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**REMOVING CARBON DIOXIDE
THROUGH OCEAN ALKALINITY
ENHANCEMENT AND SEAWEED
CULTIVATION:**

Legal Challenges and Opportunities

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EXECUTIVE SUMMARY

Scientists increasingly agree that carbon dioxide removal will be needed, alongside deep emissions cuts, to stave off the worst impacts of climate change. A wide variety of technologies and strategies have been proposed to remove carbon dioxide from the atmosphere. To date, most research has focused on terrestrial-based approaches, but they often have large land requirements, and may present other risks and challenges. As such, there is growing interest in using the oceans, which have already absorbed more than a quarter of anthropogenic carbon dioxide emissions, and could become an even larger carbon sink in the future.

This paper explores two ocean-based carbon dioxide removal strategies—ocean alkalinity enhancement and seaweed cultivation. Ocean alkalinity enhancement involves adding alkalinity to ocean waters, either by discharging alkaline rocks or through an electrochemical process, which increases ocean pH levels and thereby enables greater uptake of carbon dioxide, as well as reducing the adverse impacts of ocean acidification. Seaweed cultivation involves the growing of kelp and other macroalgae to store carbon in biomass, which can then either be used to replace more greenhouse gas-intensive products or sequestered.

This paper examines the international and U.S. legal frameworks that apply to ocean alkalinity enhancement and seaweed cultivation. Depending on where they occur, such activities may be subject to international, national, state, and/or local jurisdiction. Under international law, countries typically have jurisdiction over activities within 200 nautical miles of their coastline. In the U.S., coastal states typically have primary authority over areas within three nautical miles of the coast, and the federal government controls U.S. waters further offshore.

There are currently no international or U.S. federal laws specifically governing the use of the oceans for ocean alkalinity enhancement or seaweed cultivation for carbon removal. However, various general environmental and other laws may apply to such activities. At the international level, the most directly applicable instruments are the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (“London Convention”), and the Protocol to that Convention (“London Protocol”). Both instruments regulate the dumping of materials into ocean waters and could apply to ocean alkalinity enhancement projects involving the discharge of alkaline rocks. Assuming that is the case, non-research projects occurring under the jurisdiction of a party to the London Convention or London Protocol would have to be permitted by that party, in accordance

with the terms of those instruments. The London Convention gives parties broad authority to permit projects, provided they do not use certain, prohibited substances listed in the Convention. The London Protocol is more restrictive, however. Parties to the London Protocol likely could not permit non-research ocean alkalinity enhancement.

As well as the London Convention and Protocol, various other international and regional instruments could also apply to ocean alkalinity enhancement and seaweed cultivation projects, depending on exactly how and where they occur. Examples include the Convention on Biological Diversity, the United Nation Convention on the Law of the Sea, the International Convention for the Prevention of Pollution from Ships, the Basel Convention, and European Union Marine Strategy Framework Directive.

Potentially applicable U.S. laws include the Outer Continental Shelf Lands Act, the National Environmental Policy Act, the Endangered Species Act, the Coastal Zone Management Act, the Clean Water Act, and state environmental assessment and aquaculture permitting laws. The application of these laws will depend on, among other factors, the offshore location of the project, the materials and technology used, and whether the project makes use of the sea floor. Several of the laws establish permitting requirements, which projects would have to meet. Others require projects to undergo environmental and other reviews. Notably, however, none expressly prohibit ocean alkalinity enhancement or seaweed cultivation.

This paper focuses on international and U.S. law. Subsequent work will examine the relevant laws of selected other coastal countries.

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1. INTRODUCTION

Keeping global average temperatures “well below” 2°C above pre-industrial levels—i.e., the goal set in the 2015 Paris Agreement¹—will require a rapid and dramatic reduction in greenhouse gas emissions. Modeling by the Intergovernmental Panel on Climate Change (“IPCC”) and others shows that emissions must be reduced to “net zero” by mid-century or shortly thereafter.² According to the IPCC, achieving such steep reductions in such a short period of time will require “systems transitions [that] are unprecedented in terms of scale,” with “far-reaching” changes needed across all economic sectors.³ There is growing concern that the necessary changes will not be achieved in time, leading to excess greenhouse gas emissions, which will later need to be removed from the atmosphere.⁴ Even if steep emission reductions do occur, greenhouse gas removal will likely be needed to offset residual emissions from difficult-to-eliminate sources (e.g., aviation and heavy industry).⁵ Indeed, all of the emissions pathways identified by the IPCC as consistent with limiting warming to 1.5°C above pre-industrial levels assume some level of greenhouse gas removal,⁶ as do most of the IPCC’s 2°C-consistent emissions pathways.⁷

Past research on greenhouse gas removal has focused primarily on options for drawing carbon dioxide out of the atmosphere and storing or utilizing it in some way. Much of the focus

¹ Paris Agreement, Dec. 12, 2015, Art. 2(1)(a).

² Myles Allen et al., *Summary for Policymakers in GLOBAL WARMING OF 1.5°C: AN IPCC SPECIAL REPORT* (V. Masson-Delmotte et al. eds., 2018); OTTMAR EDENHOFFER ET AL., *CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE, CONTRIBUTION OF WORKING GROUP III TO THE FIFTH ASSESSMENT REPORT BY THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE* (2014), <http://perma.cc/T8J5-MBTA>. See also, e.g., UN ENV’T PROGRAM, *EMISSIONS GAP REPORT 2020* (2020), <https://perma.cc/6G97-9X68>;

³ Allen et al., *supra* note 2, at 15.

⁴ UN Env’t Program, *supra* note 2, at 33-34.

⁵ *Id.*

⁶ Allen et al., *supra* note 2, at 17.

⁷ Edenhoffer et al., *supra* note 2, at 14-15.

has been on terrestrial-based approaches, such as afforestation and reforestation, direct air capture, and bioenergy with carbon capture and storage (“BECCS”).⁸ While each has been shown to be technically feasible, their use presents various risks and challenges. For example, many terrestrial-based approaches require large amounts of land and other resources, which could lead to conflicts with other uses and thus limit their deployment.⁹ This has led to growing interest in the possibility of using the oceans for carbon dioxide removal.

The oceans already remove approximately ten gigatons of carbon dioxide from the atmosphere annually through natural processes.¹⁰ Initial research suggests that uptake of carbon dioxide by the oceans could be increased in a number of ways, including by adding alkalinity to the water (“ocean alkalinity enhancement”) or promoting the growth of seaweed (“seaweed cultivation”).¹¹ Given the large extent of the oceans, which cover approximately seventy-one percent of the Earth’s surface, significant amounts of carbon dioxide could be stored through these approaches.¹² Moreover, because human users of the oceans are fairly broadly dispersed, the potential for conflicts is reduced. Ocean-based approaches may have other drawbacks, however. The potential for ocean carbon dioxide removal to adversely affect marine ecosystems is currently poorly understood. There is also currently no established process for measuring and verifying the amount of carbon dioxide removed through ocean-based approaches and the longevity of its storage. As such, it would be difficult to use ocean carbon dioxide removal projects to generate carbon credits or similar instruments for sale (e.g., under an emissions trading scheme), which is likely a necessary precondition for private investment.

⁸ See generally, NATIONAL ACADEMIES OF SCIENCES, ENGINEERING AND MEDICINE, NEGATIVE EMISSIONS TECHNOLOGIES AND RELIABLE SEQUESTRATION: A RESEARCH AGENDA (2019), <https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda>.

⁹ *Id.* at 9-13.

¹⁰ Wil Burns & Charles R. Corbett, *Antacids for the Sea? Artificial Ocean Alkalinization and Climate Change*, 3 ONE EARTH 154, 154 (2020).

¹¹ See *infra* Part 2.

¹² Burns & Corbett, *supra* note 10, at 154.

Research into ocean carbon dioxide removal has recently been supported by government bodies in the U.S. and Europe. In the U.S. the Consolidated Appropriations Act of 2021 directs the Secretary of Energy to establish a “research, development, and demonstration program . . . to test, validate, or improve technologies and strategies to remove carbon dioxide from the atmosphere on a large scale.”¹³ Among the technologies covered by the program are enhanced weathering, which could include ocean alkalinity enhancement, and BECCs, which could include seaweed cultivation (depending on the ultimate use of the seaweed).¹⁴ The Act authorizes the appropriation of up to \$60 million in fiscal year 2021 for research on these and other non-direct air capture technologies.¹⁵ The U.S. Department of Energy’s Advanced Research Project Agency – Energy (“ARPA-E”) has also been allocated nearly \$50 million to study macroalgae development as part of the Macroalgae Research Inspiring Novel Energy Resources (“MARINER”) program.¹⁶

The European Union (“EU”) is similarly supporting research into ocean carbon dioxide removal. In 2020, the EU announced that it would provide over €7 million to fund an interdisciplinary research program, known as OceanNETs, to explore the feasibility and positive and negative impacts of ocean carbon dioxide removal.¹⁷ The EU has also provided over €5 million in funding for a separate project, known as NEGEM, to explore whether and how various

¹³ Consolidated Appropriations Act, 2021, H.R. 133, 116th Cong., §5001, 1076–77 (2020), <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.

¹⁴ *Id.* at 1077.

¹⁵ *Id.* at 1087 (The Act authorizes \$175 million for CDR research, \$115 million of which is allocated to direct air capture prize competitions).

¹⁶ ARPA-E, *Macroalgae Research Inspiring Novel Energy Resources*, <https://arpa-e.energy.gov/technologies/programs/mariner>.

¹⁷ European Commission, *Ocean-based Negative Emission Technologies: Project Description*, <https://cordis.europa.eu/project/id/869357> (last updated Apr. 20, 2020).

technical, economic, and socio-political factors could limit the use of different carbon dioxide removal techniques (both terrestrial and ocean-based).¹⁸

This paper is intended to complement the ongoing technical, economic, and other research into ocean carbon dioxide removal. It provides the first comprehensive analysis of the laws applicable to two commonly-discussed ocean carbon dioxide removal techniques—(1) ocean alkalinity enhancement and (2) seaweed cultivation—at both the international level and domestically in the U.S. As we show, while there are currently no international or U.S. federal laws dealing specifically with ocean alkalinity enhancement or seaweed cultivation, those projects could be regulated under various general environmental and other laws. There is some uncertainty regarding exactly how those laws, which were developed to regulate other activities, will apply to ocean alkalinity enhancement and seaweed cultivation. Much will depend on precisely where and how ocean alkalinity enhancement and seaweed cultivation projects are conducted.

The remainder of this paper is structured as follows: Part 2 begins with a brief introduction to ocean alkalinity enhancement and seaweed cultivation as carbon dioxide removal techniques. Part 3 then discusses key principles of international and U.S. law defining jurisdiction over the oceans. In part 4, we explore several international agreements that could apply to ocean alkalinity enhancement and seaweed cultivation, while part 5 discusses applicable U.S. law. Part 6 concludes.

2. OVERVIEW OF OCEAN CARBON DIOXIDE REMOVAL APPROACHES

Carbon dioxide removal refers to intentional efforts to take carbon dioxide out of the atmosphere and utilize it in some way or store it in geologic formations, terrestrial ecosystems, or the oceans.¹⁹ Ocean-based approaches to carbon dioxide removal can take a number of forms,

¹⁸ European Commission, *Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways*, <https://cordis.europa.eu/project/id/869192> (last updated Oct. 14, 2020).

¹⁹ National Academies of Sciences, Engineering and Medicine, *supra* note 8, at 1.

but are often divided into four broad categories as shown in Figure 1 below. Here, we focus on two ocean-based approaches, namely: (1) ocean alkalinity enhancement and (2) seaweed cultivation. A brief overview of each approach, its potential to remove carbon dioxide from the atmosphere, and possible co-benefits and risks is provided in this part.

