. 194(1); Straddling Fish Stocks Agreement, *supra* note 156, Art. 5(f).

> the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, 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 the sea water and reduction of amenities.[180]

UNCLOS requires countries to "take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as to not cause damage by pollution."[181] Ocean fertilization could be a source of pollution, for example, if it leads to macronutrient diversion from other parts of the ocean. This could result in a reduction in biological production in areas outside of ocean fertilization sites that could harm marine species and associated marine activities (e.g., fishing).[182] Where this occurs, UNCLOS would require the country with jurisdiction over the ocean fertilization project to:

- take all necessary measures to minimize the adverse impacts of the project and ensure that it does not cause damage to other states or their environments;[183]
- notify affected countries and competent international authorities of any imminent or actual damage from the project;[184] and
- study the risks and effects of the project and publish the results of that study.[185]

According to UNCLOS, countries that fail to fulfil the above requirements "shall be liable in accordance with international law."[186] The 2001 United Nations Resolution on the Responsibility of States for Internationally Wrongful Acts sets out the legal consequences for countries that engage in "internationally wrongful acts." According to Article 2 of the Resolution, a country commits an "internationally wrongful act" where it engages in "conduct consisting of an action or omission" that is "attributable to the [country] under international law" and "[c]onstitutes a breach of an international obligation" of the country.[187] Articles 12 and 13 of the Resolution further clarify that a country breaches an international obligation when it acts in a way that "is not in conformity with what is required of it" under an international obligation by which it is bound.[188] Under Article 30 of the Resolution, where such a breach occurs , the country must cease the offending conduct and "offer appropriate

180 UNCLOS, *supra* note 58, Art. 1(1)(4).
181 *Id*. Art. 194(2).
182 2022 NASEM Report, *supra* note 13, at 86-87.
183 UNCLOS, *supra* note 58, Art. 194, 196, 202-209, & 211-212.
184 *Id*. Art. 198. In an Advisory Opinion on seabed mining, the International Tribunal for the Law of the Sea noted that states have an obligation to conduct environmental impact assessments during consultations and notifications before a project is undertaken. *Responsibilities and obligations of States with respect to activities in the Area*, Advisory Opinion 1, 10, 51 (February 1, 2011). Similar reasoning may be applied to require ocean CDR projects to conduct environmental impact assessments during consultation and notification.
185 UNCLOS, *supra* note 58, Art. 204-206.
186 *Id*. Art 235(1).
187 Resolution Adopted by the United Nations General Assembly, Responsibility of States for Internationally Wrongful Acts, A/RES/56/83 (Jan. 28, 2002) Art. 2.
188 *Id*. Art. 12-13.

assurances and guarantees of non-repetition."[189] The country must also make "full reparation" for any injuries[190] caused by its conduct through restitution (i.e., action to re-establish the status quo ante), compensation (i.e., payments to cover any "financially assessable damage"), or satisfaction (i.e., "an acknowledgement of the breach, an expression of regret, a formal apology," or similar statement).[191]

4.1.4 International Agreements Governing Shipping

Ocean fertilization projects will often necessitate the transportation of materials via ship. For example, ships would likely be used to transport iron and other nutrients from shore to the site where they will be discharged. Such activities could be subject to a number of international agreements governing the transportation of materials via ship.

One potentially relevant international agreement is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal ("Basel Convention").[192] The Basel Convention was adopted in March 1989 and entered into force in May 1992. It regulates the import and export of certain waste materials that have been classified as hazardous. The Basel Convention defines "waste" to mean "substances or objects which are disposed of or are intended to be disposed of"[193] and includes, in Annex IV, a list of activities that constitute "disposal."[194] The list in Annex IV includes, as a form of disposal, "[r]elease into seas/oceans."[195] Ocean fertilization is unlikely to be viewed as a form of disposal, as the material is being applied for a useful purpose (fertilization) and not merely for the purpose of getting rid of the nutrients. Even if it were the case that ocean fertilization activities were viewed as a form of disposal, the Basel Convention is unlikely to apply to the import / export of materials for ocean fertilization for two reasons:

1. The Basel Convention only applies to materials that constitute "hazardous waste," defined as waste that has been designated as such in Annex I to the Convention or in domestic legislation enacted by the country of export, import, or transit.[196] The materials proposed for use in ocean fertilization are not listed as hazardous in Annex I to the Convention. A review would need to be conducted to determine if any other country has classified the materials as hazardous in its domestic legislation but, given their nature, that appears unlikely.

2. The Basel Convention does not apply to materials "the discharge of which is covered by another international agreement."[197] As discussed in Part 4.1.1 above, the London

189 *Id*. Art. 30.
190 The resolution defines "injury" to "include any damage, whether material or moral, caused by [a country's] internationally wrongful act." *See id*. Art. 31(2).
191 *Id*. Art. 31 & 34. *See also id*. Art. 35 (defining "restitution"), Art. 36 (defining "compensation"), & Art. 37 (defining "satisfaction").
192 Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal, Mar. 22, 1989.
193 *Id*. Art. 2(1).
194 *Id*. Art. 2(4) & Annex IV.
195 *Id*. Annex IV(A).
196 *Id*. Art. 1(1).
197 *Id*. Art. 1(4).

Convention and London Protocol are likely to apply to the discharge of materials for ocean fertilization, removing it from the scope of the Basel Convention.

Another agreement governing shipping is the International Convention for the Prevention of Pollution from Ships ("MARPOL"), which was adopted in November 1973 and entered into force in October 1983. MARPOL aims to prevent marine pollution due to operational or accidental releases from ships carrying harmful substances.[198] MARPOL includes six technical annexes, each dealing with a different source of marine pollution. Among other things, the annexes prohibit ships from discharging certain materials into ocean waters. For example, under Annex II, ships are prohibited from discharge noxious liquid substances into the ocean. While ocean fertilization does involve the discharge of materials into ocean waters, the materials to be discharged are not regulated under any of the MARPOL annexes. MARPOL would not, therefore, apply to ocean fertilization projects.

4.1.5 Other International Agreements

Other international agreements, some of which have potential relevance to ocean fertilization research and commercial-scale operations, include:

- ***The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*** ("ENMOD"): ENMOD was adopted in December 1976 and entered into force in October 1978.[199] At the time of writing, there were 78 parties to ENMOD, each of which had agreed "not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects."[200] ENMOD defines "environmental modification techniques" as those intended to change, "through the deliberate manipulation of natural processes, the dynamics, composition or structure of the Earth."[201] This definition could include ocean fertilization, which involves manipulating natural processes for sequestering carbon dioxide in the oceans, and thereby changes the composition of both the ocean and the atmosphere. However, ENMOD would not apply to ocean fertilization projects undertaken for peaceful purposes, including to mitigate climate change. The U.S. is a party to ENMOD.

- ***The Convention Concerning the Protection of World Cultural and Natural Heritage*** ("World Heritage Convention"): The World Heritage Convention was adopted in November 1972 and entered into force in December 1975. The 194 parties to the World Heritage Convention must identify important cultural and natural heritage sites within

198 International Convention for the Prevention of Pollution from Ships, Nov. 2, 1973.
199 United Nations, *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*, Status of Treaties, https://perma.cc/YH6D-N23T (last updated Mar. 28, 2022).
200 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, May 18, 1977, Art. I.
201 *Id*. Art. II.

their territory and "do all [they] can" to protect and conserve those sites.[202] This could have implications for the approval and conduct of ocean fertilization projects in the vicinity of, or that could otherwise affect, cultural or natural heritage sites. The U.S. is a party to the World Heritage Convention.

