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Removing Carbon Dioxide Through Artificial Upwelling and Downwelling: Legal Challenges and Opportunities

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EXECUTIVE SUMMARY

Deep economy-wide cuts in carbon dioxide and other greenhouse gas emissions are essential to limit future climate change. A 2022 report by the Intergovernmental Panel on Climate Change warned that, to keep global average temperatures within 1.5°C above pre-industrial levels, emissions must reach net-zero by mid-century. The report concluded that achieving net-zero emissions will require the removal of carbon dioxide from the atmosphere “to counterbalance hard-to-abate emissions” from sectors like agriculture, aviation, and shipping. The report further noted that, if deployed at large scales, carbon dioxide removal (“CDR”) could also be used to achieve net negative emissions and thus effectively reduce the atmospheric concentration of carbon dioxide.

A variety of CDR techniques, both terrestrial and ocean-based, have been proposed. This paper focuses on artificial upwelling and downwelling, an ocean-based approach which uses large, vertical pipes to cycle water between the surface and deep ocean. The goal is to upwell nutrient rich water from depth to the surface, where it will stimulate the growth of phytoplankton that uptake carbon dioxide from the atmosphere, and downwell carbon dioxide-saturated water from the surface to depth. This should, in theory, result in carbon dioxide being taken out of the atmosphere and sequestered in the deep ocean. However, further research is needed to fully assess the carbon sequestration potential of artificial upwelling and downwelling, as well as its possible co-benefits and risks.

Uncertainty regarding the laws governing artificial upwelling and downwelling has been identified as a potential barrier to research and deployment. This paper helps to fill existing knowledge gaps by analyzing the application of international and domestic (U.S.) law to artificial upwelling and downwelling. Subsequent work will examine relevant domestic laws in selected other coastal countries.

The legal framework applicable to artificial upwelling and downwelling projects will depend on precisely where and how they are conducted. Generally speaking, under international law, the U.S. and other coastal countries have primary jurisdiction over areas within 200 nautical miles of their coastlines. U.S. states and the federal government share authority over the 200 nautical mile zone. Ocean waters located more than 200 nautical miles from the coast of any country form part of the so-called “high seas” and are open to use by all countries in accordance with international law.

Artificial upwelling and downwelling projects could be subject to various international environmental agreements. Examples include the United Nations Convention on the Law of the Sea (“UNCLOS”), the Convention on Biological Diversity (“CBD”), the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (“London Convention”), and the Protocol to that Convention (“London Protocol”). These agreements establish general requirements for ocean-based activities, but do not include provisions specific to artificial upwelling and downwelling, resulting in some uncertainty as to how the practice will be treated.

Among other things, UNCLOS establishes rules for the conduct of marine scientific research, which could apply to the in-ocean testing of artificial upwelling and downwelling systems in some circumstances. The CBD, London Convention, and London Protocol each include provisions aimed at minimizing the impact of research and other activities on the marine environment. The parties have adopted several decisions dealing with ocean fertilization for CDR, but there is disagreement as to whether those instruments also apply to CDR via artificial upwelling and downwelling.

The application of U.S. law to artificial upwelling and downwelling is similarly uncertain. U.S. states generally have primary jurisdiction over activities occurring within three nautical miles of the coast and further in some areas. Persons wanting to use the seabed in areas under state jurisdiction—e.g., to moor pipes or other equipment for use in artificial upwelling and downwelling—may require a state-issued lease and/or other approvals. Federal government approval is required to use the seabed of the U.S. outer continental shelf which, in most areas, extends three to 200 nautical miles from the coast. Projects may also be subject to environmental review and other requirements under U.S. federal and state law. A full list of requirements is included in Appendix A to this paper.

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ACRONYMS

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

1. INTRODUCTION

In the 2015 Paris Agreement, the international community vowed to “strengthen the global response to the threat of climate change,” including by “[h]olding the increase in global average temperatures to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.”¹ Since then, numerous reports by the Intergovernmental Panel on Climate Change (“IPCC”) and others have emphasized the importance of achieving the 1.5°C goal, warning that temperature increases above that level will lead to devastating heat-waves, droughts, floods, and other climate-induced changes.² For example, in a 2022 report, the IPCC warned that “[p]rojected increases in direct flood damage” will be up to 2 times higher with global warming of 2°C compared to 1.5°C.³ The impacts on human and natural systems will be significant. The IPCC’s 2022 report noted, for example, that warming above 1.5°C will increase the risk of “concurrent climate extremes” which will, in turn, increase the potential for “simultaneous crop losses” and create other “food security risks” that could lead to widespread malnutrition.⁴ Other species will also be impacted, with the IPCC finding that “damages to and transformation of ecosystems are already key risks for every region due to past global warming and will continue to escalate with every increment of global warming.”⁵