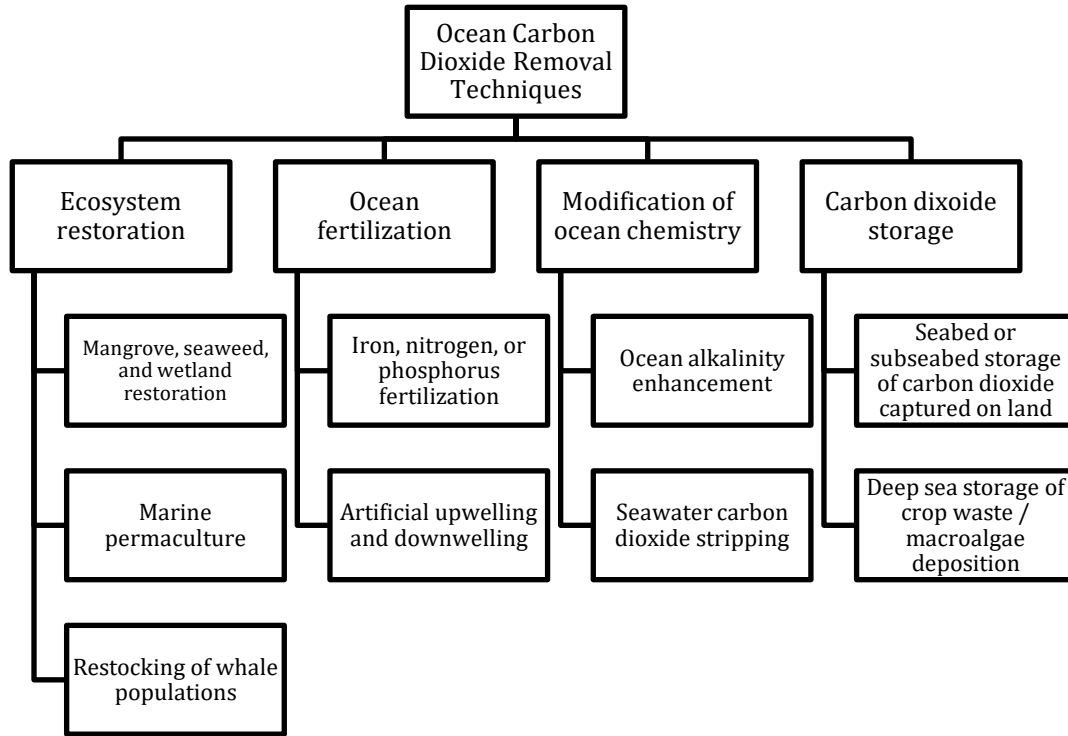


Figure 1: Types of Ocean Carbon Dioxide Removal²⁰

2.1 Ocean Alkalinity Enhancement

As the name suggests, ocean alkalinity enhancement involves adding alkalinity to ocean waters, which increases pH levels and thereby enables greater uptake of carbon dioxide by the oceans. As a result of natural processes, the oceans have absorbed approximately thirty percent of anthropogenic carbon dioxide emissions since the beginning of the Industrial Revolution.²¹ When carbon dioxide enters the oceans, it reacts with the water, forming carbonic acid.²² The acid

²⁰ Based on figure in Antonius Gagern et al., *Ocean Alkalinity Enhancement: Current State of Knowledge and Potential Role of Philanthropy* 7 (2019), <https://perma.cc/A92F-AEY4>.

²¹ Nicholas Gruber et al., *The Oceanic Sink for Anthropogenic CO₂ from 1994 to 2007*, 363 *SCIENCE* 1193, 1193 (2019).

²² Gagern, *supra* note 20, at 9.

dissociates (i.e., breaks) into hydrogen ions and bicarbonate ions.²³ Over time, calcifying organisms convert the bicarbonate ions into calcium carbonate, which forms the basis of their shells and skeletons.²⁴ When the organisms die, they sink to the ocean floor and a portion of the calcium carbonate is buried, effectively resulting in long-term storage of carbon dioxide in mineral form.²⁵

Past uptake of carbon dioxide by the oceans has increased the acidity of the water by approximately thirty-percent above pre-industrial levels.²⁶ Ocean acidification impairs the ability of many corals, crustaceans, and other calcifying organisms to form their skeletons and shells.²⁷ It also limits the conversion of dissolved carbon dioxide into bicarbonate ions and carbonate sediments which, in turn, limits the oceans' ability to absorb more carbon dioxide.²⁸ Ocean alkalinity enhancement aims to mitigate these problems by adding alkalinity to ocean waters.

Ocean alkalinity enhancement can be performed in several ways, including by discharging ground alkaline rock into ocean waters, where it reacts with dissolved carbon dioxide to produce carbonate and bicarbonate ions, which eventually become carbonate sediments on the ocean floor (i.e., via the process described above). One widely available alkaline rock is limestone, but initial research suggests that discharging it into ocean waters may be of limited use because the upper oceans are already supersaturated with calcium carbonate (i.e., the primary component of limestone), limiting its dissolution.²⁹ To address this issue, limestone could be converted to lime, which is principally calcium oxide and thus dissolves more rapidly.³⁰ Silicate-rich rocks,

²³ *Id.*

²⁴ *Id.*

²⁵ *Id.* at 8.

²⁶ Nat'l Oceanic & Atmospheric Admin., *Ocean acidification*, <https://perma.cc/DDE2-A4ZH> (last visited Jan. 21, 2020).

²⁷ See generally Nathaniel R. Mollica et al., *Ocean Acidification Affects Coral Growth by Reducing Skeletal Density*, 115 PNAS 1755 (2018).

²⁸ Gagern, *supra* note 20, at 9.

²⁹ *Id.* at 11-13.

³⁰ *Id.* at 11.

such as olivine, could also be used.³¹ In all cases, the rock would be mined and processed on land and then transported to the coast, where it would be loaded onto ships for discharge into ocean waters.

As an alternative to adding alkaline rocks to ocean waters, ocean alkalinity enhancement could be performed through an electrochemical process in which an electric current is applied to the water, causing it to separate into basic and acidic streams.³² The basic stream could be returned to the ocean, where it would increase the alkalinity of the water, leading to additional uptake of carbon dioxide. The acidic stream, which comprises hydrochloric acid, could be collected and transported to land for use in industrial processes. For this process to yield a net reduction in atmospheric carbon dioxide levels, the electricity used would have to be generated from zero-carbon sources. The most commonly discussed option involves using offshore wind turbines that are co-located with the electrochemical system.³³

Whatever approach is used, ocean alkalinity enhancement has the potential to remove and store large amounts of carbon dioxide, likely for tens of thousands of years. A 2013 study found that ocean alkalinity enhancement using silicate-based rocks could result in the storage of four gigatons of carbon dioxide annually (i.e., equivalent to twelve percent of annual global energy-related emissions).³⁴ Ocean alkalinity enhancement would also have the co-benefit of mitigating the negative effects of ocean acidification on marine ecosystems.³⁵ It also presents risks and challenges, however.

³¹ Jens Hartman et al., *Enhanced Chemical Weathering as a Geoengineering Strategy to Reduce Atmospheric Carbon Dioxide, Supply Nutrients, and Mitigate Ocean Acidification*, 51 REV. GEOPHYSICS 113 (2013).

³² This process can be performed via electrolysis or electro dialysis. *See generally*, Greg H. Rau et al., *The Global Potential for Converting Renewable Electricity to Negative-CO₂-Emissions Hydrogen*, 8 NATURE CLIMATE CHANGE 621 (2018).

³³ *Id.*

³⁴ Peter Köhler et al., *Geoengineering Impact of Ocean Dissolutions of Olivine on Atmospheric CO₂, Surface Ocean pH and Marine Biology*, 8 ENVIRON. RES. LETTERS 014009 (2013). Global energy-related carbon dioxide emissions were approximately 33 gigatons in 2019. *See* Int'l Energy Agency, *Global CO₂ Emissions in 2019*, <http://perma.cc/NTL5-TJWZ> (last updated Feb. 11, 2020).

³⁵ Burns & Corbett, *supra* note 10, at 155.

Ocean alkalinity enhancement is thought to be one of the more expensive carbon dioxide removal techniques. Initial research puts the cost of ocean alkalinity enhancement at \$55 to \$107 per ton of carbon dioxide sequestered,³⁶ which is well above recent estimates for afforestation (\$24 per ton)³⁷ and some forms of BECCS (\$15 to 400 per ton)³⁸ and direct air capture (\$27 to \$136 per ton).³⁹ Ocean alkalinity enhancement may also have other drawbacks. Some rock materials (e.g., olivine) proposed for use in ocean alkalinity enhancement contain heavy metals, which could contaminate ocean waters and harm marine ecosystems.⁴⁰ Olivine could also act as a fertilizer, stimulating the growth of certain marine plants and other organisms, which could have negative flow-off effects.⁴¹

2.2 Seaweed Cultivation

Seaweed cultivation—the growing of kelp and other macroalgae—is another ocean-based carbon dioxide removal strategy. Seaweed is fast-growing, up to two feet per day, and is both present in the wild and grown for human consumption. Like terrestrial plants, seaweed uptakes carbon from the atmosphere as it grows and stores it in biomass. However, unlike land forests, carbon storage in seaweed is not vulnerable to fire and forest degradation. Wild seaweed grows mostly near the shore, stores carbon in its biomass, and sequesters a small percentage of that carbon in the sediment below where it is grown. Some seaweed varieties, like kelp, contain gas-filled bladders in their leaves to help them float near the surface to access sunlight. Because of the bladders, the seaweed float for long distances until they burst, sinking the seaweed towards the

³⁶ Gagern et al., *supra* note 20, at 13.

³⁷ Jessica Strefler et al., *Potential and Costs of Carbon Dioxide Removal by Enhanced Weathering of Rocks*, 13 ENVTL. RES. LETTERS 030410, 18 (2018). Strefler et al. reported costs for direct air capture of \$430 to \$570 per ton, but other, more recent studies put the figure significantly lower. See e.g., Brandon R. Sutherland, *Pricing CO₂ Direct Air Capture*, 3 JOULE 1571, 1572 (2019).

³⁸ Christopher Consoli, Global CCS Institute, *Bioenergy and Carbon Capture and Storage 9* (2019), <https://perma.cc/GK6J-4BXE>.

³⁹ Brandon R. Sutherland, *Pricing CO₂ Direct Air Capture*, 3 JOULE 1571, 1572 (2019).

⁴⁰ Gagern et al., *supra* note 20, at 16.

⁴¹ *Id.* at 48.

deep-sea floor, where the carbon is sequestered for centuries to millions of years.⁴² A 2016 study estimated that seaweed naturally sequesters about 640 Mt of carbon dioxide per year (within a range of about 220 to 980 Mt of carbon dioxide per year), with approximately ninety percent of this sequestered in the deep sea.⁴³

Strategies to utilize seaweed for carbon dioxide removal focus mainly on seaweed cultivation, as natural fluxes are large and deep-sea carbon deposits are difficult to trace for accounting purposes. In 2016, global annual cultivation of seaweed reached 31.2 million tons, with 96.5 percent cultivated in aquaculture and the rest harvested from natural populations.⁴⁴ This represents nearly a third of total global aquaculture production by weight. China accounts for about half of worldwide seaweed cultivation, and Indonesia, Japan, Korea, and the Philippines are also major producers.⁴⁵ Cultivation is increasing, with an annual growth rate of approximately eight percent.⁴⁶ Seaweeds are harvested for food, medicine, cosmetics, and bioenergy, with little current use solely for carbon offsetting.⁴⁷

Seaweed can either be grown on the sea floor, attached to a hard surface, or along anchored lines or nets.⁴⁸ Its growth requires adequate nutrients and light, and salinity, temperatures, and pH levels that do not limit growth.⁴⁹ Cultivation typically occurs within 110 nautical miles (“n.m.”) (200 kilometers) of shore, with many farms located less than one n.m. (two kilometers) from the coast. Research is investigating the potential for cultivation further out into

⁴² Dorte Krause-Jensen and Carlos M. Duarte, *Substantial role of macroalgae in marine carbon sequestration*, 9 NATURE GEOSCIENCE 737, 739 (2016), <https://www.nature.com/articles/ngeo2790>.

⁴³ *Id.* at 739.

⁴⁴ Sara Garcia-Poza et al., *The Evolution Road of Seaweed Aquaculture: Cultivation Technologies and the Industry 4.0*, 17 INT’L J. ENVTL. RES. & PUB. HEALTH 6528, 6537 (2020).

⁴⁵ *Id.* at 6537.

⁴⁶ Halley E. Froehlich et al., *Blue Growth Potential to Mitigate Climate Change through Seaweed Offsetting*, 29 CURRENT BIOLOGY 3087, 3087 (2019).

⁴⁷ *Id.* at 3087.

⁴⁸ Garcia-Poza et al., *supra* note 44, at 6539.

⁴⁹ *Id.* at 6537–6538.

the open ocean, including the use of floating platforms powered by solar panels⁵⁰ or co-located with offshore wind to utilize the in-place infrastructure to facilitate seaweed growth.⁵¹

To offset emissions, cultivated seaweed may be used to replace more greenhouse gas-intensive products, or may be sunk in the deep sea. In order to be a truly carbon negative technology, the seaweed would likely need to be sunk or used in BECCS systems or as biochar. A 2019 study found that sinking seaweed has the potential to sequester 1,110 tonnes of CO₂ per square kilometer of seaweed cultivation area,⁵² but notes that cost constraints would limit the ability of the industry to scale up cultivation for sequestration through sinking.⁵³ Utilizing seaweed for mitigation by replacing greenhouse gas-intensive products may be more cost-effective, if not carbon negative. Seaweed biofuels could mitigate about 1,500 tons of carbon dioxide per square kilometer of seaweed cultivation area per year in terms of avoided emissions from fossil fuels.⁵⁴ Seaweed could also be used to reduce cattle methane emissions, as a 2016 experiment showed that the addition of seaweed to cattle diet could reduce methane emissions from cattle production by ninety-nine percent,⁵⁵ although research is still at a preliminary stage.