- ***The Convention on the Conservation of Migratory Species of Wild Animals*** ("Convention on Migratory Species"): The Convention on Migratory Species was adopted in June 1979 and entered into force in November 1983.[203] At the time of writing, there were 131 parties to the Convention on Migratory Species, each of which had agreed to "endeavour [sic] to provide immediate protection for migratory species" that are endangered and "conclude agreements covering the conservation and management of migratory species" that have an unfavorable conservation status or a conservation status that would benefit from international cooperation.[204] The parties have adopted a number of resolutions, decisions, and concerted actions aimed at coordinating international action to protect migratory marine species.[205] Marine species covered by these provisions include marine mammals and fish,[206] so ocean fertilization project developers would need to ensure their activities do not threaten those species' habitat. The U.S. is not a party to the Convention on Migratory Species.

- ***The Convention on International Trade in Endangered Species of Wild Fauna and Flora*** ("CITES"): CITES was adopted in 1973 and entered into force in 1975.[207] At the time of writing, there were 184 parties to CITES.[208] CITES aims to protect species threatened with extinction through parties agreeing that "[t]rade in specimens of these species must be subject to particularly strict regulation."[209] Although CITES is aimed at trade, legal bodies may cite to the treaty in determining which species are threatened and to inform habitat protection obligations.[210] The U.S. is a party to CITES.

- ***The Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters*** ("Aarhus Convention"): The Aarhus Convention was adopted in June 1998 and entered into force in October 2001.[211] The

202 Convention Concerning the Protection of World Cultural and Natural Heritage, 1037 U.N.T.S. 151, Nov. 16, 1972, Art. 4. The World Heritage Convention lists 50 marine protected areas across 37 countries. A map of the protected marine areas is available online. UNESCO World Heritage Convention, *World Heritage List*, https://perma.cc/A6HE-G8E6 (last visited June 27, 2022).

203 Convention on the Conservation of Migratory Species of Wild Animals, *CMS Anniversary Timeline*, https://perma.cc/8MYV-57DX (last visited Mar. 28, 2022).

204 Convention on the Conservation of Migratory Species of Wild Animals, June 23, 1979, Art. 2.

205 UN Environment Programme, Convention on the Conservation of Migratory Species of Wild Animals, Progress Report on Relevant Activities Undertaken within the Framework of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) for the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea (Undated), https://perma.cc/JVF7-ZLL4.

206 Convention on the Conservation of Migratory Species of Wild Animals, June 23, 1979, Appendices I and II.

207 What is CITES? https://cites.org/eng/disc/what.php (last visited Jan. 18, 2022).

208 *Id*.

209 Convention on International Trade in Endangered Species of Wild Fauna and Flora, March 3, 1.

210 *See*, *e.g.*, The South China Sea Arbitration (The Republic of Philippines v. The People's Republic of China), PCA Case No. 2013-19, para. 956.

211 United Nations Economic Commission for Europe, *About the Convention*, Aarhus Convention, https://perma.cc/R9HN-WAAM (last visited Oct. 27, 2021).

forty-seven European and Asian parties[212] to the Convention agree to "guarantee . . . rights of access to information, public participation in decision-making, and access to justice in environmental matters."[213] To that end, the parties must ensure that the public is informed of, and consulted about, proposed activities that "may have a significant effect on the environment."[214] Whether a particular ocean fertilization project may have significant environment effects would need to be determined on a case-by-case basis. If the State is a party to the Aarhus Convention, the government entity approving any environmentally-significant project would need to comply with various procedural obligations set out in the Aarhus Convention, including (among other things):

- The government entity must take steps to "encourage" the project proponent "to identify the public concerned, to enter into discussions, and to provide information" about the project before applying for approval.[215]
- The government entity must publish information and allow members of the public to submit "comments, information, analyses, or other opinions" about the project.[216] Any submissions must be given due consideration by the government entity[217] and requests for information must be responded to within one month of submission.[218] The U.S. is not a party to the Aarhus Convention.

- ***The Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean*** ("Escazú Agreement"): The Escazú Agreement was adopted in March 2018 and entered into force in April 2021. There were 24 signatories and 12 ratifying parties to the Escazú Agreement at the time of writing.[219] Similar to the Aarhus Convention, the Escazú Agreement commits its parties to ensuring the rights of access to environmental information, public participation in the environmental decision-making process, and access to justice in environmental matters.[220] The U.S. is not a party to the Escazú Agreement.
- ***The Antarctic Treaty***: Adopted in December 1959, the Antarctic Treaty entered into force in June 1961, and had fifty-four parties at the time of writing.[221] The Antarctic Treaty provides for "[f]reedom of scientific investigation in Antarctica," defined as

212 United Nations Economic Commission for Europe, *Map of Parties*, Aarhus Convention, https://perma.cc/AP3D-7QKK (last visited Oct. 27, 2021).
213 Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 2161 U.N.T.S. 447, June 25, 1998, Art. 3.
214 *Id*. Art. 6.
215 *Id*. Art. 6(5).
216 *Id*. Art. 6(2) & (6)-(7).
217 *Id*. Art. 6(8).
218 *Id*. Art. 4.
219 Observatory on Principle 10 in Latin America and the Caribbean, *Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean*, https://perma.cc/4HTY-PDYL (last visited Mar. 28, 2022).
220 Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean, April 3, 2018, Art. 1.
221 Secretariat of the Antarctic Treaty, *The Antarctic Treaty*, https://perma.cc/Q4HF-ZL8K (last visited Oct. 27, 2021).

the "area south of 60° South Latitude."[222] The parties to the Antarctic Treaty have agreed to cooperate on scientific research and, to that end, exchange "information regarding plans for scientific programs in Antarctica" and "scientific observations and results from Antarctica" to the "greatest extent feasible and practicable" (among other things).[223] Additional requirements are imposed by the Protocol on Environmental Protection to the Antarctic Treaty, which was adopted in October 1991 and entered into force in January 1998.[224] The protocol requires parties to undertake an environmental review of proposed research projects to evaluate "their possible impacts on the Antarctic environment and dependent and associated ecosystems and on the value of Antarctica for the conduct of scientific research."[225] Projects must be planned and conducted so as to "limit adverse impacts on the Antarctic environment and dependent and associated ecosystems" and avoid:

i. adverse effects on climate or weather patterns;

ii. significant adverse effects on air or water quality;

iii. significant changes in the atmospheric, terrestrial . . . , glacial or marine environments;

iv. detrimental changes in the distribution, abundance or productivity or species or populations of species of fauna and flora;

v. further jeopardy to endangered or threatened species or populations of such species; or

vi. degradation of, or substantial risk to, areas of biological, scientific, historic, aesthetic or wilderness significance."[226]

These requirements would apply to ocean fertilization research projects conducted by a party in the Antarctic region. The U.S. is a party to the Antarctic Treaty.

4.2 Relevant Principles of Customary International Law

Ocean fertilization research and deployment could implicate the so-called "no harm" rule of customary international law. As articulated in the 1992 Declaration of the United Nations Conference on the Environment and Development, the no harm rule requires each country "to ensure that activities within their jurisdiction or control do not cause damage to the

222 Antarctic Treaty, 402 U.N.T.S. 71, Art. II & VI.
223 *Id.* Art. II & III.
224 Secretariat of the Antarctic Treaty, *The Protocol on Environmental Protection to the Antarctic Treaty*, https://perma.cc/65AW-JQF9 (last visited Oct. 27, 2021).
225 Protocol on Environmental Protection to the Antarctic Treaty, Art. 3(2)(c) & 8.
226 *Id.*, Art. 3(2)(a)-(b).

environment of other [countries] or of areas beyond the limits of national jurisdiction."[227] The International Tribunal for the Law of the Sea described the rule as imposing an obligation of "due diligence" on countries to "exercise best possible efforts" or "do the utmost" to avoid or minimize transboundary environmental damage.[228] What constitutes best efforts will depend on the circumstances.[229] At a minimum, however, countries must closely oversee activities that could cause transboundary environmental damage (e.g., by adopting and strictly enforcing relevant domestic laws).[230] In this regard, the International Court of Justice ("ICJ") has stated that the due diligence obligation "entails not only the adoption of appropriate rules and measures, but also a certain level of vigilance in their enforcement and the exercise of administrative control applicable to public and private operators, such as the monitoring of activities undertaken by such operators."[231] Thus, to fulfil their obligation under the no harm rule, countries should ensure they have adequate domestic laws and take other measures to prevent any adverse environmental impacts from ocean fertilization projects.