To date, warnings from the IPCC and others have gone largely unheeded by the international community, which has continued to emit substantial carbon dioxide and other greenhouse gases (“GHGs”). As a result, atmospheric carbon dioxide levels are now higher than at any other point in the last two million years, and global average temperatures are already 1.09°C above pre-industrial levels.⁶ Rapid and significant emissions reductions are essential to limit further temperature increases. A 2022 IPCC report concluded that emissions must reach net-zero by the early 2050s to keep global warming to 1.5°C or by the early 2070s to keep warming to 2°C.⁷ The report further found that achieving net-zero emissions will require the “deployment of [carbon dioxide removal (“CDR”) technologies] to counterbalance hard-to-abate residual emissions” from “agriculture, aviation, shipping, [and] industrial processes.”⁸ According to the report, CDR could also be used to “lower[] net . . . emissions in the near-term,” and to achieve “net negative . . . emissions in the long-term if deployed at levels exceeding annual residual emissions.”⁹

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

2 See e.g., 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); Hans-O. Pörtner et al., *Summary for Policymakers in CLIMATE CHANGE 2022: IMPACTS, ADAPTATION AND VULNERABILITY* (Hans-O. Pörtner et al. eds, 2022).

3 Pörtner et al, *supra* note 2, at SPM-14.

4 *Id.* at SPM-14 & SPM-19.

5 *Id.* at SPM-14.

6 Richard P. Allan et al., *Summary for Policymakers in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS 5 & 8* (Valerie Masson-Delmotte et al. eds., 2021).

7 Jim Skea et al., *Summary for Policymakers in CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE SPM-30* (2022).

8 *Id.* at SPM-47 – SPM-48.

9 *Id.* at SPM-48.

A number of CDR techniques have been proposed, all of which aim to take carbon dioxide out of the atmosphere, and store or utilize it in some way. This could occur on land, for example, through reforestation and afforestation (i.e., wherein trees and other plants are used to absorb and store carbon dioxide) and direct air capture and sequestration (i.e., wherein carbon dioxide is removed through a mechanical process and injected underground for long-term storage).¹⁰ However, these and other land-based approaches often require large amounts of land, energy, water, and other resources, which could lead to conflicts with other users and thus limit their deployment.¹¹ The potential for conflicts may be reduced where CDR is performed in the ocean.

A 2021 report by the National Academies of Sciences, Engineering, and Medicine (“NASEM”) found that the “ocean holds great potential for uptake and longer-term sequestration of” carbon dioxide and recommended research to advance understanding of six key ocean-based CDR techniques.¹² This paper focuses on one of those techniques—artificial upwelling (“AU”) and artificial downwelling (“AD”)—which aims to enhance the natural cycling of water between the deep ocean and the surface to increase uptake of carbon dioxide.¹³ This would be achieved by installing vertical pipes in the ocean to upwell cooler, more nutrient-rich water from depths to the surface, where it would stimulate the growth of phytoplankton that uptake carbon dioxide through photosynthesis.¹⁴ The pipes could also be used downwell surface water and thereby transport carbon dioxide to the deep ocean.¹⁵

The 2021 NASEM Report identified a number of potential barriers to AU / AD research and deployment. Among other things, the NASEM Report noted that there is “significant uncertainty” regarding the legal framework governing AU / AD research and deployment, both internationally and domestically in the U.S.¹⁶ This paper aims to fill that gap in knowledge, providing the first comprehensive analysis of how existing international and domestic (U.S.) law would apply to AU / AD projects. The remainder of the paper is structured as follows: Part 2 introduces AU / AD, its potential benefits, and risks. Part 3 then discusses key principles of international and U.S. law defining jurisdiction over the ocean. In Part 4, we explore key international agreements and principles of customary international law that could apply to AU / AD projects, while Part 5 discusses applicable U.S. law. Part 6 concludes.