Seaweed cultivation may also have climate adaptation and environmental co-benefits. Dense seaweed areas are associated with a high pH which may help to protect coral and other

⁵⁰ Tim Flannery, *How farming giant seaweed can feed fish and fix the climate*, THE CONVERSATION (July 31, 2017), <https://perma.cc/4V6U-89RX>. The solar panels may be used to power the floating platforms to move from ideal cultivation locations to ideal sinking locations. Co-locating seaweed cultivation with solar panel-installed platforms, similar to offshore wind, can also help efficiently utilize limited marine space and provide infrastructure for seaweed growth and ship docking.

⁵¹ Bela H. Buck et al., *Offshore and Multi-Use Aquaculture with Extractive Species: Seaweeds and Bivalves* in AQUACULTURE PERSPECTIVE OF MULTI-USE SITES IN THE OPEN OCEAN 26 (Bela H. Buck & Richard Langan eds., 2017).

⁵² Froehlich et al., *supra* note 46, at e2.

⁵³ *Id.* at 3087.

⁵⁴ Carlos M. Duarte et al., *Can seaweed farming play a role in climate change mitigation and adaptation?*, 4 FRONTIERS IN MARINE SCIENCE 1, 1 (2017).

⁵⁵ *Id.* at 4.

calcifying organisms from the adverse effects of ocean acidification.⁵⁶ Seaweed farms provide oxygen-rich habitats, which can combat hypoxia in eutrophic coastal areas.⁵⁷ And because seaweed farms dampen wave energy, they can buffer against coastal erosion.⁵⁸ However, large-scale seaweed cultivation also brings environmental and ecosystem risks. By domesticating wild seaweed species and thus reducing genetic diversity, cultivation may make crops more susceptible to disease and parasites.⁵⁹ Seaweed farms may remove light and nutrient resources from underlying and surrounding habitats.⁶⁰ Further, large-scale cultivation requires the addition of artificial material, like polymer rope, that may be discarded or lost causing pollution to marine environments.⁶¹ Because large-scale cultivation has not been implemented in many countries, significant knowledge gaps exist over the ultimate environmental impact of such aquaculture operations.

3. JURISDICTION OVER THE OCEANS

Regulatory jurisdiction over the oceans 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 the oceans. UNCLOS has been ratified or otherwise adopted by 167 countries and the European Union.⁶² The U.S. has not ratified UNCLOS, but recognizes many of

⁵⁶ *Id.*

⁵⁷ *Id.* at 5.

⁵⁸ *Id.* at 4.

⁵⁹ Iona Campbell et al., *The Environmental Risks Associated With the Development of Seaweed Farming in Europe*, 6 FRONTIERS IN MARINE SCIENCE 1, 9 (2019).

⁶⁰ *Id.* at 4–5.

⁶¹ *Id.* at 7.

⁶² United Nations, *Law of the Sea*, <https://perma.cc/AZ7L-APX4> (last updated Jan. 19, 2021).

its provisions, including those discussed in this Part, as forming part of customary international law.⁶³

Under UNCLOS, non-landlocked countries (“Coastal States”) have jurisdiction over areas within 200 n.m. of the low water line along their coasts (the “baseline”) and further in some circumstances.⁶⁴ The 200 n.m. zone is generally divided into three 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 the Coastal State.⁶⁵
- The *exclusive economic zone* (“EEZ”), which comprises the waters situated beyond the territorial sea, up to 200 n.m. from the baseline.⁶⁶ Within the EEZ, the Coastal State has sovereign rights to explore, exploit, conserve, and manage natural resources and undertake other activities for the economic exploitation of the zone, among other things.⁶⁷
- 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,⁶⁸ 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.⁶⁹ Each Coastal State has sovereign rights over its continental shelf for the purpose of exploring and exploiting natural resources.⁷⁰

⁶³ *Id.* See also U.S. Dept. of State, Law of the Sea Convention, <https://perma.cc/A8A5-QA98> (last updated Mar. 7, 2019).

⁶⁴ United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS].

⁶⁵ *Id.* Art. 2-3.

⁶⁶ *Id.* Art. 55 & 57.

⁶⁷ *Id.* Art. 56.

⁶⁸ The “continental margin” refers to the submerged prolongation of the land mass of the Coastal State. See *id.* Art. 76(1).

⁶⁹ *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.*

⁷⁰ *Id.* Art. 77.

Except as noted above, Coastal States generally do not have jurisdiction over areas more than 200 n.m. from shore, which form part of the high seas.⁷¹ UNCLOS provides for “freedom of the high seas,” which is defined to include, “for both coastal and land-locked states: (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.”⁷²

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”).⁷³ 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 Florida extend nine n.m. from the coastline.⁷⁴ For the purposes of the SLA, a state’s

⁷¹ *Id.* Art. 86-87.

⁷² *Id.* Art. 87.

⁷³ Proclamation No. 5030, 48 Fed. Reg. 10605 (Mar. 14, 1983).

⁷⁴ 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).

“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.”⁷⁵

Offshore waters within state boundaries fall under the primary jurisdiction of the relevant coastal state, though the federal government also has some regulatory authority within state waters. Each coastal state has title to, and ownership of, all lands beneath its state waters and the natural resources (including minerals, marine animals, and plant life) within those lands and waters.⁷⁶ The federal government has relinquished all of its rights to, and interests in, land and resources within state waters (though it retains some regulatory authority).⁷⁷

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 those “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.”⁷⁸ As discussed in subpart 3.2.1 above, state jurisdiction typically ends three n.m. from shore (except in 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:
 - 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.⁷⁹

⁷⁵ 43 U.S.C. § 1301(c).

⁷⁶ *Id.* § 1311(a)(1).

⁷⁷ *Id.* § 1311(b).

⁷⁸ *Id.* § 1331.

⁷⁹ UNCLOS, *supra* note 64, Art. 76(1) & (4).

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).⁸⁰

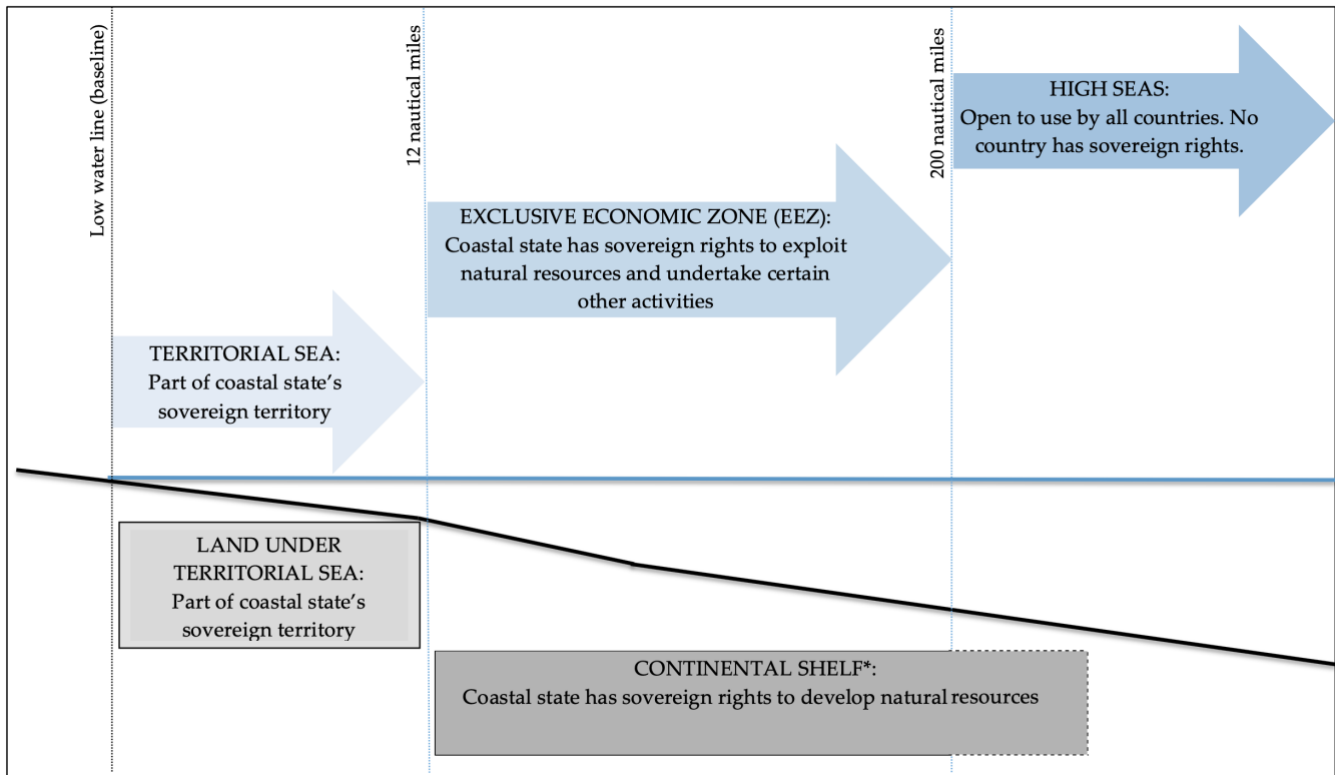


Figure 2: Offshore Zones Identified in UNCLOS⁸¹

* 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.

4. INTERNATIONAL LEGAL FRAMEWORK FOR OCEAN CARBON DIOXIDE REMOVAL

Activities performed at sea are governed by various international agreements. While there are no agreements dealing specifically with the governance of ocean-based carbon dioxide

⁸⁰ *Id.* Art. 76(5).

⁸¹ ROMANY M. WEBB & MICHAEL B. GERRARD, OVERCOMING IMPEDIMENTS TO OFFSHORE CARBON DIOXIDE STORAGE: LEGAL ISSUES IN THE U.S. AND CANADA 8 (2019), <https://perma.cc/92MV-4Y5Q>.

removal, several instruments contain provisions that could apply to research or commercial-scale operations. These include UNCLOS, the Convention on Biological Diversity (“CBD”), the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (“London Convention”), and the Protocol to that Convention (“London Protocol”). Those instruments and their application to ocean carbon dioxide removal via ocean alkalinity enhancement and seaweed cultivation are discussed in this Part.

4.1 Convention on Biological Diversity

Adopted in 1992, the CBD aims to promote “the conservation of biological diversity, [and] the sustainable use of its components.”⁸² At the time of writing, the CBD had been ratified or otherwise accepted by 195 countries, as well as the European Union.⁸³ The U.S. had signed, but not ratified, the CBD.⁸⁴

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.”⁸⁵ 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.”⁸⁶ For projects that could have transboundary effects, parties must “[p]romote . . . notification, exchange of information and consultation” with potentially affected countries.⁸⁷ 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.⁸⁸ Parties should also have in place “national arrangements for

⁸² Convention on Biological Diversity, May 22, 1992 [hereinafter “CBD”].

⁸³ Convention on Biological Diversity, *List of Parties*, <https://perma.cc/ZY3W-9PC3> (last visited Jan. 19, 2021).

⁸⁴ *Id.*

⁸⁵ CBD, *supra* note 82, Art. 7(c).

⁸⁶ *Id.* Art. 14(1)(a).

⁸⁷ *Id.* Art. 14(1)(c).

⁸⁸ *Id.* Art. 14(1)(d).

emergency responses” to projects that represent a “grave and imminent danger to biological diversity.”⁸⁹

Provided the above requirements are met, the CBD would not prevent countries from undertaking or authorizing ocean alkalinity enhancement, seaweed cultivation, or other carbon dioxide removal projects, even if those projects adversely affect biodiversity.⁹⁰ However, the Conference of the Parties to the CBD has adopted a series of non-binding decisions, which recommend that countries avoid such projects. The first decision, adopted in 2008, applied specifically to ocean fertilization.⁹¹ The decision:

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.⁹²

⁸⁹ *Id.* Art. 14(1)(e).

⁹⁰ 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 id.* at Art. 4(b).

⁹¹ Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Ninth Meeting, Decision IX/116 (2008). The decision does not define what constitutes “ocean fertilization.” Within the scientific community, the term “ocean fertilization” is generally used to refer to the addition of nutrients to ocean waters to stimulate the growth of photosynthesizing life, such as plankton, and thereby increase the natural biological pump which transports carbon dioxide from the surface ocean downward. The process is distinct from both ocean alkalinity enhancement and seaweed cultivation. *See generally*, ROYAL SOCIETY AND ROYAL ACADEMY OF ENGINEERING, GREENHOUSE GAS REMOVAL 43 (2018), <https://royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf>.