The ICJ has also recognized that countries have a procedural obligation, under customary international law, to "undertake an environmental impact assessment where there is a risk that [a] proposed . . . activity may" cause "significant" transboundary environmental damage.[232] There is no agreed upon definition of what constitutes "significant" damage. However, the International Law Commission has interpreted the term as requiring damage that is more than merely "detectable," but not necessarily "serious" or "substantial."[233]

Prior to undertaking or authorizing a project that has the potential to cause transboundary environmental damage, the responsible country must conduct a preliminary assessment to determine whether there is a risk of significant damage.[234] If the country finds that a project poses a risk of significant damage, it must undertake a more comprehensive environmental impact assessment. Under international law, the country must complete the assessment prior to the commencement of the project, but otherwise has broad discretion in conducting the assessment.[235] In this regard, the ICJ has observed that international law does not "specify the scope and content of an environmental impact assessment" and thus "it is for each

227 Declaration of the United Nations Conference on Environment and Development, Principle 2, UN Doc A/CONF.151/26/Rev. 1, June 3-14, 1992. The no harm rule was first articulated by an arbitral tribunal in the so-called "Trail Smelter" dispute between the United and Canada. *See* Trail Smelter (United States v. Canada), Awards, 3 Reports of Intl. Arbitral Awards 1905 (1938 & 1941). The rule was subsequently recognized by the International Court of Justice. *See* Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, ICJ Rep 226 (July 1996); Case Concerning Pull Mills on the River Uruguay (Argentina v. Uruguay), Judgement, I.C.J. Rep. 2010, 14 (Apr. 2010) [hereinafter "Pulp Mills Case"].

228 Responsibilities and Obligations of States Sponsoring Persons and Entities with respect to Activities in the Area, Advisory Opinion, Int'l Tribunal for the Law of the Sea, Case No. 17, 110 (Feb. 2011).

229 *Id*. at 117 (noting that "due diligence is a variable concept. It may change over time as measures considered sufficiently diligent at a certain moment may become not diligent enough in light, for instance of new scientific or technical knowledge. It may also change in relation to the risks involved in the activity").

230 *Id*. at 111 – 116. *See also* Pulp Mills Case, *supra* note 227, at 187 & 197.

231 *Id*. at 197.

232 *Id.* at 204.

233 International Law Commission, Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, with Commentaries 152 (2001), https://perma.cc/7BB3-B4MM.

234 Certain Activities Carried out by Nicaragua in the Border Area (Costa Rica v. Nicaragua), Judgement, ICJ Rep. 2015, 665 at 706-707 (Dec. 2015) [hereinafter "Certain Activities Case"].

235 Pulp Mills Case, *supra* note 227, at 205.

[country] to determine in its domestic legislation or in the authorization for the project, the specific content of the environmental impact assessment required in each case."[236] The U.S. and many other countries do, however, have domestic laws governing the conduct of environmental impact assessments. Many countries' laws require consultation with potentially affected parties and the general public during the environmental impact assessment. Where the environmental impact assessment confirms that a project could cause significant transboundary environmental harm, the relevant country must notify and consult with other potentially affected countries and relevant international organizations.[237]

236 *Id*.
237 Certain Activities Case, *supra* note 234, at 707.

5. U.S. LAWS GOVERNING OCEAN FERTILIZATION

The U.S. has jurisdiction over offshore areas extending 200 n.m. from its coast and further in some circumstances.[238] Under international law, the U.S. has full "sovereign rights" within that area, including rights to explore, exploit, conserve, and manage natural resources.[239] The U.S. is also responsible for protecting and preserving the marine environment and must oversee marine scientific research within its jurisdictional areas.[240] There is no comprehensive domestic legal framework specific to ocean fertilization in the U.S. There are, however, a number of general environmental and other domestic laws that could have implications for ocean fertilization projects undertaken in U.S. waters. This Part discusses key U.S. federal and state laws that could apply to ocean fertilization in areas under U.S. jurisdiction.

5.1 Discharging Materials into U.S. Waters

5.1.1 Application of the Marine Protection, Research, and Sanctuaries Act

Ocean fertilization projects may, depending on exactly where they occur, be regulated under the Marine Protection, Research, and Sanctuaries Act ("MPRSA").[241] Adopted to implement the U.S.' obligations under the London Convention, the MPRSA regulates "the dumping of all types of materials into ocean waters" within twelve nautical miles of the U.S. coast and further in some circumstances.[242] The MPRSA defines "dumping" broadly to include any "disposition of material."[243] The term "material" is also defined broadly to mean "matter of any kind of description."[244] Applying those definitions, the iron and other nutrients used for ocean fertilization would constitute "material," and their discharge into ocean waters would constitute "dumping" for the purposes of the MPRSA.

In general, and with some exceptions, the MPRSA prohibits the dumping of materials into ocean waters without a permit from the Environmental Protection Agency ("EPA"). Permits are required where:

238 *See supra* Part 3.1.
239 UNCLOS, *supra* note 58, Art. 56(1)(a).
240 *Id.* Art. 56(1)(b).
241 33 U.S.C. § 1401.
242 *Id.* § 1401(b).
243 *Id.* § 1402(f). There are several exceptions to the definition for: (1) "a disposition of any effluent from any outfall structure to the extent that such disposition is regulated under the provisions of the Federal Water Pollution Control Act . . . or under the provisions of the Atomic Energy Act of 1954;" (2) "a routine discharge of effluent incidental to the propulsion of, or operation of motor-driven equipment on, vessel;" (3) "the construction of any fixed structure or artificial island []or the intentional placement of any device in ocean waters or on or in the submerged lands beneath such waters, for a purpose other than disposal, when such construction or such placement is otherwise regulated by Federal or State law or occurs pursuant to an authorized Federal or State program." None of those exceptions will apply to the discharge of materials for enhanced weathering.
244 *Id.* § 1402(c).

- the materials to be dumped are transported from within the U.S. (regardless of where the dumping occurs);[245] or
- the materials are transported from outside the U.S. and:
  - transportation occurs on a vessel registered in the U.S. (regardless of where the dumping occurs); or
  - the dumping occurs within twelve nautical miles of the U.S. coast (regardless of how the materials are transported).[246]

Thus, under the MPRSA, a permit is not required for discharges occurring more than twelve nautical miles from the U.S. coast unless the discharge comes from a U.S. vessel or a foreign vessel that was loaded in the U.S. A discussion in the legislative history of the MPRSA suggests that Congress didn't think it had jurisdiction over discharges more than twelve nautical miles from shore by foreign vessels loaded in other countries.[247] In the discussions around the passage of the bill, one senator noted that "the United States has no authority to control the act of dumping" in areas more than twelve nautical miles from shore "except as to its own citizens or U.S.-flag vessels, and only to a limited extent by foreigners."[248]

EPA can only issue permits under the MPRSA if satisfied that the dumping of materials into ocean waters "will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities."[249] EPA regulations provide for the issuance of several different types of permits, including:

- research permits, which are available where dumping occurs as part of a "research project," where EPA determines that "the scientific merit of a proposed project outweighs the potential environmental or other damage that may result from dumping;"[250]
- general permits, which may be issued for the dumping of materials that "will have minimal adverse environmental impact and are generally disposed of in small quantities;"[251] and
- special permits, which may be issued for the dumping of other materials that meet specified criteria established by EPA.[252] The criteria relate to the effects of dumping on the environment and other ocean users and the available alternatives to dumping.[253]

245 *Id.* § 1411(a)(1) (prohibiting any person transporting material from the U.S. for the purpose of dumping it into ocean waters). See also id. § 1402(b) (defining "ocean waters" to mean "those waters of the open seas lying seaward of the baseline from which the territorial sea is measured").
246 *Id.* § 1411(a)(2) & (b).
247 117 Cong. Rec. 38,852 (1971).
248 *Id.*
249 33 U.S.C. § 1412(a).
250 40 C.F.R. § 220.3(e).
251 *Id.* § 220.3(a).
252 *Id.* § 220.3(b).
253 *Id.* Pt. 227.