10 See *generally*, NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE, NEGATIVE EMISSIONS TECHNOLOGIES AND RELIABLE SEQUESTRATION: A RESEARCH AGENDA (2019), <https://perma.cc/TV94-7BK6>.

11 *Id.* at 9-13.

12 NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE, A RESEARCH STRATEGY FOR OCEAN-BASED CARBON-BASED CARBON DIOXIDE REMOVAL AND SEQUESTRATION 2 (2022), <https://perma.cc/UTK2-DSP3> [hereinafter “2022 NASEM Report”]. One of the authors of this paper – Romany M. Webb – served on the ad hoc committee appointed by NASEM to draft the report.

13 *Id.* at 3.

14 *Id.*

15 *Id.*

16 *Id.* at 106.

2. OVERVIEW OF ARTIFICIAL UPWELLING AND DOWNWELLING

Upwelling—i.e., the upward movement of water from the deep ocean to the surface—occurs naturally through the movement of ocean currents and their interactions with landmasses.¹⁷ Natural upwelling brings nutrients from the deep ocean to the surface, stimulating the growth of phytoplankton, which convert carbon dioxide into organic carbon through photosynthesis. A portion of the organic carbon ends up sequestered in phytoplankton organisms that die and sink to the seabed. In effect, then, the natural upwelling process removes carbon dioxide from the atmosphere and sequesters it, at least temporarily, in the deep ocean.

In some areas of the ocean, natural upwelling either does not occur or does not occur quickly enough to maximize phytoplankton growth and associated carbon dioxide sequestration.¹⁸ AU aims to enhance the natural process by bringing more nutrient-rich deep ocean water to the surface. This should, in theory, stimulate phytoplankton growth and thus lead to additional uptake of carbon dioxide from the atmosphere. It is possible that upwelled waters will also bring dissolved carbon dioxide from the deep ocean to the surface, where it may re-enter the atmosphere, counteracting the intended effect.¹⁹

Upwelling naturally causes downwelling or the movement of water from the surface to the deep ocean (and, similarly, downwelling causes upwelling).²⁰ AD or the purposeful downward transfer of surface water has been proposed as a means of enhancing the sequestration of dissolved and particulate organic carbon in the deep ocean.²¹ Importantly, however, AD may not result in permanent carbon storage because the downwelled carbon would eventually upwell.²² Moreover, some studies suggest that proposed AD techniques are likely to be impractical, or prohibitively costly.²³ For example, a 2005 study of seven proposed techniques concluded that AD is, by itself, “highly unlikely to ever be a competitive method of sequestering carbon in the deep ocean.”²⁴ AD could, however, be useful when combined with AU. The 2021 NASEM report found that combining AD with AU could reduce the potential for outgassing (i.e., where carbon dioxide brought to the surface in upwelled water enters the atmosphere), but noted that “this is a wholly untested scenario.”²⁵ The report also indicated that AD could be used for non-CDR purposes (e.g., to counteract eutrophication and hypoxia).²⁶

17 Andrew Bakun et al., *Greenhouse gas, upwelling-favorable winds, and the future of coastal ocean upwelling ecosystems*, 16 *GLOBAL CHANGE BIOLOGY* 1213-1228 (2010).

18 IAN JONES, *ENGINEERING STRATEGIES FOR GREENHOUSE GAS MITIGATION* 72-105 (2011).

19 NATIONAL RESEARCH COUNCIL, *CLIMATE INTERVENTION: CARBON DIOXIDE REMOVAL AND RELIABLE SEQUESTRATION* 56-63 (2015), <https://perma.cc/WW5H-7759>.

20 T. M. Lenton & N. E. Vaughan, *The radiative forcing potential of different climate geoengineering options*, 9 *ATMOSPHERIC CHEMISTRY & PHYSICS* 5539-5561 (2009).

21 2021 NASEM Report, *supra* note 12, at 105.

22 *Id.*

23 S. Zhou & P.C. Flynn, *Geoengineering Downwelling Ocean Currents: A Cost Assessment*, 71 *CLIMATE CHANGE* 203 (2005).

24 *Id.* at 203.

25 2021 NASEM Report, *supra* note 12, at 105.

26 *Id.* at 103.