⁹² *Id.* at Art. C(4). The decision included an exemption for “small scale research studies within coastal waters” and provided that “[s]uch studies should only be authorized if justified by the need to gather specific scientific data, and should be subject to a thorough prior assessment of the potential impacts of the research studies on the marine environment, and be strictly controlled, and not be used for generating and selling carbon offsets or any other commercial purposes.” *Id.*

A second decision, applying more broadly to “geoengineering activities,” was adopted by the Conference of the Parties to the CBD in 2010.⁹³ The 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.”⁹⁴ 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, with the exception of small scale scientific research studies that could be conducted in a controlled setting . . . and only if they are justified by the need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment. (Internal citations omitted.)⁹⁵

That guidance was reaffirmed by the Conference of the Parties to the CBD in 2012⁹⁶ and again in 2016.⁹⁷

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.”⁹⁸ 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

⁹³ 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 Decision”].

⁹⁴ *Id.*

⁹⁵ *Id.* Art. 8(w).

⁹⁶ Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Eleventh Meeting, Decision XI/20, Art 6-9 (2012) [hereinafter “2012 Decision”].

⁹⁷ Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Thirteen Meeting, Decision XIII, Art. 14 (2016).

⁹⁸ 2010 Decision, *supra* note 93, at footnote 3.

anthropogenic climate change and its impacts.”⁹⁹ That definition would encompass ocean alkalinity enhancement, seaweed cultivation, and other ocean carbon dioxide removal projects undertaken for the purpose of mitigating climate change. Nevertheless, the decision’s impact on ocean carbon dioxide removal projects is limited because it is non-binding, and merely “invites” countries to “consider” the guidelines provided.

4.2 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. At the time of writing, UNCLOS had been ratified or otherwise adopted by 167 countries and the European Union and signed, but not ratified or adopted, by an additional fourteen countries.¹⁰⁰ The U.S. has neither signed nor ratified UNCLOS. Notably, however, the U.S. has ratified the Agreement for Implementation of the Provisions of UNCLOS Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (“Straddling Fish Stocks Agreement”).¹⁰¹ The U.S. recognizes many other UNCLOS provisions as forming part of customary international law.

Article 194 of UNCLOS imposes a general obligation on parties to take all necessary measures to “prevent, reduce and control pollution of the marine environment.”¹⁰² That obligation was reiterated and elaborated on in the Straddling Fish Stocks Agreement, which

⁹⁹ 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>; 2012 Decision, *supra* note 96, Art. 5.

¹⁰⁰ United Nations, *Chronological Ratifications of, and Accessions and Successions to the Convention and Related Agreements*, <https://perma.cc/JK47-SZG5> (last visited Jan. 9, 2020).

¹⁰¹ Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, Sept. 8, 1995 [hereinafter “Straddling Fish Stocks Agreement”]. At the time of writing, there were 91 parties to the Straddling Fish Stocks Agreement. *See* United Nations, *supra* note 100.

¹⁰² UNCLOS, *supra* note 64, Art. 194(1).

requires parties to “minimize pollution” and “protect biodiversity in the marine environment,” among other things.¹⁰³

For the purposes of UNCLOS, pollution is defined broadly to mean:

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.¹⁰⁴

Under this definition, ocean carbon dioxide removal techniques that involve adding materials to ocean waters, such as ocean alkalinity enhancement, could be considered forms of pollution if they harm the marine environment.¹⁰⁵ As the risk of harm is likely to vary between projects, a case-by-case assessment would need to be undertaken.¹⁰⁶ The assessment should consider not only the risks posed by the project but also its likely effectiveness in sequestering carbon dioxide and thus mitigating climate change.¹⁰⁷ This is relevant because carbon dioxide and certain impacts of climate change (e.g., ocean acidification) also arguably constitute pollution for the purposes of UNCLOS.¹⁰⁸

If ocean carbon dioxide removal projects were found to involve pollution of the marine environment, UNCLOS would require the party under whose jurisdiction it occurs 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;¹⁰⁹

¹⁰³ Straddling Fish Stocks Agreement, *supra* note 101, Art. 5.

¹⁰⁴ UNCLOS, *supra* note 64, Art. 1(1)(4).

¹⁰⁵ See generally, Jesse L. Reynolds, *International Law*, in CLIMATE ENGINEERING AND THE LAW 57, 76-77 (Michael B. Gerrard & Tracy Hester eds., 2018).

¹⁰⁶ *Id.* at 77.

¹⁰⁷ *Id.* at 77-78.

¹⁰⁸ *Id.* at 76 (asserting that “GHGs and probably global warming qualify under UNCLOS as pollution of the marine environment”).

¹⁰⁹ UNCLOS, *supra* note 64, Art. 194, 196, 202-209, & 211-212.

- notify affected countries and competent international authorities of any imminent or actual damage from the project;¹¹⁰ and
- study the risks and effects of the project and publish the results of that study.¹¹¹

According to UNCLOS, countries that fail to fulfil these requirements “shall be liable in accordance with international law.”¹¹² The 2001 United Nations Resolution on the Responsibility of States for Internationally Wrongful Acts provides that, where a country breaches an international obligation and that breach causes harm to another, the former must cease the offending conduct and “offer appropriate assurances and guarantees of non-repetition.”¹¹³ The country must also make “full reparation” for any injuries 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).¹¹⁴

4.3 London Convention and Protocol

The London Convention was adopted in 1972 with the aim of “promot[ing] 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.¹¹⁵ In 1996, the parties to the London Convention adopted a new protocol, which is intended to update the Convention and will eventually replace it once ratified by all contracting parties.¹¹⁶ The London Protocol sets more ambitious goals than

¹¹⁰ *Id.* Art. 198.

¹¹¹ *Id.* Art. 204-206.

¹¹² *Id.* Art 235(1).

¹¹³ Resolution Adopted by the United Nations General Assembly, Responsibility of States for Internationally Wrongful Acts, A/RES/56/83 (Jan. 28, 2002) at Art. 30. *See also id.* Art. 2 (specifying when a country will be considered to have committed a “wrongful act”).

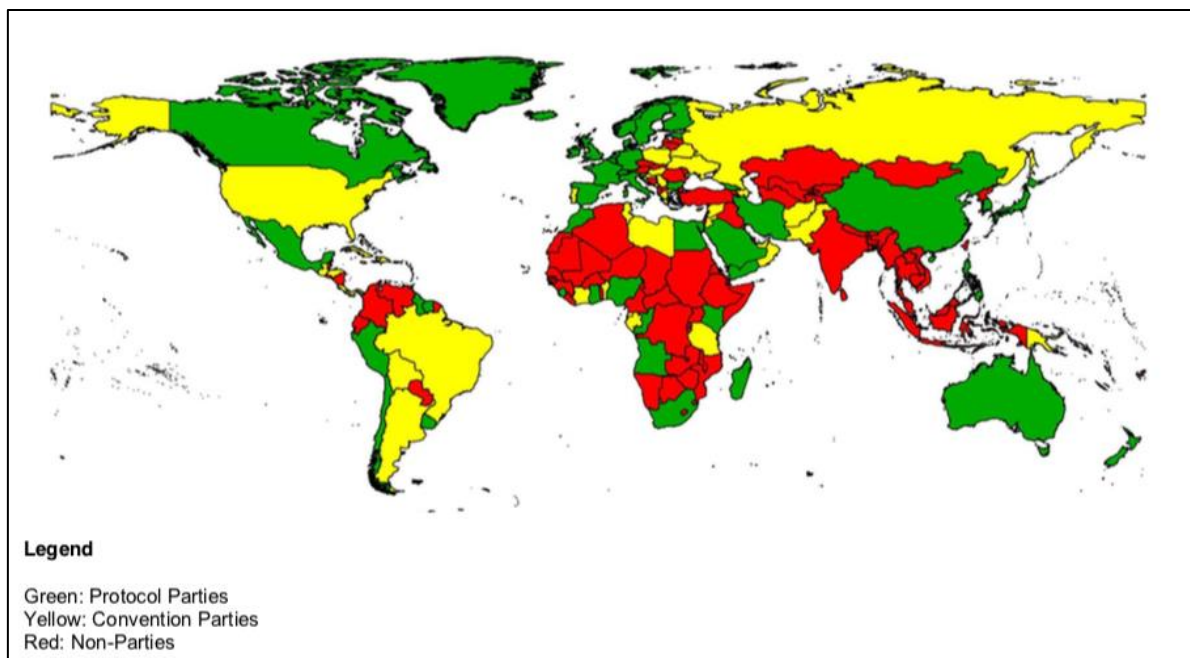
¹¹⁴ *Id.* Art. 31 & 34. *See also id.* Art. 35 (defining “restitution”), Art. 36 (defining “compensation”), & Art. 37 (defining “satisfaction”).

¹¹⁵ Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972 [hereinafter “London Convention”], Art. I-II.

¹¹⁶ 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.

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.”¹¹⁷

Figure 3: Parties to the London Convention and London Protocol¹¹⁸



At the time of writing, there were eighty-seven parties to the London Convention, and fifty-three parties to the London Protocol (see Figure 3 and Table 1).¹¹⁹ 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.¹²⁰

¹¹⁷ *Id.*

¹¹⁸ *Id.*

¹¹⁹ International Maritime Organization, *Map of Parties to the London Convention/Protocol*, <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Parties%20to%20the%20LCLP%20February%202019.pdf> (last updated Feb. 22, 2019).

¹²⁰ Env'tl. Prot. Agency, *Ocean Dumping: International Treaties*, <https://perma.cc/9KSU-756N> (last updated Feb. 28, 2019).

Table 1: Contracting Parties to the London Protocol

Angola	Georgia	Mexico	Slovenia
Australia	Germany	Morocco	South Africa
Belgium	Ghana	Netherlands	South Korea
Bulgaria	Greenland	New Zealand	Spain
Canada	Guyana	Nigeria	Suriname
Chile	Iceland	Norway	Sweden
China	Iran	Peru	Switzerland
Denmark	Ireland	Philippines	UK
Egypt	Italy	Republic of the	Uruguay
Estonia	Japan	Congo	Yemen
Finland	Kenya	Saudi Arabia	
France	Madagascar	Sierra Leone	

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.¹²¹ Parties to the London Convention must prohibit the dumping of eight substances listed in Annex I to the Convention (“prohibited substances”),¹²² but can permit the dumping of other (non-prohibited) substances.¹²³ 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”).¹²⁴

Ocean alkalinity enhancement and other carbon dioxide removal techniques that involve adding materials to ocean waters may be found to constitute the “dumping” of “waste or other matter.” Both the London Convention and London Protocol define “waste or other matter” broadly to include “material of any kind, form or description.”¹²⁵ 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.”¹²⁶ 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”).¹²⁷

¹²¹ London Convention, *supra* note 115, Art. VII; London Protocol, *supra* note 116, Art. 10.

¹²² The prohibited substances are (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, and (8) industrial waste.

¹²³ London Convention, *supra* note 115, Art. IV.

¹²⁴ London Protocol, *supra* note 116, Art. 4. The allowed substances are (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 unarmful materials, and (8) carbon dioxide streams from carbon dioxide capture processes for sequestration. *Id.* Annex 1.

¹²⁵ London Convention, *supra* note 115, Art. III; London Protocol, *supra* note 117, Art. I.

¹²⁶ London Convention, *supra* note 115, Art. III; London Protocol, *supra* note 117, Art. I.

¹²⁷ London Convention, *supra* note 115, Art. III; London Protocol, *supra* note 117, Art. I

In 2008, the parties to the London Convention and Protocol adopted a non-binding resolution, which declares “ocean fertilization activities” to fall within the scope of those instruments.¹²⁸ The 2008 resolution indicates that “ocean fertilization activities other than legitimate scientific research” (“non-research projects”) do not qualify for the dumping exemption because they are “contrary to the aims of the Convention and Protocol.”¹²⁹ Ocean alkalinity enhancement and other carbon dioxide removal techniques that involve adding materials to ocean waters are likely to be treated similarly to ocean fertilization.¹³⁰ Assuming that is the case, and the dumping exemption does not apply, non-research ocean carbon dioxide removal projects would be subject to the terms of the London Convention and London Protocol. Parties to the London Convention could, consistent with that instrument, permit any non-research carbon dioxide removal project that does not use prohibited substances.¹³¹ In contrast, parties to the London Protocol could not permit such projects, unless they involved the use of allowed substances.¹³² The materials proposed for use in ocean alkalinity enhancement do not appear on the list of prohibited substances in the London Convention or the list of allowed substances in the London Protocol.¹³³ Consequently, non-research ocean alkalinity enhancement could be permitted under the London Convention, but not the London Protocol. Thus, non-research projects could not be performed in the territory of, or using ships or aircraft registered with, or loaded in, a party to the London Protocol.