Dumping can only occur at sites designated by EPA. The designated sites must be chosen so as to mitigate any adverse impacts of dumping on the environment "to the greatest extent practicable."[254] Where EPA decides to authorize dumping through a research or general permit, it may specify the designated site for dumping in the permit itself.[255] In contrast, where dumping is authorized through a special permit, a separate site designation is required.[256] When doing a separate designation, EPA must select sites that will "minimize the interference of disposal activities with other activities in the marine environment, particularly avoiding areas of existing fisheries or shellfish, and regions of heavy commercial or recreational navigation."[257] In selecting sites, EPA must consider:

> (1) Geographical position, depth of water, bottom topography and distance from coast;
>
> (2) Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases;
>
> (3) Location in relation to beaches and other amenity areas;
>
> (4) Types and quantities of wastes proposed to be disposed of, and proposed methods of release, including methods of packing the waste, if any;
>
> (5) Feasibility of surveillance and monitoring;
>
> (6) Dispersal, horizontal transport and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any;
>
> (7) Existence and effects of current and previous discharges and dumping in the area (including cumulative effects);
>
> (8) Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance and other legitimate uses of the ocean;
>
> (9) The existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys;
>
> (10) Potentiality for the development or recruitment of nuisance species in the disposal site;
>
> (11) Existence at or in close proximity to the site of any significant natural or cultural features of historical importance.

Before issuing a site designation, EPA must also complete any necessary environmental and other reviews under the National Environmental Policy Act ("NEPA"), Endangered Species Act

254 33 U.S.C. § 1412(c).
255 *Id.* § 228.4(a) & (d).
256 *Id.* § 228.4(b).
257 40 C.F.R. § 228.5.

("ESA"), the Coastal Zone Management Act ("CZMA"), and other statutes[258]:

- NEPA requires federal agencies to prepare an Environmental Impact Statement ("EIS") for any major federal action they undertake, fund, or authorize that "significantly affect[s] the quality of the human environment."[259] While this requirement has been held not to apply to actions taken under the MPRSA,[260] EPA voluntarily conducts a NEPA review when designating dump sites.[261] EPA would need to undertake a case-by-case assessment to determine whether designating a particular dump site is likely to significantly affect the quality of the human environment and thus requires preparation of an EIS.[262] In making that determination, EPA may consider factors such as the size and nature of the area, the materials that will be dumped there, and any risks to fish, wildlife, or other parts of the marine environment. Any required EIS would need to assess the natural, economic, social, and cultural resource effects of the installation, and EPA would be required to release relevant documents to the public and consider their input.[263]

- Section 7 of the ESA requires federal agencies to consult with the National Marine Fisheries Service about any activity that could affect endangered or threatened marine species or their habitat.[264]

- Section 305 of the Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to consult with the National Marine Fisheries Service before conducting, authorizing, or funding any action that may adversely affect waters designated as "essential fish habitat."[265]

- Section 307 of the Coastal Zone Management Act requires federal agencies to ensure that any actions affecting land or water use or natural resources within the boundaries of a coastal state (i.e., typically three nautical miles from shore) are performed in a manner consistent with any applicable state coastal management plan to the maximum extent practicable.[266] The federal agency must provide the state with a "consistency determination," which describes the action and its expected effects, and explains how it

258 33 C.F.R. §§ 64.21, 64.23, & 66.01-5. *See also* U.S. Coast Guard, Aids to Navigation Manual Administration (2005), https://perma.cc/5USF-EHGP.

259 42 U.S.C. § 4321 et seq., 4332(2)(C).

260 Maryland v. Train, 415 F. Supp. 116 (D. Md. 1976) (holding that EPA is not required to prepare an EIS for actions taken under the MPRSA because, "[w]here federal regulatory action is circumscribed by extensive procedures, including public participation, for evaluating environmental issues and is taken by an agency with recognized environmental expertise, formal adherence to the NEPA requirements is not required unless Congress has specifically so directed").

261 *See* Policy and Procedures for Voluntary Preparation of National Environmental Policy Act (NEPA) Documents, 63 Fed. Reg. 58045, 58046 (Oct. 29, 1998).

262 *Id.* at 58046 (noting that EPA will make "decisions on preparing EISs for proposed ocean disposal sites . . . on a case-by-case basis").

263 42 U.S.C. 4332(2)(C).

264 16 U.S.C. § 1563(a)(1). A species is considered "endangered" if it "is in danger of extinction throughout all or a significant portion of its range." *See id.* § 1532(6). A species is "threatened" if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." *See id.*

265 *Id.* § 1855(b)(2).

266 16 U.S.C. § 1456(c).

is consistent with the state coastal management plan.[267] If the state objects, the federal agency must work with it to address the objection.[268]

5.1.2 Application of Other Federal Laws

There is some uncertainty over whether the Clean Water Act ("CWA") would apply to discharges associated with ocean fertilization, but research suggests that the MPRSA would preempt application of the CWA in ocean waters. CWA Section 403 authorizes EPA to permit "a discharge into the territorial sea, the waters of the contiguous zone, or the oceans."[269] However, MPRSA Section 106 states that "all licenses, permits, and authorizations other than those issued pursuant to this subchapter shall be void and of no legal effect, to the extent that they purport to authorize any activity regulated by this subchapter, and whether issued before or after the effective date of this subchapter."[270] This would appear to preempt any ocean fertilization discharge permits issued under the CWA, given that the MPRSA appears to regulate ocean fertilization activities. In terms of enforcement, a Congressional Research Service Report describes the delineation between the MPRSA and the CWA as follows: "The [MPRSA] preempts the CWA in coastal waters or open oceans, and the CWA controls in estuaries."[271]

The MPRSA likely also preempts the application of permitting for dumping in marine sanctuaries under the National Marine Sanctuaries Act ("NMSA"), given the broad preemption language in the MPRSA. Prohibitions on dumping in marine sanctuaries, however, would not be preempted. The NMSA gives the Secretary of Commerce the authority to issue regulations providing for the "comprehensive and coordinated conservation and management" of marine sanctuaries.[272] If such regulations for a particular sanctuary prohibited dumping, EPA would be prohibited from issuing an MPRSA permit to dump in that sanctuary. Further, even if EPA could permit dumping in a marine sanctuary, it would be required to consult with NOAA about any fertilization activity "likely to destroy, cause the loss of, or injure any sanctuary resource."[273]

5.1.3 Application of State Laws

A review of potentially applicable state laws suggests that none would apply to ocean fertilization projects. Several states have specific laws prohibiting the unauthorized discharge of oil into state waters, but these do not apply to the materials used in ocean fertilization – i.e. iron, nitrogen, or phosphorous. A few states prohibit the pollution of state waters, including ocean areas, but the implementation of these laws involves permitting under the CWA. As