AU / AD would be performed using vertical pipes to cycle water between the surface and deep ocean.²⁷ Ships would be required to install the pipes, which would likely be less than twenty-meters in diameter, but may be hundreds of meters in length.²⁸ The pipes would be equipped with pumps and may need to be powered by an external energy source. Many proposals envision the use of plastic pipes to efficiently and cheaply move water.²⁹ The pipes could be moored into the ocean bed or floating, and some models are powered by solar energy panels attached to the apparatus.³⁰ Others rely on the motion of waves to move water through the pipes. At end of life, the pipes, pumps, and any other equipment would be removed from the ocean and disposed of or recycled on land. There is, however, a risk that equipment could disintegrate or otherwise fail while in the ocean and thus cause pollution.³¹

There have been some ocean-based trials of AU / AD systems, but they have been relatively small in scale (i.e., generally impacting an area no larger than tens of kilometers) and of short duration (i.e., typically less than a week).³² The systems typically proved effective in cycling water between the deep ocean to the surface.³³ In some AU experiments, enhanced phytoplankton growth was demonstrated, but none of the studies established that enhanced growth led to increased uptake of atmospheric carbon dioxide or sequestration of organic carbon.³⁴ AD for CDR and sequestration has never been tested in the field.³⁵

2.1 CDR Potential of AU / AD

The CDR potential of AU / AD is thought to be relatively low. The 2021 NASEM Report estimated that AU / AD projects could remove and sequester between 0.1 and 1.0 gigatonnes of atmospheric carbon dioxide per year.³⁶ The report noted that achieving that level of sequestration may require tens of millions to hundreds of millions of pumps and that deployment on that scale could conflict with shipping and fishing activity.³⁷ An earlier study estimated that, even if 4.32 million pumps were installed in nitrogen-rich areas of the ocean, carbon dioxide sequestration through AU would be increased by only 1.1 gigatonnes from 2020 to 2050.³⁸ Another study estimated that 0.8 billion pipes would need to be deployed

27 Alexander Proelss & Chang Hong, *Ocean Upwelling and International Law*, 43 OCEAN DEV. & INT'L. 371-385 (2012).

28 See generally OceanNETs, *Artificial Upwelling*, ABOUT NETS, <https://perma.cc/C786-WNHS> (last visited Mar. 28, 2022).

29 Jinying Leng et al, *Impact of Structure Design of Artificial Upwelling Tube*, APPLIED MECHANICS & MATERIALS (2014).

30 Jung Dong-Ho et al., *Key Technologies for Floating Type Artificial Upwelling System to Strengthen Primary Production*, 26 J. OCEAN ENGINEERING & TECH. 78 (2012).

31 2021 NASEM Report, *supra* note 12, at 103.

32 *Id.* at 94.

33 *Id.*

34 *Id.* At the time of writing, additional AD field trials were expected to be conducted as part of an ongoing research project, funded by the European Research Council and led by researchers at the GEOMAR Helmholtz Centre for Ocean Research. As part of the so-called "Ocean artUP" project, a field trial will be conducted in the North Atlantic Ocean, off the Canary and Cape Verde Islands. See Ocean artUp, <https://perma.cc/XZR5-2942> (last visited May 1, 2022).

35 2021 NASEM Report, *supra* note 12, 95.

36 *Id.* at 107.

37 *Id.* at 102.

38 Lenton & Vaughan, *supra* note 20, at 5553.

to increase carbon dioxide sequestration in the ocean by 1 gigatonne.³⁹ Both estimates were based solely on model simulations and have not been verified through field research. The 2021 NASEM Report concluded that “there is a gap between the technological readiness of AU and projected sequestration potential.”⁴⁰ According to the report, “the limited field studies have largely been constrained to coastal regimes with limited operational periods (shorter than weeks) and relatively shallow source water and low upwelling rates . . . , whereas model simulations have explored [carbon] sequestration potential using temporally and spatially extensive deployments with much deeper source waters and higher rates of upwelling.”⁴¹ The model predictions should, therefore, “be considered unrealistic until AU technology could feasibly be deployed at demonstration scale.”⁴²

AU / AD is thought to be one of the more costly CDR approaches. The 2021 NASEM Report found that the costs may exceed \$100-\$150 per tonne of carbon dioxide sequestered and indicated that “[e]stimates of a kilometer-scale deployment are in the tens of million dollars.”⁴³ The report further noted that, before deployment could occur, there would need to be a large investment in developing new pipe and pump systems capable of withstanding harsh ocean conditions. According to the report, “regional-scale networks of pumps could cost on the order of ~\$40 million for technological development alone.”⁴⁴