Although non-research ocean fertilization projects have been found not to qualify for the dumping exemption, that exemption may apply research projects in some cases. The 2008 resolution

¹²⁸ Resolution LC-LP.1(2008) on the Regulation of Ocean Fertilization, Art. 3 (Oct. 31, 2008) [hereinafter “2008 Resolution”]. The resolution defined “ocean fertilization” to mean “any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans,” but expressly excluded “conventional aquaculture, or mariculture, or the creation of artificial reefs.” *Id.* Art. 2 and Footnote 3.

¹²⁹ *Id.* Art. 8.

¹³⁰ The 2008 Resolution indicated that, due to the limited understanding of their effectiveness and potential environmental impacts, ocean fertilization projects not involving “legitimate scientific research” could not be justified. There is similarly limited understanding of the effectiveness and potential impacts of other carbon dioxide removal techniques. *Id.* Preamble.

¹³¹ London Convention, *supra* note 115, Art. IV.

¹³² London Protocol, *supra* note 116, Art. 4.

¹³³ London Convention, *supra* note 115, Annex 1; London Protocol, *supra* note 116, Annex 1.

indicates that ocean fertilization projects that constitute “legitimate scientific research” should be regarded as a “placement of matter for a purpose other than mere disposal.”¹³⁴ Such projects will, therefore, qualify for the dumping exemption if they are found not to be contrary to the aims of the London Convention and London Protocol. The parties have agreed that ocean fertilization research projects should be assessed on a case-by-case basis¹³⁵ and, in 2010, adopted a framework to guide that assessment.¹³⁶ The framework provides for the assessment of projects by the country under whose jurisdiction they occur.¹³⁷ Countries must follow the guidelines set out in the framework, which provides for a two-stage assessment process, comprising:

1. an initial assessment which considers whether the project “has proper scientific attributes” and qualifies as “legitimate scientific research” into ocean fertilization; and
2. an environmental assessment which considers the potential short- and long-term effects of the project on the marine environment, characterizes the nature and extent of project-related risks, and identifies measures to manage those risks.¹³⁸

Based on the assessment, the responsible country must determine whether or not the project is contrary to the aims of the London Convention and Protocol. The assessment framework declares that countries “should” only conclude that a project is not contrary to the aims of the London Convention and Protocol if “conditions are in place to ensure that, as far as practicable, environmental disturbance would be minimized, and the scientific benefits maximized.”¹³⁹ The framework is not legally binding, however.

¹³⁴ 2008 Resolution, *supra* note 128, Art. 3.

¹³⁵ *Id.* Art. 4-5.

¹³⁶ Resolution LC-LP.2(2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (Oct. 14, 2010) [hereinafter “2010 Resolution”].

¹³⁷ *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 115, Art. VII; London Protocol, *supra* note 116, Art. 10.

¹³⁸ 2010 Resolution, *supra* note 136, Annex 6.

¹³⁹ *Id.*

In 2013, the Parties to the London Protocol agreed to an amendment, which would codify the above approach to assessing ocean fertilization projects.¹⁴⁰ 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.¹⁴¹

While the article refers generally to “marine geoengineering activities,” annex 4 only lists “ocean fertilization,” thus limiting the scope of the amendment.¹⁴² Under annex 4, countries cannot permit ocean fertilization projects, unless they are found to constitute “legitimate scientific research.”¹⁴³ 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.¹⁴⁴

In the future, annex 4 could be amended to include other carbon dioxide removal techniques, such as ocean alkalinity enhancement, and subject those techniques to the assessment process described above. However, that would have little legal effect, at least until the 2013 amendment to the London Protocol enters into force. Under the terms of the London Protocol, amendments do not enter into force until ratified by two-thirds of the parties to the Protocol, and then only for the parties that have ratified the amendment.¹⁴⁵ To date, just six of the forty-five parties to the London Protocol have ratified the 2013 amendment, which is well below the two-thirds threshold required.¹⁴⁶ Even if the threshold is met, the amendment will only affect the London Protocol. Countries that are party

¹⁴⁰ 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).

¹⁴¹ *Id.* Annex 1, Art. 1.

¹⁴² *Id.*

¹⁴³ *Id.*

¹⁴⁴ *Id.*

¹⁴⁵ London Protocol, *supra* note 116, Art. 21.

¹⁴⁶ The six countries are Estonia, Finland, Germany, the Netherlands, Norway, and the U.K.

to the London Convention, but not the London Protocol, will continue to be subject only to the 2008 and 2010 resolutions. Those resolution are not binding.

In sum, assuming ocean alkalinity enhancement is treated similarly to ocean fertilization, projects involving “legitimate scientific research” are likely to qualify for the dumping exemption from the London Convention and London Protocol. Research projects would not, therefore, be subject to the permitting requirements in the London Convention or London Protocol and could take place after an environmental review by the country under whose jurisdiction they occur. In contrast, non-research projects are unlikely to qualify for the dumping exemption, and would thus require a permit under the London Convention or London Protocol. Parties to the London Convention could permit projects, provided they did not use any prohibited substance (which is unlikely). Projects could not, however, be permitted by parties to the London Protocol.

4.4 International Agreements Governing Shipping

Various other international agreements could, in some circumstances, apply to ocean carbon dioxide removal projects. There are, for example, several international agreements regulating the transportation of materials via ship, which could occur in some projects. As an illustration, in ocean alkalinity enhancement projects, ground rock may be shipped from land for discharge into ocean waters. Alternatively, where ocean alkalinity enhancement is performed electrochemically, the hydrochloric acid generated during the process would need to be shipped back to shore.

The International Convention for the Prevention of Pollution from Ships (“MARPOL”) aims to prevent marine pollution due to operational or accidental releases from ships carrying harmful substances.¹⁴⁷ MARPOL includes six technical annexes, each dealing with a different source of pollution. Annex II deals with pollution from ships transporting “noxious liquid substances” in bulk.¹⁴⁸ For the purposes of Annex II, hydrochloric acid is considered a noxious liquid waste,¹⁴⁹ and thus can only be carried on ships meeting certain design, construction, and operational standards

¹⁴⁷ International Convention for the Prevention of Pollution from Ships, Nov. 2, 2973.

¹⁴⁸ *Id.* Annex II.

¹⁴⁹ *Id.* Annex II, reg. 1 (defining “noxious liquid substance” to include “any substance identified in the Pollution Category column of chapter 17 or 18 of the International Bulk Chemical Code”). *See also* Int’l. Maritime Org., International Bulk Chemical Code, Chapter 17, <https://perma.cc/4KMR-HWQF> (listing “hydrochloric acid” as a pollutant).

specified in the Annex.¹⁵⁰ With some limited exceptions, Annex II prohibits ships from discharging hydrochloric acid and other noxious liquid substances into the sea,¹⁵¹ but that is unlikely to impede electrochemical ocean alkalinity enhancement projects because the acid generated therein would be captured and returned to shore. Other ocean alkalinity enhancement projects that involve discharging ground rock into ocean waters would not be subject to the restrictions in Annex II of MARPOL because the rock materials do not constitute “noxious liquid substances” regulated under the Annex. Nor are the materials regulated under any other Annex of MARPOL.

Another potentially relevant international agreement is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (“Basel Convention”), which regulates the import and export of certain waste materials that have been classified as hazardous.¹⁵² The Basel Convention defines “waste” to mean “substances or objects which are disposed of or are intended to be disposed of”¹⁵³ and includes, in Annex IV, a list of activities that constitute “disposal.”¹⁵⁴ The list in Annex IV includes, as a form of disposal, “[r]elease into seas/oceans.”¹⁵⁵ Rock-based ocean alkalinity enhancement involves the release of materials into ocean waters and thus could be considered a form of disposal under the Basel Convention. However, even if this were the case, the Basel Convention is unlikely to apply to the import / export of materials for ocean alkalinity enhancement for two reasons:

1. The Basel Convention does not apply to materials “the discharge of which is covered by another international agreement.”¹⁵⁶ As discussed in Part 4.3 above, the London Convention and London Protocol are likely to apply to the discharge of materials for ocean alkalinity enhancement, removing it from the scope of the Basel Convention.

¹⁵⁰ *Id.* Annex II, reg. 11-12.

¹⁵¹ *Id.* Annex II, reg. 13.

¹⁵² Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal, Mar. 22, 1989.

¹⁵³ *Id.* Art. 2(1).

¹⁵⁴ *Id.* Art. 2(4) & Annex IV.

¹⁵⁵ *Id.* Annex IV(A).

¹⁵⁶ *Id.* Art. 1(4).

2. 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.¹⁵⁷ The rock proposed for use in ocean alkalinity enhancement is not listed as hazardous in Annex I to the Convention or U.S. domestic legislation. A review would need to be conducted to determine if any other country has classified the rock as hazardous but, given its nature, that appears unlikely.

The Basel Convention also would not apply to the import/export of hydrochloric acid generated as a by-product of electrochemical ocean alkalinity enhancement. Regardless of whether it has been classified as hazardous by any country, the acid is not a “waste” for the purposes of the Basel Convention because it is destined for use in industrial processes and not disposal.

4.5 Potentially Relevant European Union Instruments

The EU has not adopted explicit regulations applicable to ocean-based carbon dioxide removal.¹⁵⁸ However, general environmental rules and standards may apply to ocean carbon dioxide removal strategies. The Treaty on the Functioning of the European Union (“TFEU”) establishes that EU environmental policy must be based on the precautionary principle.¹⁵⁹ Although the precautionary principle is not defined by the TFEU, the EU General Court, formerly called the Court of First Instance, has found that the principle applies in situations where there is scientific uncertainty about a preventive measure.¹⁶⁰ In such situations, the Court reasons that political institutions should determine an appropriate level of protection for society from the preventive measure, and that scientific experts should undertake a risk assessment before the preventive measure is deployed.¹⁶¹ Research into ocean carbon dioxide removal and trials of different approaches could be justified as a way of informing decisions on deployment under the

¹⁵⁷ *Id.* Art. 1(1).

¹⁵⁸ Ralph Bodle et al., *Options and Proposals for the International Governance of Geoengineering*, Ecologic Institute, Berlin 106 (2014); Stefan Schäfer et al., *The European Transdisciplinary Assessment of Climate Engineering (EuTRACE): Removing Greenhouse Gases from the Atmosphere and Reflecting Sunlight away from Earth* 92 (2014).

¹⁵⁹ Consolidated version of the Treaty on the Functioning of the European Union, Article 191(2) (2012), <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN>.

¹⁶⁰ Case T-13/99, *Pfizer Animal Health v. Council*, 2002 E.C.R II-3318, 3375.

¹⁶¹ *Id.* at 3375–81

precautionary principle. The TFEU clarifies that, in areas of research and technological development, the EU has competency to define and implement programs, but this shall not prevent Member States from exercising their own competency.¹⁶² In other words, the EU may establish its own programs to research ocean alkalinity enhancement and seaweed cultivation strategies, but this would not prevent Member States from separately researching these strategies. Proposed amendments in 2020 to the European Climate Law, although they do not lay out specifics, state that “[t]he natural sink of forests, soils, agricultural lands and wetlands should be maintained and further increased and carbon removal technologies, such as carbon capture and storage and carbon capture and utilisation, should be made cost-effective and deployed.”¹⁶³

Ocean carbon dioxide removal activities in EU waters would need to be in accord with the EU Marine Strategy Framework Directive, which applies to the territorial seas of Member States and extends out to the edge of each State’s jurisdictional rights,¹⁶⁴ meaning typically the EEZ up to 200 n.m. from shore.¹⁶⁵ The Directive aims to protect and preserve the marine environment, and prevent and reduce inputs with a view to phasing out marine pollution,¹⁶⁶ defined as:

[T]he direct or indirect introduction into the marine environment, as a result of human activity, of substances or energy, including human-induced marine underwater noise, which results or is likely to result in deleterious effects such as harm to living resources and marine ecosystems, including loss of biodiversity, hazards to human health, the hindering of marine activities, including fishing, tourism and recreation and other legitimate uses of the sea.¹⁶⁷

As described above, both ocean alkalinity enhancement and large-scale seaweed cultivation may require the addition of materials to ocean waters, which could have potentially harmful impacts

¹⁶² Consolidated version of the Treaty on the Functioning of the European Union, Article 4(3) (2012), <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN>.

¹⁶³ Proposal for a Parliament and Council Regulation 2020/0036 at 7 (2020) <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0080&from=EN>.

¹⁶⁴ Council Directive 2008/56/EC, Art. 3(1)(a) 2008 O.J. (L 164). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0056-20170607>.

¹⁶⁵ Ronan Joseph Long, *The Marine Strategy Framework Directive: A New European Approach to the Regulation of the Marine Environment, Marine Natural Resources and Marine Ecological Services*, 29 J. ENERGY & NAT. RESOURCES L. 1, 22–23 (2011).

¹⁶⁶ Council Directive, *supra* note 164, Art. 1(2).