267 *Id.* § 1456(c)(1)(C); 15 C.F.R. § 930.39.
268 40 C.F.R. § 930.34.
269 33 U.S.C. § 1343(a).
270 *Id.* § 1416(a); Rosado v. Wheeler, 473 F. Supp. 3d 115, 122 (E.D.N.Y. 2020) ("The MPRSA generally applies to ocean waters beyond U.S. territory, and in this regard, complements the Clean Water Act, which prohibits the discharge of pollutants into the navigable waters of the United States.").
271 Claudia Copeland, Cong. Research Serv., RS20028, Ocean Dumping Act: A Summary of the Law (2016), https://perma.cc/6XDG-LUAP.
272 16 U.S.C. § 1431(b)(2).
273 *Id.* § 1434(d)(1)(A).

explained above, the MPRSA likely preempts the CWA for ocean fertilization projects. For instance, Connecticut General Statute § 22a-427 states that "[n]o person or municipality shall cause pollution of any of the waters of the state or maintain a discharge of any treated or untreated wastes in violation of any provision of this chapter."[274] The law includes a framework through which the state can permit discharges, but the framework involves the state's implementation of permitting under the CWA. The law states that "[t]he commissioner shall not issue or renew a permit unless such issuance or renewal is consistent with the provisions of the federal Clean Water Act."[275] Given the MPRSA's likely preemption of the CWA for ocean fertilization, these permits are unlikely to be applicable. Further, since the language of the MPRSA purports to preempt "all licenses, permits, and authorizations" other than those issued under the MPRSA, any state permitting regime of ocean fertilization is likely preempted. This language does not, on its face, preempt state authority to prohibit ocean fertilization altogether. Delaware prohibits "all disposal of solid wastes into the ocean waters of the State."[276] However, this is unlikely to apply to ocean fertilization projects, as the state statute defines "solid waste" as "discarded material."[277] Materials for use in ocean fertilization are not being discarded (i.e. gotten rid of), but rather discharged for the purpose of fertilization.

5.2 Sourcing Materials for Use in Ocean Fertilization

Obtaining iron, nitrogen, and phosphate for use in ocean fertilization may require the construction of new, or expansion of existing, mines in the U.S. and/or overseas. This could have a range of negative environmental and other effects.[278] For example, mine construction typically requires land-clearing, and mine operation often leads to air, soil, and water pollution and associated public health problems. The processing of mined materials could have further environmental and public health impacts.

This section provides an overview of the key environmental laws governing mining and processing activities in the U.S. Generally speaking, before any such activities can occur, the miner must obtain rights to the relevant minerals.[279] Where the minerals are privately owned, the miner may contract with the owner for their purchase or lease. The procedure for obtaining rights to minerals under federal and state ownership is more complex.

5.2.1 Requirements for Mining on Federal and State Land

The U.S. federal government owns approximately 700 million acres of subsurface mineral

274 Conn. Gen. Stat. § 22a-427.
275 *Id.* § 22a-430.
276 Del. Code Ann. tit. 7, § 6073.
277 *Id.* § 6002. Under the statute "'Solid waste' means any garbage, refuse, refuse-derived fuel, demolition and construction waste wood, sludge from a waste treatment plant, water supply treatment plant or air pollution control facility and other discarded material, including solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial, mining and agricultural operations . . ." *Id.*
278 For a discussion of possible effects in mining processes for enhanced weathering, *see* Romany M. Webb, The Law of Enhanced Weathering for Carbon Dioxide Removal 10-11 (2020), https://perma.cc/64XP-QTZ3; Romany M. Webb, The Law of Enhanced Weathering for Carbon Dioxide Removal: Volume 2 – Legal Issues Associated with Materials Sourcing 4-5 (2021), https://perma.cc/N332-BYS6.
279 *See generally*, *Id.*

resources.[280] While some of those resources are found on so-called "split estate" lands, where the surface is under private or state government ownership, most underlie federally-owned land.[281] Mining is prohibited on certain federal land, including in national parks and monuments, wilderness areas, and some wildlife refuges, as well as on land that has been set aside for military reservations.[282] It is, however, generally permissible on other federal land.

The Department of the Interior's Bureau of Land Management ("BLM") oversees most mining on federal lands. The mining of iron and phosphate on federal lands are governed by two key statutes:

- the General Mining Law of 1872, which governs the mining of most hardrock minerals, including iron ore;[283] and
- the Mineral Leasing Act of 1920, which governs the mining of "coal, phosphate, sodium, potassium, oil, oil shale, gilsonite . . . [and] gas."[284]

The General Mining Law confers broad rights on U.S. citizens and certain others ("eligible miners") to explore for and extract "valuable mineral deposits in lands belonging to the United States."[285] Under the General Mining Law, eligible miners can acquire rights to minerals on federal land through a process known as "location," which is based on historic claim-staking practices.[286] Briefly, location enables a miner to claim a parcel of land which has been found to contain valuable mineral deposits by marking the boundaries of the claimed area, posting a location notice on the area, and recording that notice with BLM and other relevant agencies.[287] At the time of filing the notice, the miner must pay a location fee ($40 at the time of writing) and maintenance fee ($165 at the time of writing) to BLM.[288] Additional maintenance fees must be paid annually thereafter.[289] The miner is not, however, required to pay any rents or other fees in connection with its occupancy of the claimed land or royalties on the minerals extracted from that land.

On location, the miner acquires an unpatented claim to the land and minerals, which gives him/her exclusive rights to mine the site.[290] However, before engaging in mining activities, the

280 Bureau of Land Mgmt., *What We Manage*, About, https://perma.cc/85KT-ARDP (last visited Jan. 8, 2021).
281 Approximately 60 million acres of federally-owned minerals are located on so-called "split estate" lands, where the surface is not owned by the federal government, but rather under state government or private ownership. *See generally* Bureau of Land Mgmt., Split Estate: Rights, Responsibilities, and Opportunities (2007), https://perma.cc/D3PX-37FZ.
282 Bureau of Land Mgmt., *Locating a Mining Claim*, Mining Claims, https://perma.cc/CQH6-7VBS (last visited Jan. 8, 2021).
283 30 U.S.C. § 22.
284 *Id.* § 181.
285 *Id*. § 22.
286 Bureau of Land Mgmt., Mining Claims and Sites on Federal Lands (2011), https://perma.cc/8P9U-U489.
287 43 C.F.R. §§ 3832.1 - 3821.12.
288 30 U.S.C. § 28g; 43 C.F.R. §§ 3830.11(c) & 3830.21.
289 30 U.S.C. § 28f; 43 C.F.R. § 3834.11. BLM can waive the requirement for annual maintenance payments in certain circumstances. *See* 30 U.S.C. § 28f(d); 43 C.F.R. § 3835.1.
290 Historically, individuals holding unpatented claims could apply to BLM to have them patented, at which point the individual would acquire full title to the land. However, since 1994, Congress has prohibited BLM from accepting new patent applications through annual appropriations. *See e.g.,* Further Consolidated Appropriations Act of 2020, Pub. L. 116-94, 113 Stat. 2534, § 404.

miner must generally submit an operating plan to BLM for approval.[291] On receiving the plan, BLM must make it available for public review and comment.[292] BLM must also conduct an environmental review under NEPA and, where activities could harm endangered or threatened species, consult with FWS under the ESA.[293] BLM may approve the plan if it determines that the proposed mining activities will not result in "unnecessary or undue degradation of public lands."[294] Mining activities must be performed in accordance with any approved plan and applicable environmental and other laws (discussed below).