¹⁶⁷ *Id.* at Art. 3(8).

on biodiversity. Both strategies, but especially seaweed cultivation, could compete for space with fishing, tourism, and recreation in the oceans.

In order to ensure pollution is avoided, EU Member States were required to develop and implement a marine strategy by 2016, including an assessment of the environment status of marine waters, and a program of measures to achieve or maintain good environmental status.¹⁶⁸ If Member States do not meet their reporting obligations, the Commission may refer them to the European Court of Justice.¹⁶⁹ Member States must review these marine strategies every six years,¹⁷⁰ so if seaweed cultivation or ocean alkalinity enhancement were ramped up, Member States may need to demonstrate in their review that the plans result in the avoidance of harm to the marine environment.

Several other EU directives and policy initiatives may also apply to seaweed cultivation. Two stand out as especially relevant. The Marine Strategy Framework Directive aims to ensure that aquaculture development does not negatively affect biodiversity, introduce invasive species, or contribute to eutrophication.¹⁷¹ The Maritime Spatial Planning Directive states that use of maritime spaces for multiple purposes requires integrated planning of space usage.¹⁷² Thus, for seaweed cultivation to expand significantly in the EU for carbon dioxide removal purposes, cultivation will need to avoid both biodiversity and competing space challenges. Currently, however, there is no EU licensing scheme for seaweed cultivation specifically or aquaculture more generally.¹⁷³

¹⁶⁸ *Id.* at Art. 5(2).

¹⁶⁹ See, e.g., European Commission, *Marine environment: Commission decides to refer BULGARIA to the Court of Justice of the EU over late reporting under the Marine Strategy Framework Directive* (2020), https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1234.

¹⁷⁰ Council Directive, *supra* note [164], Art. 17(2).

¹⁷¹ Consolidated Council Directive 2008/56/EC, Annex I, 2008 O.J. (L 164), <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN>.

¹⁷² Council Directive 2014/89/EU, Preamble, 2014 O.J. (L 257) 135, 135, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0089&from=EN>.

¹⁷³ See Bodle et al. & Schäfer et al., *supra* note 158.

5. U.S. LAWS GOVERNING OCEAN ALKALINITY ENHANCEMENT AND SEAWEED CULTIVATION

As discussed in Part 3 above, the U.S. has jurisdiction over offshore areas extending 200 n.m. from its coast, and further in some circumstances.¹⁷⁴ Under international law, the U.S. has full “sovereign rights” within that area, including rights to explore, exploit, conserve, and manage natural resources.¹⁷⁵ The U.S. is responsible for protecting and preserving the marine environment and must oversee marine scientific research and the development and use of artificial islands and other structures within its jurisdictional areas.¹⁷⁶ This part discusses key U.S. federal and state laws that could apply to ocean alkalinity enhancement and seaweed cultivation projects undertaken in areas under U.S. jurisdiction.

5.1 Siting Facilities in U.S. Waters

Ocean alkalinity enhancement and seaweed cultivation projects could, in some circumstances, require use of the seabed. For example, where wind energy is used to power electrochemical ocean alkalinity systems, offshore wind turbines would likely need to be anchored to the seabed.¹⁷⁷ Seaweed cultivation could also be co-located with offshore wind turbines. In order to take advantage of higher wind speeds further from shore, the wind turbines would likely be situated in federal waters, but some projects could occur closer to shore.

5.1.1 Projects in U.S. Federal Waters

Persons wishing to make use of the OCS underlying U.S. federal waters (extending three, or in Texas and west coast of Florida, nine to 200 n.m. from the coast) must obtain approval from the federal government.¹⁷⁸ The Department of the Interior’s Bureau of Ocean Energy Management

¹⁷⁴ See *supra* Part 3.1.

¹⁷⁵ UNCLOS, *supra* note 64, Art. 56(1)(a).

¹⁷⁶ *Id.* at Art. 56(1)(b).

¹⁷⁷ Floating wind turbines, although not yet a widely used technology, are in early development. See Xin Shen et al., *Study of the unsteady aerodynamics of floating wind turbines*, 145 ENERGY 793, 793 (2018).

¹⁷⁸ ADAM VANN, CONG. RESEARCH SERV., R40175, WIND ENERGY: OFFSHORE PERMITTING 3 (2012), <https://perma.cc/36W3-3E66> (indicating that “[u]se of federal and federally controlled lands, including the OCS [i.e., the outer continental shelf], requires some form of permission”).

(“BOEM”) is authorized to lease areas of the OCS under the OCSLA.¹⁷⁹ Under section 8(p)(1) of the OCSLA, BOEM may only grant leases for activities that:

- (A) support exploration, development, production, or storage of oil or natural gas . . . ;
- (B) support transportation of oil or natural gas, excluding shipping activities;
- (C) produce or support production, transportation, or transmission of energy from sources other than oil and gas; or
- (D) use, for energy-related purposes or for other authorized marine-related purposes, facilities currently or previously used for activities [relating to oil, gas, and other mineral development on the OCS].¹⁸⁰

BOEM could issue leases for the development of wind turbines to power electrochemical ocean alkalinity enhancement or seaweed cultivation projects under paragraph (C) above. Leases must be issued through a competitive auction process, unless BOEM determines that there is no competitive interest in the area.¹⁸¹ BOEM can propose areas for leasing on its own motion or accept requests from interested parties but, in both cases, must publish a notice in the Federal Register seeking expressions of interest in the area.¹⁸² If an expression(s) of interest is received, BOEM must auction leases;¹⁸³ otherwise leases will be issued on a non-competitive basis.¹⁸⁴

When issuing leases, BOEM must comply with various procedural requirements, including conducting an environmental review, and consulting with other federal, state, and local government agencies as follows:

- The National Environmental Policy Act (“NEPA”) requires federal agencies, including BOEM, to conduct an environmental impact statement (“EIS”) for any major federal action “significantly affecting the quality of the human environment.”¹⁸⁵ The requirement applies whether the agency

¹⁷⁹ 43 U.S.C. § 1301 et seq.

¹⁸⁰ 43 U.S.C. § 1337(p)(1).

¹⁸¹ *Id.* § 1337(p)(3). *See also* 30 C.F.R. Part 585, Subpart B. For a more detailed discussion of federal requirements on BOEM leasing, *see* ROMANY M. WEBB & MICHAEL B. GERRARD, POLICY READINESS FOR OFFSHORE CARBON DIOXIDE STORAGE IN THE NORTHEAST 17-21 (2017), <https://perma.cc/V3NF-7VE5>.

¹⁸² 30 C.F.R. §§ 585.210 & 585.230.

¹⁸³ *Id.* §§ 585.220 & 585.231.

¹⁸⁴ *Id.* §§ 585.212 & 585.231.

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

takes the action itself or authorizes or funds the action.¹⁸⁶ The EIS must assess the natural, economic, social, and cultural resource effects of the action,¹⁸⁷ and the agency is required to release relevant documents to the public and consider their input.

- Under the Endangered Species Act (“ESA”),¹⁸⁸ BOEM must consult with the Fish and Wildlife Service (“FWS”) before issuing any lease or taking any other action that may affect terrestrial or freshwater species, which have been listed as endangered¹⁸⁹ or threatened¹⁹⁰.¹⁹¹ BOEM consults with FWS to ensure activities do not harm seabirds under the Migratory Bird Treaty Act.¹⁹² Where an action may affect endangered or threatened marine species, or could harm “essential fish habitat” designated under the Magnuson-Stevens Fishery Conservation and Management Act, BOEM must consult with the National Marine Fisheries Service (“NMFS”).¹⁹³ The National Marine Sanctuaries Act makes it unlawful to “destroy, cause the loss of, or injure any sanctuary resource managed under law or regulations for that sanctuary” in any area designated a marine sanctuary by the Secretary of Commerce.¹⁹⁴ Any anchoring or discharging of material in a marine sanctuary would require a permit from NOAA.¹⁹⁵
- BOEM is also required to ensure authorized activities do not harm historic properties and religious sites of importance to American Indians. The National Historic Preservation Act requires federal agencies to take into account the effect of any license authorization on historic properties.¹⁹⁶ On the OCS, these include shipwrecks, sunken aircraft, and prehistoric

¹⁸⁶ 40 C.F.R. § 1508.18(a).

¹⁸⁷ 42 U.S.C. 4332(2)(C).

¹⁸⁸ 30 C.F.R. § 585.203.

¹⁸⁹ A species is considered “endangered” if it “is in danger of extinction throughout all or a significant portion of its range.” *See* 16 U.S.C. § 1532(6).

¹⁹⁰ A species is considered “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.* § 1532(20).

¹⁹¹ *Id.* § 1536(a)(2).

¹⁹² *Id.* § 703(a).

¹⁹³ *Id.* § 1855(b)(2).

¹⁹⁴ *Id.* § 1436(1).

¹⁹⁵ *See, e.g.*, 15 C.F.R. §§ 922.61-62.

¹⁹⁶ 54 U.S.C. §§306101-31

archeological sites.¹⁹⁷ If a place of religious significance to American Indians may be affected, BOEM may need to consult with Indian religious practitioners pursuant to the American Indian Religious Freedom Act.¹⁹⁸

- BOEM must consult with other federal agencies with an interest in, and state and local governments affected by, the lease.¹⁹⁹ Where the BOEM lease will affect²⁰⁰ land or water use or natural resources in state waters, and the relevant state has adopted a management plan under the Coastal Zone Management Act (“CZMA”), BOEM must ensure consistency with the state plan.²⁰¹ BOEM must submit a consistency determination to the relevant state,²⁰² and, if the state objects to the determination, BOEM must work with it to address the objection.²⁰³

Once BOEM has completed the various reviews and consultations, it will evaluate the effect of leasing on the human, marine, and coastal environments.²⁰⁴ It must then develop measures to mitigate any adverse effects.²⁰⁵

¹⁹⁷ BOEM, *National Historic Preservation Act*, <https://perma.cc/N6KH-2CWN> (last visited Jan. 21, 2020).

¹⁹⁸ BOEM, *Characterizing Tribal Cultural Landscapes Volume I: Project Framework* (2017), <https://perma.cc/J9ZP-EUAF>; 42 U.S.C. §1996.

¹⁹⁹ 43 U.S.C. § 1337(p)(7) (requiring the BOEM to “provide for coordination and consultation with the Governor of any State or the executive of any local government that may be affected by a lease”); 30 C.F.R. § 585.203 (providing that, when awarding leases, the BOEM will consult with “relevant federal agencies” and “any affected State, the executive of any affected local government, and any affected Indian Tribe).

²⁰⁰ An activity “will affect” land or water use or natural resources if it has “any reasonably foreseeable effect on any coastal use or resource . . . Effects are not just environmental effects, but include effects on coastal uses. Effects include both direct effects which result from the activity and occur at the same time and place as the activity, and indirect (cumulative and secondary) effects which result from the activity and are later in time or farther removed in distance, but are still reasonably foreseeable.” 15 C.F.R. § 930.11(g).

²⁰¹ 16 U.S.C. § 1456(c).

²⁰² *Id.* § 1456(c)(1)(C); 15 C.F.R. § 930.39.

²⁰³ If resolution cannot be reached, BOEM may only proceed with leasing after serving the state with a notice, which clearly describes how leasing is consistent with the state management plan, to the maximum extent practicable. *See id.* § 930.43.

²⁰⁴ 30 C.F.R. § 585.211(b)(2).

²⁰⁵ *Id.* § 585.211(2).

With a BOEM-issued lease in hand, the lessee has the right to install and operate facilities on a designated portion of the OCS,²⁰⁶ subject to the lessee obtaining any necessary approvals from other agencies.²⁰⁷ If the lessee wishes to install a structure that will be permanently or temporarily attached to the seabed, he/she/it must obtain a permit from the Army Corps of Engineers (“ACE”).²⁰⁸ Thus, for example, an ACE permit would be required to anchor or otherwise attach offshore wind platforms or other facilities to the seabed. In issuing permits, ACE evaluates the probable impacts of construction of the facility on the public interest, balancing its beneficial and detrimental effects.²⁰⁹ As part of this balancing test, ACE will consider the need for the construction, and its likely effect on other uses of the area.²¹⁰ In addition, if the construction is in an area with recognized historic, cultural, scenic, conservation, recreational, or similar values, ACE must consider its likely effects on those values.²¹¹ ACE must also complete any necessary environmental and/or other reviews, for example, under NEPA²¹² and work with the relevant coastal state(s) to ensure the project is consistent with any management plan(s) adopted under the CZMA.²¹³

Construction of offshore wind platforms and other facilities may also raise supply chain and flight path consideration considerations. To the extent that any construction is deemed to be engaging in trade, the vessels carrying construction materials may need to obtain a certificate of

²⁰⁶ *Id.* § 585.200(a).

²⁰⁷ *Id.* For a more detailed discussion, see Webb & Gerrard, *supra* note 181, at 24-26.

²⁰⁸ 33 C.F.R. § 322.3(a)-(b).

²⁰⁹ *Id.* § 320.4(a)(1).

²¹⁰ *Id.* § 320.4(a)(2).

²¹¹ *Id.* § 320.4(e).

²¹² *Id.* §§ 320.4(h), 325.2(a)(4). ACE’s NEPA review will need to be coordinated with any reviews undertaken by other federal, state, and/or local agencies.

²¹³ 16 U.S.C. § 1456(c). Under the CZMA, all federally-approved actions that affect coastal uses or resources must be consistent with state management plans, to the maximum extent practicable. See *Id.* § 1456(c)(3). This includes actions undertaken by non-federal agencies that require federal approval. Such actions are deemed to affect coastal uses or resources if they occur within state waters and the relevant state has listed the action in its management plan. See 15 C.F.R. § 930.53. Actions requiring ACE permits have been listed in the management plans adopted by Connecticut, Delaware, Massachusetts, New Jersey, New York, Rhode Island, and Virginia.

documentation with endorsement for that trade from the U.S. Coast Guard.²¹⁴ Trade includes the transportation of merchandise between points within 20 n.m. of shore,²¹⁵ which could include transportation of construction materials. The Jones Act further requires that shipping between U.S. ports must be conducted by U.S.-flag ships,²¹⁶ and within U.S. waters extending 200 n.m. offshore, platforms attached to the seabed must be serviced by U.S.-flag ships, if the ship departs from a U.S. port.²¹⁷ Building out the infrastructure of these projects would thus require investment both in the projects themselves and likely in U.S.-flag ships capable of carrying supplies to build and service them.

Federal Aviation Administration (“FAA”) regulations require notice for any the construction of any structure above 200 feet.²¹⁸ If the FAA decides the structure may result in obstruction or interference with the navigable airspace, the agency will then conduct a study to determine the extent of the adverse impact.²¹⁹ Wind turbines specifically may be required to meet white paint and synchronized red light requirements.²²⁰

5.1.2 Projects in U.S. State Waters

Seaweed cultivation projects would likely be undertaken relatively near to shore in U.S. state waters. Generally, as the land underlying state waters is publicly owned, a lease or similar authorization must be obtained from the relevant coastal state prior to the construction of any facilities utilizing the seafloor. Various other state approvals may also be required. Several coastal states have established environmental review requirements, sometimes referred to as little NEPAs, that require an assessment of the environmental impacts of permitted activities.²²¹ Further, several

²¹⁴ 42 U.S.C. § 12102.

²¹⁵ 46 C.F.R. § 67.3.

²¹⁶ 46 U.S.C. § 50101.

²¹⁷ JOHN FRITTELLI, CONG. RESEARCH SERV., R45725, SHIPPING UNDER THE JONES ACT: LEGISLATIVE AND REGULATORY BACKGROUND 9 (2019), <https://fas.org/sgp/crs/misc/R45725.pdf> .

²¹⁸ 14 C.F.R. § 77.9.

²¹⁹ 49 U.S.C. § 44718(b).

²²⁰ FAA, *Wind Turbine FAQs*, <https://perma.cc/K3XD-2TVF> (last updated Jan. 21, 2021).

²²¹ NEPA.gov, *States and Local Jurisdictions with NEPA-like Environmental Planning Requirements*, <https://perma.cc/Z674-SSZI> (last visited Jan. 21, 2021). Examples include the California

states have laws dealing specifically with aquaculture or seaweed farming. For example, in Alaska, a permit is required from the Alaska Department of Fish and Game to engage in seaweed farming in state waters.²²² Other states with similar requirements include California, where a license for commercial kelp harvesting is required by the California Department of Fish and Wildlife,²²³ and Maine, where an aquaculture farm lease may be required by the state Department of Marine Resources.²²⁴ In some states, state jurisdiction over coastal waters overlaps with local jurisdiction. For example, New York courts have recognized municipality ownership of submerged lands in some instances.²²⁵ This could create overlapping state and local permitting processes for aquaculture activities.²²⁶

Seaweed cultivation projects in state waters may also require various federal approvals. For example, vessels carrying materials to seaweed farms would likely need to obtain a certificate of documentation from the U.S. Coast Guard.²²⁷ Permits may also be required from ACE under the Rivers and Harbors Act (“RHA”) and the CWA. Under RHA, ACE permits are required for certain regulated activities, including the placement or removal of structures and modification of the navigable waterway, conducted within three miles of the shore.²²⁸ Seaweed farms could interfere with navigation and thus require ACE permits even if they do not involve structures attached to the

Environmental Policy Act, the New York State Environmental Quality Review Act, and similar acts in several other coastal states.

²²² Alaska Department of Fish and Game, *Applying for Operation Permit*, <https://perma.cc/7AXF-WS3V> (last visited Jan. 21, 2021)

²²³ California Department of Fish and Wildlife, *Commercial Harvest of Kelp and Other Marine Algae*, <https://perma.cc/73H2-HF79> (last visited Jan. 21, 2021).

²²⁴ State of Maine Department of Marine Resources, *Aquaculture Lease Applications and Forms*, <https://perma.cc/HT5G-B2RE> (last visited Jan. 21, 2021).

²²⁵ See, e.g., *Town of Oyster Bay v. Commander Oil Corp.*, 96 N.Y.2d 566, 572 (N.Y., 2001).

²²⁶ For instance, the Town of Islip, New York established a Bay Bottom Licensing Program, approved by the New York State Department of Environmental Conservation (DEC). See *Town of Islip, Great South Bay Shellfish Cultivation Facility*, <https://perma.cc/F43D-LOG5> (last visited Jan. 21, 2021). Across New York, DEC is responsible for issuing commercial fishing and aquaculture permits. 6 C.R.R.-N.Y. § 48.3(a).

²²⁷ 42 U.S.C. § 12102; 46 C.F.R. § 67.7, 67.3 (Any vessel that engages with fisheries must obtain a certificate, and fisheries under these regulations include marine vegetation).

²²⁸ 33 U.S.C. § 403.

sea floor. CWA section 404 permits are required to discharge dredge and fill materials into waters within three miles of the shore.²²⁹ This in turn would trigger a CWA section 401 water quality certification requirement from the state or tribe in which the discharge originates.²³⁰ Aquaculture projects typically require CWA permits because they discharge seabed sediments that qualify as fill materials under the Act.²³¹ These permits may either be issued as general permits, if impacts are minor, or individual permits, with more lengthy and complicated requirements.²³² Some analysis suggests that seaweed operations would require individual ACE permits, since large-scale commercial seaweed aquaculture is a relatively novel activity in the U.S. with little known environmental impacts.²³³

5.2 Discharging Materials into U.S. Waters

Ocean alkalinity enhancement and other carbon dioxide removal projects that involve discharging materials into ocean waters may, depending on exactly where they occur, be regulated under the Marine Protection, Research, and Sanctuaries Act (“MPRSA”).²³⁴ 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.²³⁵ The MPRSA defines “dumping” broadly to include any “disposition of material.”²³⁶ The term “material” is also defined broadly to mean “matter of any kind of

²²⁹ *Id.* § 1344.

²³⁰ *Id.* § 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.*

²³¹ Eric Laschever et al., *U.S. Aquaculture’s Promise: Policy Pronouncements and Litigation Problems*, 50 ENVTL. L. REP. 10826, 10828 (2020).

²³² Catherine Janasie & Amanda Nichols, *Navigating the Kelp Forest: Current Legal Issues Surrounding Seaweed Wild Harvest and Aquaculture*, 33 NAT. RESOURCES & ENV’T 17, 18 (2018).

²³³ *Id.*

²³⁴ 33 U.S.C. § 1401.

²³⁵ *Id.* § 1401(b).

²³⁶ *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

description.”²³⁷ Applying those definitions, the materials used for rock-based ocean alkalinity enhancement would constitute “material,” and their discharge into ocean waters would constitute “dumping” for the purposes of the MPRSA. The same is true of seaweed matter discharged into ocean waters from ships or platforms to facilitate sinking into the deep sea.

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:

- the materials to be dumped are transported from within the U.S. (regardless of where the dumping occurs);²³⁸ 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).²³⁹

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.”²⁴⁰ Dumping can only occur in EPA-designated dump sites, which are chosen to mitigate the adverse impacts of dumping on the

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.

²³⁷ *Id.* § 1402(c).

²³⁸ *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”).

²³⁹ *Id.* § 1411(a)(2) & (b).

²⁴⁰ *Id.* § 1412(a).

environment, as well as the extent to which it interferences with other activities.²⁴¹ At the time of writing, there were ninety-eight dump sites.²⁴² Ninety-seven of those sites were approved only for the dumping of dredged material (i.e., removed from beneath navigable waters) and one only for the dumping of fish processing wastes.²⁴³ Thus, because ocean alkalinity enhancement and seaweed cultivation projects would not use dredged material or fish processing wastes, none of the existing dump sites could be used for such projects (unless they were re-designated by EPA).

Persons wanting to engage in ocean alkalinity enhancement or seaweed sequestration could apply to EPA for designation of a new dump site or approval to use an existing site.²⁴⁴ On receiving an application, EPA will evaluate the physical, chemical, and biological characteristics of the site, as well as the impacts of past dumping in areas with similar characteristics, to determine whether it is suitable for use.²⁴⁵ EPA must also conduct an environmental review under NEPA²⁴⁶ and consult with various federal and state bodies as required under the ESA, Magnuson-Stevens Fisheries Conservation and Management Act, and the CZMA.²⁴⁷

Once EPA designates an area as a dump site, it may permit the dumping of materials therein. Permits are issued by the relevant EPA regional office, which must consider “the environmental effect of the proposed dumping operation, the need for ocean dumping, alternatives to ocean dumping, and the effect of [dumping] on esthetic, recreational and economic values and on other uses of the oceans.”²⁴⁸

²⁴¹ *Id.* § 1412(c); 40 C.F.R. § 228.5.

²⁴² Env'tl. Prot. Agency, *Ocean Disposal Map*, OCEAN DUMPING, <https://perma.cc/XG2L-UYLG> (last visited Jan. 21, 2021).

²⁴³ *Id.*

²⁴⁴ 40 C.F.R. § 221.1(f).

²⁴⁵ *Id.* §§ 228.4 & 228.6.

²⁴⁶ 42 U.S.C. § 4321 et seq. NEPA requires federal agencies to prepare an environmental impact statement (EIS) in relation to any major federal action that “significantly affect[s] the quality of the human environment.” *See id.* § 4332(2)(C). That requirement has been held not to apply to actions taken under the MPRSA, but EPA voluntarily conducts a NEPA review when designating sites pursuant to the Act. *See Policy and Procedures for Voluntary Preparation of National Environmental Policy Act (NEPA) Documents*, 63 Fed. Reg. 58045, 58046 (Oct. 29, 1998).

²⁴⁷ *See supra* Part 5.1.1.

²⁴⁸ 40 C.F.R. § 227.1.

5.3 Related Activities

While both ocean alkalinity enhancement and seaweed cultivation are performed offshore, they may necessitate various onshore activities. Rock-based ocean alkalinity enhancement will, for example, require the mining and processing of suitable rocks on land. Ocean alkalinity enhancement performed using electrochemical processes will generate by-products (e.g., hydrochloric acid) that will be transported back to land and used in industrial processes.

5.3.1 Mining and Processing of Materials for Use in Rock-Based OAE

Mining and processing activities are regulated under various federal, state, and local laws. Before any activities can occur, the miner must obtain rights to the relevant minerals. Where the minerals are privately owned, the miner may contract with their purchase or lease. The procedure for obtaining rights to minerals under federal and state ownership is more complex.

The U.S. federal government owns approximately 700 million acres of subsurface mineral resources.²⁴⁹ 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.²⁵⁰ 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 Indian or military reservations.²⁵¹ 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 land under the General Mining of Law of 1987,²⁵² which confers broad rights on U.S. citizens and certain others (“eligible miners”) to explore for and extract “valuable mineral

²⁴⁹ Bureau of Land Mgmt., *What We Manage*, ABOUT, <https://perma.cc/85KT-ARDP> (last visited Jan. 8, 2021).

²⁵⁰ 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>.

²⁵¹ Bureau of Land Mgmt., *Locating a Mining Claim*, MINING CLAIMS, <https://perma.cc/COH6-7VBS> (last visited Jan. 8, 2021).