The above system of location could be used to claim iron but not phosphate. Persons wanting to mine phosphate on federal land must obtain a lease from BLM under the Mineral Leasing Act.[295] Prior to issuing leases, BLM must conduct any required environmental reviews and consultations, for example under NEPA and the ESA. Leases are generally issued via competitive auction.[296] The lessee must pay rent of $0.25-$1.00 per acre of land leased per year and royalties equivalent to at 5% of the gross value of the phosphates extracted from the leased land.[297] Before engaging in any mining activities, the lessee must provide BLM with a mining plan, specifying measures that will be put in place to "prevent or control fire, soil erosion, subsidence, pollution of surface and ground water, pollution of air, damage to fish or wildlife or other natural resources and hazards to public health or safety" (among other things).[298] When performing mining activities, the lessee must act in accordance with the plan, and any applicable environmental or other laws.

Most state-owned rock and minerals are also available for purchase or through leases for mineral development on state-owned lands.[299] Each state has its own administrative regime for mineral sales and leasing, but several employ a process similar to that used by BLM. Like BLM, state land management agencies often develop resource management plans, which identify areas in which mineral development is permitted. Within those areas, the state land manager (or another state body) may sell or lease minerals, typically via a competitive auction process.[300]

5.2.2 Environmental Approvals Required for Mining

Regardless of whether they occur on federal, state, or private land, mining and processing operations must comply with any requirements imposed by applicable environment and other

291 Plans are required for mining operations on land administered by BLM that involve more than "casual use" of the land. *See* 43 C.F.R. § 3809.11(a).
292 *Id*. § 3809.411.
293 *Id*.
294 *Id*.
295 30 U.S.C. § 211. See also 43 C.F.R. Pt. 3500.
296 *See generally*, 43 C.F.R. Pt 2500, Subpt. 3508.
297 30 U.S.C. § 212; 43 C.F.R. §§ 3504.15 & 3504.21.
298 43 C.F.R. § 3592.1.
299 *See generally*, Aaron M. Flynn, Cong. Research Serv., RL32813, Hardrock Mining: State Regulation (2005), https://perma.cc/K5P3-52KE.
300 *See e.g.,* Fla. Stat. Ann. § 253.45 (authorizing the sale or lease, by competitive bidding, of minerals and certain other substances "in, on, or under any land the title to which is vested in the state" of Florida); Haw. Rev. Stat. §§ 182-4 & 182-5 (authorizing the auction of minerals on state lands); N.C. Gen. Stat. §§ 14608 & 146-9 (authorizing the sale, lease, or other disposal of "any and all mineral deposits belonging to the State").

laws. For example:[301]

- Mining and processing operations that release rock particles into the air may, depending on the size of the released particles, be regulated as a source of particulate matter pollution under the Clean Air Act ("CAA").[302] Pursuant to the CAA, EPA has established National Ambient Air Quality Standards for two classes of particulate matter—PM2.5 (i.e., inhalable particles of 2.5 microns or less in diameter) and PM10 (i.e., inhalable particles of 10 microns or less in diameter).[303] A permit from EPA or an authorized state or local entity is required to construct or operate any facility that constitutes a "major stationary source" of PM2.5 or PM10.[304] Some states also require permits for other facilities, such as those that emit PM2.5 or PM10 at levels below the major source threshold or emit larger particles (i.e., exceeding 10 microns in diameter).[305] Many states also impose additional requirements, for example, mandating the use of control measures to limit dust from the handling, transport, and storage of mined materials.[306]

- Mining and processing operations that involve the discharge of rock or other materials into waterways may require a permit under the CWA.[307] A permit is required under the CWA to discharge any "pollutant,"[308] with that term defined broadly to include "rock, sand, cellar dirt, and industrial, municipal, and agricultural waste."[309] Discharges occur where a pollutant is added to waters of the U.S. from a "point source," defined as a "discernible, confined and discrete conveyance."[310] Thus, for example, a discharge will be considered to occur and a permit required if waste materials from mining or processing operations are deposited into a waterbody via pipeline or truck. Where the waste is disposed as fill material, which includes mining overburden, tailings, or similar rock-based material, the discharge must be permitted by ACE or an authorized state agency under section 404 of the CWA.[311] This in turn would trigger a CWA section 401 water quality certification requirement from the state or tribe in which the discharge

301 For a more detailed discussion of the environmental approvals required for mining, *see* Romany M. Webb, The Law of Enhanced Weathering for Carbon Dioxide Removal: Volume 2 – Legal Issues Associated with Materials Sourcing 27-38 (2021), https://perma.cc/N332-BYS6.
302 42 U.S.C. § 7401 et seq.
303 National Ambient Air Quality Standards for Particulate Matter, 85 Fed. Reg. 82,684 (Dec. 18, 2020).
304 42 U.S.C. §§ 7475, 7502, 7503. The size threshold for "major" stationary sources varies depending on local air quality (among other things).
305 *See e.g.,* Fla. Admin. Code Ann. r. 62-210.300 (requiring permits for facilities that emits any air pollutant, regardless of amount); 9 Va. Admin. Code § 5-80-1105(C) (requiring permits for facilities emitting more than 25 tons per year of particulate matter of any size).
306 *See e.g.,* 9 Va. Admin. Code § 5-40-90 (requiring "reasonable precautions" to be taken to prevent dust from storage piles becoming airborne).
307 33 U.S.C. § 1251 et seq.
308 *Id.* §§ 1311, 1342, & 1344.
309 *Id.* § 1362(6).
310 *Id.* §§ 1362(12), (14), & (16).
311 *Id.* § 1344. *See also* 33 C.F.R. § 323.2(e) (defining "fill material" to include "overburden from mining" and other rock that, when placed into waters of the U.S., has the effect of replacing any portion of the water with dry land or changing the bottom elevation).

originates.[312] A section 402 (NPDES) permit from EPA or an authorized state agency is required for the discharge of other materials from a point source.[313]

- Mining wastes that are not discharged into waterways must be handled in accordance with the requirements of the Resource Conservation and Recovery Act ("RCRA").[314] Most mining wastes are regulated as non-hazardous wastes under subtitle D of RCRA.[315] EPA regulations, adopted under subtitle D, impose limited restrictions on where and how non-hazardous wastes can be disposed of.[316] States can adopt, and many have adopted, additional or more stringent requirements, with some mandating that non-hazardous waste only be disposed of at designated facilities or in designated ways.[317]

5.3 Projects Implicating Tribal Rights

Some ocean fertilization projects, particularly those impacting fish or fish habitat, may implicate tribal rights. Native American tribes have secured rights to protect their property and way of life through several treaties with the U.S. government, which have, in turn, been recognized through congressional legislation and judicial decisions. Several treaties secure the rights of Native Americans to fish in historical fishing waters. For instance, the 1855 Treaty of Point Elliott states: "The right of taking fish at usual and accustomed grounds and stations is further secured to said Indians in common with all citizens of the Territory."[318] The geographic scope of the fishing rights is not specified in the treaties, but the Washington Supreme Court recognized that they would extend to areas ceded to the United States by the tribes, and those areas "actually used" and occupied by tribes for an extended period of time.[319] As recognized by the 9th Circuit, tribal rights to take fish create an implied duty on the part of state and federal governments to avoid damage to fish habitat.[320]

Ocean fertilization projects could, in some circumstances, impact the ability of tribes to take fish from historically-recognized ocean fishing areas. Where this is the case and the projects require permits from U.S. federal agencies, those agencies must consult with the

312 33 U.S.C. § 1341(a)(1). Section 401 applies to discharges into U.S. waters (up to 2.6 n.m. from shore). *Id.* The state or tribe where the discharge originates must certify that the activity will meet water quality standards. *Id.*
313 30 U.S.C. § 1342.
314 42 U.S.C. § 6901 et seq.
315 In 1980, Congress enacted the Bevill Amendment to RCRA, which conditionally exempt certain mining and other wastes from regulation as hazardous wastes, pending a review by EPA. *See* Solid Waste Disposal Act Amendments of 1980, Pub. L. 96-482, 94 Stat. 2334 (1980). EPA completed its review of mining wastes in 1985, concluding that most should be treated as non-hazardous. *See* Envtl. Prot. Agency, Report to Congress: Wastes from the Extraction and Benefaction of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale (1985), http://perma.cc/869U-X5MW.
316 40 C.F.R. Pt. 257.
317 *See e.g.,* N.Y. Comp. Code R. & Regs. tit. 6, § 360.9(b) (requiring all waste to be sent to approved facilities and not disposed of on land or in any other manner outside such facilities).
318 Treaty with the Dwamish, Suquamish, etc., (commonly known as Treat of Point Elliot), art. 5, Jan. 22, 1855, 12 Stat. 927.
319 State v. Buchanan, 138 Wash. 2d 186, 207 (1999).
320 *See* Richard Du Bey, Andrew S. Fuller & Emily Miner, *Tribal Treaty Rights and Natural Resource Protection: The Next Chapter United States v. Washington - The Culverts Case*, 7 Am. Indian L. Rev. 54, 55 (2019).

tribes affected prior to issuing permits. Executive Order 13175 states: "Each agency shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications."[321] Policies that have tribal implications are "regulations, legislative comments or proposed legislation, and other policy statements or actions that have substantial direct effects on one or more Indian tribes"[322] Permits granted by federal agencies for ocean fertilization projects that may implicate treaty rights, such as those to take fish in historical fishing areas, may thus require consultation with tribes. NOAA has prepared guidelines for such consultations, which detail the procedures for initiating consultation, responding to requests for consultation, and determining consultation structure.[323]

321 Exec. Order No. 13175, 65 F.R. 67249 § 5(a) (2000).
322 *Id*. § 1(a).
323 NOAA, NOAA Procedures for Government-to-Government Consultation With Federally Recognized Indian Tribes and Alaska Natives (2013).

6. CONCLUSION

CDR will be needed, alongside deep emissions cuts, to meet global temperature goals set in the Paris Agreement. One widely discussed CDR technique is ocean fertilization, which involves the addition of iron, nitrogen, and/or phosphorous to surface ocean waters. The approach aims to enhance the growth of phytoplankton, which uptake carbon dioxide, convert it into organic carbon, and enhance storage of that carbon in the deep sea. More study is needed to understand the effectiveness of the approach, as well as potential environmental risks and co-benefits.

International environmental laws will likely apply to some aspects of ocean fertilization projects. UNCLOS, the CBD, the London Convention, and the London Protocol include provisions aimed at minimizing the impact of research and other activities on the marine environment, which could apply to ocean fertilization activities that bring environmental risks. The parties to the CBD, London Convention, and London Protocol have also issued decisions relevant to ocean fertilization, urging parties to refrain from certain ocean fertilization activities until they are better understood. The decisions represent global understanding of legal thinking of such projects, but they are not legally binding. In general, the international legal framework for ocean fertilization includes several gaps, and no comprehensive framework governs.

In terms of U.S. domestic law, the MPRSA will apply to certain ocean fertilization projects. Covered projects will require a permit from EPA and be subject to environmental review and other requirements. The sourcing of materials for use in ocean fertilization may also require permits and other approvals under various U.S. laws, including the General Mining Law, CAA, and CWA.

APPENDIX A: RATIFICATION OF KEY INTERNATIONAL AGREEMENTS

Country	UNCLOS	CBD	LC	LP
Islamic Republic of **Afghanistan**		X	X	
Republic of **Albania**	X	X		
People's Democratic Republic of **Algeria**	X	X		
Principality of **Andorra**		X		
Republic of **Angola**	X	X		X
Antigua and Barbuda	X	X	X	X
Republic of **Argentina**	X	X	X	
Republic of **Armenia**	X	X		
Commonwealth of **Australia**	X	X	X	X
Republic of **Austria**	X	X		
Republic of **Azerbaijan**	X	X	X	
Commonwealth of the **Bahamas**	X	X		
Kingdom of **Bahrain**	X	X		
People's Republic of **Bangladesh**	X	X		
Barbados	X	X	X	X
Republic of **Belarus**	X	X	X	
Kingdom of **Belgium**	X	X	X	X
Belize	X	X		
Republic of **Benin**	X	X	X	
Kingdom of **Bhutan**		X		
Plurinational State of **Bolivia**	X	X	X	
Bosnia and Herzegovina	X	X		
Republic of **Botswana**	X	X		
Federative Republic of **Brazil**	X	X	X	
Negara **Brunei Darussalam**	X	X		
Republic of **Bulgaria**	X	X	X	X
Burkina Faso	X	X		
Republic of **Burundi**		X		
Republic of **Cabo Verde**	X	X	X	
Kingdom of **Cambodia**		X		
Republic of **Cameroon**	X	X		
Canada	X	X	X	X
Central African Republic		X		
Republic of **Chad**	X	X		
Republic of **Chile**	X	X	X	X
People's Republic of **China**	X	X	X	X

Country	UNCLOS	CBD	LC	LP
Republic of **Colombia**		X		
Union of the **Comoros**	X	X		
Republic of the **Congo**	X	X	X	X
Cook Islands	X	X		
Republic of **Costa Rica**	X	X	X	
Republic of **Cote d'Ivoire**	X	X	X	
Republic of **Croatia**	X	X	X	
Republic of **Cuba**	X	X	X	
Republic of **Cyprus**	X	X	X	
Czech Republic	X	X		
Democratic People's Republic of Korea		X	X	X
Democratic Republic of the Congo	X	X		
Kingdom of **Denmark**	X	X	X	X
Republic of **Djibouti**	X	X		
Commonwealth of **Dominica**	X	X		
Dominican Republic	X	X	X	
Republic of **Ecuador**	X	X		
Arab Republic of **Egypt**	X	X	X	X
Republic of **El Salvador**		X		
Republic of **Equatorial Guinea**	X	X	X	
State of **Eritrea**		X		
Republic of **Estonia**	X	X		X
Kingdom of **Eswatini**	X	X		
Federal Democratic Republic of **Ethiopia**		X		
European Union	**X**	**X**		
Republic of **Fiji**	X	X		
Republic of **Finland**	X	X	X	X
Republic of **France**	X	X	X	X
Gabonese Republic (**Gabon**)	X	X	X	
Islamic Republic of the **Gambia**	X	X		
Georgia	X	X		X
Federal Republic of **Germany**	X	X	X	X
Republic of **Ghana**	X	X		X
Hellenic Republic (**Greece**)	X	X	X	
Grenada	X	X		
Republic of **Guatemala**	X	X	X	X
Republic of **Guinea**	X	X		
Republic of **Guinea-Bissau**	X	X		
Republic of **Guyana**	X	X		X
Republic of **Haiti**	X	X	X	
Republic of **Honduras**	X	X	X	
Hungary	X	X	X	

Country	UNCLOS	CBD	LC	LP
Republic of **Iceland**	X	X	X	X
Republic of **India**	X	X		
Republic of **Indonesia**	X	X		
Islamic Republic of **Iran**		X	X	X
Republic of **Iraq**	X	X		
Ireland	X	X	X	X
State of **Israel**		X		
Republic of **Italy**	X	X	X	X
Jamaica	X	X	X	
Japan	X	X	X	X
Hashemite Kingdom of **Jordan**	X	X	X	
Republic of **Kazakhstan**		X		
Republic of **Kenya**	X	X	X	X
Republic of **Kiribati**	X	X	X	
State of **Kuwait**	X	X		
Kyrgyz Republic (**Kyrgyzstan**)		X		
Lao People's Democratic Republic	X	X		
Republic of **Latvia**	X	X		
Republic of **Lebanon**	X	X		
Kingdom of **Lesotho**	X	X		
Republic of **Liberia**	X	X		
Libya		X	X	
Principality of **Liechtenstein**		X		
Republic of **Lithuania**	X	X		
Grand Duchy of **Luxembourg**	X	X	X	X
The former Yugoslav Republic of **Macedonia**				
Republic of **Madagascar**	X	X		X
Republic of **Malawi**	X	X		
Malaysia	X	X		
Republic of **Maldives**	X	X		
Republic of **Mali**	X	X		
Republic of **Malta**	X	X	X	
Republic of the **Marshall Islands**	X	X		X
Islamic Republic of **Mauritania**	X	X		
Republic of **Mauritius**	X	X		
United Mexican States (**Mexico**)	X	X	X	X
Federated States of **Micronesia**	X	X		
Principality of **Monaco**	X	X	X	
Mongolia	X	X		
Montenegro	X	X	X	
Kingdom of **Morocco**	X	X	X	X