²⁵² 30 U.S.C. § 22 et seq. Some materials have been excluded from the scope of the General Mining Law. See *id.* § 611.

deposits.”²⁵³ Under the General Mining Law, eligible miners can acquire rights to federally-owned minerals through a process known as “location,” which is based on historic claim-staking practices.²⁵⁴ 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.²⁵⁵ On location, the miner acquires an unpatented claim to the land and minerals, which gives him/her exclusive rights to mine the site.²⁵⁶ However, before engaging in mining activities, the miner must generally submit an operating plan to BLM for approval.²⁵⁷ On receiving the plan, BLM must make it available for public review and comment.²⁵⁸ BLM must also conduct an environmental review under NEPA and, where activities could harm endangered or threatened species, consult with FWS under the ESA.²⁵⁹ BLM may approve the plan if it determines that the proposed mining activities will not result in “unnecessary or undue degradation of public lands.”²⁶⁰

The above system of location cannot be used to claim so-called “common varieties” of limestone found on federal land.²⁶¹ That stone must, instead, be purchased from the federal

²⁵³ *Id.* § 22.

²⁵⁴ BUREAU OF LAND MGMT., MINING CLAIMS AND SITES ON FEDERAL LANDS (2011), <https://perma.cc/8P9U-U489>.

²⁵⁵ 43 C.F.R. §§ 3832.1 - 3821.12.

²⁵⁶ 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.

²⁵⁷ 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).

²⁵⁸ *Id.* § 3809.411.

²⁵⁹ *Id.*

²⁶⁰ *Id.*

²⁶¹ The Multiple Surface Use Act of 1955 excluded “common varieties of sand, stone, gravel, pumice, pumicite, [] cinders and . . . petrified wood” from the scope of the General Mining Law. *See* 30 U.S.C. § 611. For the purposes of the Multiple Surface Use Act, the term “stone” has been interpreted broadly to include limestone. *See* BUREAU OF LAND MGMT., H-3630-1 MINERAL MATERIALS FAIR MARKET VALUE (FMV) EVALUATIONS (P) 3 (2016), <https://perma.cc/EB8H-ST8C>. The exclusion in the Multiple Surface Use Act does not, however, apply to “limestone of chemical

government under the Materials Act of 1947.²⁶² The Materials Act authorizes BLM to sell common varieties of limestone and certain other materials on federal land outside national forests, provided that the sale would “not be detrimental to the public interest,” in the sense that “the aggregate damage to public lands and resources would exceed the public benefits that BLM expects” from the sale.²⁶³ Sales cannot occur on land that has been identified as inappropriate for mining in a resource management plan issued by BLM.²⁶⁴ In other areas, stone is generally sold through a competitive auction process, after which BLM may award the highest bidder a contract for sale.²⁶⁵ Prior to awarding the contract, BLM may direct the bidder to submit an operating plan²⁶⁶ and must complete any required environmental reviews and consultations, for example under NEPA and the ESA.

Most state-owned rock and minerals are also available for purchase or lease.²⁶⁷ 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.²⁶⁸

or metallurgical grade or that is suitable for making cement.” That limestone is subject to location under the Mining Law. *See* 43 C.F.R. § 3830.12.

²⁶² 30 U.S.C. § 601.

²⁶³ *Id.* *See also* 40 C.F.R. § 3601.11. Materials located on land situated in national forests may be sold by the Secretary of Agriculture (through the Forest Service) under the Materials Act. *See* 30 U.S.C. § 601.

²⁶⁴ 43 C.F.R. § 3601.12(c).

²⁶⁵ The highest bidder will only be awarded a contract for sale if his/her/its bid is equal to or above the fair market value of the materials and he/she/it is able to meet any obligations imposed by BLM. *See id.* §§ 3602.41, 3602.43, & 3602.45. BLM can enter into non-competitive contracts for sale in some circumstances. *See id.* § 3602.31.

²⁶⁶ *Id.* §§ 3601.40-3691.44.

²⁶⁷ *See generally*, AARON M. FLYNN, CONG. RESEARCH SERV., RL32813, HARDROCK MINING: STATE REGULATION (2005), <https://www.everycrsreport.com/reports/RL32813.html>.

²⁶⁸ *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

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 laws. For example:

- 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”).²⁶⁹ Pursuant to the CAA, EPA has established National Ambient Air Quality Standards for two classes of particulate matter—PM_{2.5} (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).²⁷⁰ 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 PM_{2.5} or PM₁₀.²⁷¹ Some states also require permits for other facilities, such as those that emit PM_{2.5} or PM₁₀ at levels below the major source threshold or emit larger particles (i.e., exceeding 10 microns in diameter).²⁷² Many also impose additional requirements, e.g., mandating the use of control measures to limit dust from the handling, transport, and storage of mined materials.²⁷³
- Mining and processing operations that involve the discharge of rock or other materials into waterways may require a permit under the CWA.²⁷⁴ A permit is required under the CWA to discharge any “pollutant,”²⁷⁵ with that term defined broadly to include “rock, sand, cellar dirt,

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”).

²⁶⁹ 42 U.S.C. § 7401 et seq.

²⁷⁰ National Ambient Air Quality Standards for Particulate Matter, 85 Fed. Reg. 82,684 (Dec. 18, 2020).

²⁷¹ 42 U.S.C. §§ 7475, 7502, 7503. The size threshold for “major” stationary sources varies depending on local air quality (among other things).

²⁷² 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).

²⁷³ See e.g., 9 VA. ADMIN. CODE § 5-40-90 (requiring “reasonable precautions” to be taken to prevent dust from storage piles becoming airborne).

²⁷⁴ 33 U.S.C. § 1251 et seq.

²⁷⁵ *Id.* §§ 1311, 1342, & 1344.

and industrial, municipal, and agricultural waste.”²⁷⁶ 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.”²⁷⁷ 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 comprises mining overburden, tailings, or similar rock-based material, the discharge must be permitted by the Army Corps of Engineers or an authorized state agency under section 404 of the CWA.²⁷⁸ A section 402 (NPDES) permit from EPA or an authorized state agency is required for the discharge of other materials.²⁷⁹

- Mining wastes that are not discharged into waterways must be handled in accordance with the requirements of the Resource Conservation and Recovery Act (“RCRA”).²⁸⁰ Most mining wastes are regulated as non-hazardous wastes under subtitle D of RCRA.²⁸¹ EPA regulations, adopted under subtitle D, impose limited restrictions on where and how non-hazardous wastes can be disposed of.²⁸² States can and have adopted additional, more stringent requirements, with some

²⁷⁶ *Id.* § 1362(6).

²⁷⁷ *Id.* §§ 1362(12), (14), & (16).

²⁷⁸ *Id.* § 1344 (authorizing the Army Corps of Engineers or an approved state to issue permits “for the discharge of dredged or fill material”). 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).

²⁷⁹ 30 U.S.C. § 1342 (authorizing EPA or an approved state to issue permits “for the discharge of any pollutant” other than dredged or fill material).

²⁸⁰ 42 U.S.C. § 6901 et seq.

²⁸¹ 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 BENEFICATION OF METALLIC ORES, PHOSPHATE ROCK, ASBESTOS, OVERBURDEN FROM URANIUM MINING, AND OIL SHALE (1985), <http://perma.cc/869U-X5MW>.

²⁸² 40 C.F.R. Pt. 257.

mandating that non-hazardous waste only be disposed of at designated facilities or in designated ways.²⁸³

5.3.2 Transporting By-Products from Electrochemical Ocean Alkalinity Enhancement

The hydrochloric acid produced during electrochemical ocean alkalinity enhancement would most likely be transported to shore via ship. While in U.S. waters, the ships would be regulated by the U.S. Coast Guard or the U.S. Department of Transportation, depending on how the acid is transported. The U.S. Coast Guard regulates ships transporting hydrochloric acid in bulk, while the Department of Transportation, through the Pipeline and Hazardous Materials Administration (“PHMSA”), regulates the non-bulk transportation of hydrochloric acid.

U.S. Coast Guard regulations require ships transporting hydrochloric acid in bulk to be certified and meet various design and other requirements.²⁸⁴ For example, the ships must transport hydrochloric acid in an independent cargo tank that does not form part of the hull, is separated from bunkers by double walls, and is lined with natural rubber, neoprene, or other approved materials.²⁸⁵ The ship must display a warning sign during load and unloading of the tanks and carry documentation indicating, among other things, the amount of hydrochloric acid on board and its location.²⁸⁶

The above requirements only apply to ships transporting hydrochloric acid in bulk. Ships engaged in non-bulk transportation are subject to different requirements, set out in regulations adopted pursuant to the Hazardous Materials Transportation Act (“HMTA”).²⁸⁷ For the purposes of the HMTA, hydrochloric acid has been designated as a hazardous material.²⁸⁸ Regulations issued under the HMTA require ships transporting hazardous materials to be registered with PHMSA.²⁸⁹

²⁸³ 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).

²⁸⁴ 46 C.F.R. § 153.900. See also *id.* § 153.1 and Table 1 to Part 153.

²⁸⁵ *Id.* §§ 153.252, 153.554, & 153.557. See also *id.* Table 1 to Part 153.

²⁸⁶ *Id.* §§ 153.901, 153.907, 153.955 & 153.1045.

²⁸⁷ 49 U.S.C. § 5101 et seq. Certain ships are exempt from the PHMSA regulations. See e.g., 49 C.F.R. § 176.5(b)(3) (exempting small ships of fifteen gross tons or less).

²⁸⁸ 49 C.F.R. § 172.101

²⁸⁹ *Id.* § 171.2.

Registered ships must transport hydrochloric acid in approved receptacles that are clearly marked as containing corrosive materials and stored in approved locations.²⁹⁰ While the receptacles are on board, the ship must carry documentation, including details of their contents and location.²⁹¹

Once the hydrochloric acid reaches shore, it would need to be offloaded to a temporary storage facility. Storage facilities accepting hydrochloric acid may, depending on their size, be subject to reporting requirements under the Emergency Planning and Community Right-to-Know Act (“EPCRA”).²⁹² The EPCRA applies to, among other things, facilities handling large amounts of any chemical that has been classified as posing a physical or health hazard.²⁹³ Health hazard chemicals include those that cause skin corrosion or irritation which is a characteristic of hydrochloric acid.²⁹⁴ Notably, however, only facilities handling 10,000 pounds (4,540 kilograms) or more of hydrochloric acid at any one time are subject to the EPCRA.²⁹⁵ Within three months of becoming subject to the EPCRA and annually thereafter, the facility must report to the relevant State Emergency Response Commission (or, if there is no Commission, the relevant state Governor).²⁹⁶

6. CONCLUSION

Deep economy-wide cuts in carbon dioxide and other greenhouse gas emissions are essential to avert the worst impacts of climate change. However, many scientists now agree that simply cutting future emissions will not be enough, and it will also be necessary to remove previously-emitted carbon dioxide from the atmosphere. There is growing interest in the potential for enhanced carbon dioxide removal via the oceans, which have absorbed approximately twenty-five percent of all carbon dioxide released into the atmosphere to date.²⁹⁷

²⁹⁰ *Id.* §§ 172.101, 172.442, 173.202, & 197.800.

²⁹¹ *Id.* §§ 176.24 & 176.30

²⁹² 42 U.S.C. § 11001 et seq.

²⁹³ 29 C.F.R. § 1910.1200(c); 40 C.F.R. § 370.2, 370.10, & 370.66.

²⁹⁴ 29 C.F.R. § 1910.1200(c) & Appendix A.

²⁹⁵ 40 C.F.R. § 370.10.

²⁹⁶ *Id.* §§ 370.30 & 370.40-370.41.

²⁹⁷ Gagern et al., *supra* note 20, at 9.

A number of approaches have been proposed for increasing carbon dioxide removal and storage in the oceans. One option is ocean alkalinity enhancement, which can be performed either by discharging ground alkaline rock into ocean waters or through an electrochemical process, involving the application of an electric current to water.²⁹⁸ Both techniques ultimately increase ocean pH levels, which enables greater uptake of carbon dioxide.²⁹⁹ Another approach to increase carbon dioxide uptake is seaweed cultivation, which involves the farming of kelp and other macroalgae that absorbs carbon dioxide as it grows and stores it in biomass.³⁰⁰

The legal framework applicable to ocean alkalinity enhancement, seaweed cultivation, and other carbon dioxide removal projects will differ depending on precisely where they occur. Under international law, each country has jurisdiction over areas within 200 n.m. of its coastline, and further in some circumstances.³⁰¹ In the U.S., coastal states have primary control over areas within three n.m. (or, in Texas and on the west coast of Florida, nine n.m.) of the coast, while the federal government controls U.S. waters further offshore.³⁰²

There are no international or U.S. federal laws dealing specifically with use of the oceans for carbon dioxide removal, but various general environmental and other laws could apply to projects depending on how they are conducted. Moreover, projects conducted in areas under the jurisdiction of other countries, would be subject to their laws. Potentially applicable laws in key countries will be explored in a series of (forthcoming) papers convened by the authors.

²⁹⁸ See *supra* Part 2.1.

²⁹⁹ *Id.*

³⁰⁰ See *supra* Part 2.2.

³⁰¹ See *supra* Part 3.1.

³⁰² See *supra* Part 3.2.