Country	UNCLOS	CBD	LC	LP
Republic of **Mozambique**	X	X		
Republic of the Union of **Myanmar**	X	X		
Republic of **Namibia**	X	X		
Republic of **Nauru**	X	X	X	
Federal Democratic Republic of **Nepal**	X	X		
Kingdom of the **Netherlands**	X	X	X	X
New Zealand	X	X	X	X
Republic of **Nicaragua**	X	X		
Republic of the **Niger**	X	X		
Federal Republic of **Nigeria**	X	X	X	X
Niue	X	X		
Republic of **North Macedonia**	X	X		
Kingdom of **Norway**	X	X	X	X
Sultanate of **Oman**	X	X	X	
Islamic Republic of **Pakistan**	X	X	X	
Republic of **Palau**	X	X		
State of **Palestine**	X	X		
Republic of **Panama**	X	X	X	
Independent State of **Papua New Guinea**	X	X	X	
Republic of **Paraguay**	**X**	**X**		
Republic of **Peru**		X	X	X
Republic of the **Philippines**	X	X	X	X
Republic of **Poland**	X	X	X	
Republic of **Portugal**	X	X	X	
State of **Qatar**	X	X		
Republic of Korea	X	X		
Republic of Moldova	X	X		
Romania	X	X		
Russian Federation	X	X	X	
Republic of **Rwanda**		X		
Saint Kitts and Nevis	X	X		X
Saint Lucia	X	X	X	
Saint Vincent and the Grenadines	X	X	X	
Independent State of **Samoa**	X	X		
Republic of **San Marino**		X		
Democratic Republic of **Sao Tome and Principe**	X	X		
Kingdom of **Saudi Arabia**	X	X		X
Republic of **Senegal**	X	X		
Republic of **Serbia**	X	X	X	
Republic of **Seychelles**	X	X	X	
Republic of **Sierra Leone**	X	X	X	X

Country	UNCLOS	CBD	LC	LP
Republic of **Singapore**	X	X		
Slovak Republic (**Slovakia**)	X	X		
Republic of **Slovenia**	X	X	X	X
Solomon Islands	X	X	X	
Federal Republic of **Somalia**	X	X		
Republic of **South Africa**	X	X	X	X
Republic of **South Sudan**		X		
Kingdom of **Spain**	X	X	X	X
Democratic Socialist Republic of **Sri Lanka**	X	X		
Republic of the **Sudan**	X	X		
Republic of **Suriname**	X	X	X	X
Kingdom of **Swaziland**				
Kingdom of **Sweden**	X	X	X	X
Swiss Confederation (**Switzerland**)	X	X	X	X
Syrian Arab Republic		X	X	
Republic of **Tajikistan**		X		
Kingdom of **Thailand**	X	X		
Democratic Republic of **Timor-Leste**	X	X		
Republic of **Togo**	X	X		
Kingdom of **Tonga**	X	X	X	X
Republic of **Trinidad and Tobago**	X	X		X
Republic of **Tunisia**	X	X	X	
Republic of **Turkey**		X		
Turkmenistan		X		
Tuvalu	X	X		
Republic of **Uganda**	X	X		
Ukraine	X	X	X	
United Arab Emirates		X	X	
United Kingdom of Great Britain and Northern Ireland	X	X	X	X
United Republic of Tanzania	X	X	X	
United States of America			X	
Oriental Republic of **Uruguay**	X	X		X
Republic of **Uzbekistan**		X		
Republic of **Vanuatu**	X	X	X	X
Bolivarian Republic of **Venezuela**		X		
Socialist Republic of **Viet Nam**	X	X		
Republic of **Yemen**	X	X		X
Republic of **Zambia**	X	X		
Republic of **Zimbabwe**	X	X		

APPENDIX B: PERMITTING AND ENVIRONMENTAL REVIEW REQUIREMENTS

The table below identifies the minimum permitting requirements for key water-based activities likely to be undertaken in connection with ocean fertilization projects in U.S. waters. All ocean fertilization projects in U.S. waters will require the listed permits. Depending the specifics of each project, additional permits may also be required for the listed activities. For example, projects that could harm marine or other species or their habitats may require permits under the Endangered Species Act, Marine Mammal Protection Act, Migratory Bird Treaty Act, and other species protection laws.

Minimum Permitting Requirements for Water-Based Activities Undertaken in Connection with Ocean Fertilization

Activity	Location	Approval Required	Issuing Agency	Criteria for Issuance
Discharge of materials into ocean waters	U.S. state waters	Dump site designation under the MPRSA@	U.S. Environmental Protection Agency (EPA)	EPA must consider the physical, chemical, and biological characteristics of the proposed dump site and the impacts of past dumping in areas with similar characteristics. Environmental review and consultation with government, tribal, and other stakeholders* may be required.
		Ocean dumping permit under the MPRSA	EPA	EPA must consider the need for, and effects of, dumping.
		Documentation under NEPA	EPA	EPA must conclude that an environmental review is not required under NEPA and issue documentation to that effect or conduct the required environmental review and publish the findings. An EIS is required under NEPA where a federally-authorized activity significantly affects the human environment.
		Consistency determination under the CZMA	Varies (often state environmental agency)	The state must be satisfied that the federal action is consistent "to the maximum extent practicable" with the enforceable policies of any state coastal management plan adopted under the CZMA.^

Activity	Location	Approval Required	Issuing Agency	Criteria for Issuance
Discharge of materials into ocean waters	U.S. federal waters	Dump site designation under the MPRSA#@	EPA	EPA must consider the physical, chemical, and biological characteristics of the proposed dump site and the impacts of past dumping in areas with similar characteristics. Environmental review and consultation with government, tribal, and other stakeholders* may be required.
		Ocean dumping permit under the MPRSA#	EPA	EPA must consider the need for, and effects of, dumping.
		Documentation under NEPA	EPA	EPA must conclude that an environmental review is not required under NEPA and issue documentation to that effect or conduct the required environmental review and publish the findings. An EIS is required under NEPA where a federally-authorized activity significantly affects the human environment.
		Consistency determination under the CZMA#	Varies by state (usually state environmental agency)	The state must be satisfied that the federal action is consistent "to the maximum extent practicable" with the enforceable policies of any state coastal management plan adopted under the CZMA.^

* The issuing agency may be required to consult with other government agencies under the CZMA, Endangered Species Act, Magnuson-Stevens Fishery Conservation and Management Act, National Historic Preservation Act, and other federal laws. Consultation may also be required with Native American tribes and other stakeholders.

^ The federal agency authorizing the activity must provide the relevant state with a "consistency determination," explaining how its actions are consistent "to the maximum extent practicable" with any state coastal management plan adopted under the CZMA. The state must agree with the consistency determination. If it disagrees, the federal agency must work with the state to address its objections.

Only required if materials are discharged within 12 nautical miles of the U.S. coast or, if discharge occurs further offshore, using a vessel that is registered or was loaded in the U.S.

@ Separate site designation only required if dumping is authorized through a special permit.

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