2.2 Potential Co-Benefits and Risks of AU / AD

AU / AD may bring local environmental benefits but also poses environmental risks. AU in warmer regions could cool surface ocean waters, lessening the impact of global warming on ocean temperatures, and thereby reducing the severity of typhoons⁴⁵ and slowing coral bleaching.⁴⁶ AU could also increase fish populations and has been used in Japan to increase fishing yields.⁴⁷ It has similarly been shown to enhance seaweed growth in certain areas and thus could be combined with seaweed cultivation to increase CDR.⁴⁸ AD has been proposed as a way of counteracting eutrophication and hypoxia by moving oxygen-rich surface water into the deep ocean.⁴⁹

As for risks, AU may have a substantial termination effect, where if it were stopped, global temperatures could exceed those that would have occurred if it had never been used.⁵⁰ This is

39 Andrew Yool et al., *Low efficiency of nutrient translocation for enhancing oceanic uptake of carbon dioxide*, 111 J. GEOPHYSICAL RES. C08009 (2009).

40 2021 NASEM Report, *supra* note 12, at 97.

41 *Id.*

42 *Id.*

43 *Id.* at 108.

44 *Id.* at 109.

45 Brian Kirke, *Enhancing fish stocks with wave-powered artificial upwelling*, 46 OCEAN & COASTAL MGMT. 901 (2003).

46 Ellias Y. Feng et al., *Modeling Coral Bleaching Mitigation Potential of Water Vertical Translocation – An Analogue to Geoengineered Artificial Upwelling*, 7 Frontiers in Marine Science (2020).

47 Proelss & Hong, *supra* note 27.

48 2021 NASEM Report, *supra* note 12, at 95.

49 Anders Stigenbrandt and Bengt Liljebladh, *Oxygenation of Large Volumes of Natural Waters by Geo-Engineering: With Particular Reference to a Pilot Experiment in Byfjorden*, in *MACROENGINEERING SEAWATER IN UNIQUE ENVIRONMENTS* 303 (V. Badescu & R.B. Cathcart eds., 2011).

50 JOINT GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS OF MARINE ENVIRONMENTAL PROTECTION (GESAMP), *HIGH LEVEL REVIEW OF A WIDE RANGE OF PROPOSED MARINE GEOENGINEERING TECHNIQUES* 61 (2019), <https://perma.cc/8GX8-M25T>.

because AU can lower the temperature of surface ocean waters, which leads to less thermal radiation back to space. The extra heat is stored predominantly in the ocean's subsurface waters, and when AU is stopped, the heat makes its way back to the surface.⁵¹ The change in ocean surface temperatures caused by AU could also lead to changes in global rainfall patterns and drought.⁵² Additionally, if AU increases the uptake of carbon dioxide by the ocean, it could contribute to ocean acidification. AU may also decrease water column stratification in the ocean, resulting in increased mixing of surface and deep ocean waters.⁵³ These changes could, in turn, induce shifts in phytoplankton species growth and composition, drive depletion of mid-water oxygen levels, and lead to increases in methane and nitrous oxide releases.⁵⁴

51 A. Oschlies et al., *Climate engineering by artificial ocean upwelling: Channelling the sorcerer's apprentice*, 37 *GEOPHYSICAL RES. LETTERS* (2010).

52 Katharine Ricke et al., *Reversing Sahelian Droughts*, 48 *GEOPHYSICAL RES. LETTERS* 1 (2021).

53 2021 NASEM Report, *supra* note 12, at 105.

54 GESAMP, *supra* note 50, at 62.

3. JURISDICTION OVER OCEANS

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

3.1 International Legal Framework

The United Nations Convention on the Law of the Sea (“UNCLOS”) defines the extent of countries’ jurisdiction over ocean waters and submerged land. UNCLOS had been ratified or otherwise adopted by 167 countries and the European Union.⁵⁵ The U.S. has not ratified UNCLOS, but recognizes many of its provisions, including those discussed in this Part, as forming part of customary international law.⁵⁶

Under UNCLOS, non-landlocked countries (“Coastal Countries”) have jurisdiction over ocean areas within 200 nautical miles (“n.m.”) of the low water line along their coasts (the “baseline”) and further in some circumstances.⁵⁷ The 200 n.m. zone is generally divided into four key parts (see Figure 2), each of which has a different legal status as follows:

- The **territorial sea**, which comprises the waters and submerged land extending twelve n.m. from the baseline, and forms part of the sovereign territory of Coastal Countries.⁵⁸ Within its territorial sea, the coastal country has full sovereign rights over the water and submerged land and the airspace above.
- The **contiguous zone**, which extends twelve to twenty-four nautical miles from the baseline.⁵⁹ Unlike the territorial sea, the contiguous zone does not form part of Coastal Countries’ sovereign territory. However, within the contiguous zone, Coastal Countries can exercise the control necessary to prevent and punish infringements of customs, fiscal, immigration, and sanitary laws within their territory.⁶⁰
- The **exclusive economic zone** (“EEZ”), which overlaps with, but extends beyond, the contiguous zone up to 200 n.m. from the baseline.⁶¹ Again, the EEZ does not form part of Coastal Countries’ sovereign territory, but countries do have sovereign rights to explore, exploit, conserve, and manage natural resources and undertake other activities for the economic exploitation of the zone. Coastal Countries also have jurisdiction over artificial islands, installations, structures, marine scientific research, and marine protection in their EEZs.⁶²

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

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

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

58 *Id.* Art. 2-3.

59 *Id.* Art. 33.

60 *Id.*

61 *Id.* Art. 55 & 57.

62 *Id.* Art. 56.

- The **continental shelf**, which comprises the submerged land extending beyond the territorial sea to the farthest of 200 n.m. from the baseline or the outer edge of the continental margin,⁶³ 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.⁶⁴ Each Coastal Country has sovereign rights over its continental shelf for the purpose of exploring and exploiting natural resources.⁶⁵

Coastal Countries do not have jurisdiction over ocean waters more than 200 n.m. from shore. Those waters, known as the “high seas,” are open to use by all coastal and landlocked countries in accordance with international law.⁶⁶ UNCLOS provides for “freedom of the high seas,” which is defined to include, “for both coastal and land-locked [countries]: (a) freedom of navigation; freedom of overflight; freedom to lay submarine cables and pipelines . . . ; freedom to construct artificial islands and other installations . . . ; freedom of fishing . . . ; [and] (f) freedom of scientific research.”⁶⁷ The seabed underlying the high seas (known as the “Area”) is similarly open to use by all countries.⁶⁸ Activities in the area must, however, be conducted “exclusively for peaceful purposes” and “for the benefit of mankind as a whole.”⁶⁹

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

3.2 U.S. Jurisdictional Areas

Consistent with international law the U.S. has claimed jurisdiction over all waters up to 200 n.m. from its coast (“U.S. waters”).⁷⁰ 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

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

64 *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.*

65 *Id.* Art. 77.

66 *Id.* Art. 86-87.

67 *Id.* Art. 87.

68 *Id.* Art. 1 & 136-149.

69 *Id.* Art. 140-141.

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

Florida extend nine n.m. from the coastline.⁷¹ For the purposes of the SLA, a state’s “coastline” is defined as “the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters.”⁷²

Offshore waters within state boundaries fall under the primary jurisdiction of the relevant coastal state. With limited exceptions, coastal states have title to, and ownership of, all lands beneath their state waters and the right to take natural resources (including minerals, marine animals, and plant life) within those lands and waters.⁷³ The federal government has relinquished all of its property rights to, and interests in, land and resources within state waters.⁷⁴ However, the federal government retains authority to regulate state waters “for the constitutional purposes of commerce, navigation, national defense, and international affairs.”⁷⁵ Local governments also have limited authority in state waters in some areas. For example, in parts of New York, local governments own the submerged land under state waters pursuant to Colonial patents.⁷⁶ The New York state government has also ceded title to some submerged lands to local governments through legislative enactments.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 comprising the “submerged lands lying seaward and outside of the area [subject to state jurisdiction] . . . and of which the subsoil and seabed appertain to the U.S.”⁷⁸ As discussed in Part 3.2.1 above, state jurisdiction typically ends three n.m. from shore (except off Texas and the west coast of Florida, where it ends nine n.m. from shore), at which point the OCS begins. The OCS extends to the seaward limit of U.S. jurisdiction, defined under international law as the farthest of:

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

71 43 U.S.C. § 1312 (providing that “[t]he seaward boundary of each original coastal State is approved and confirmed as a line three geographical 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).

72 43 U.S.C. § 1301(c).

73 *Id.* § 1311(a)(1).

74 *Id.* § 1311(b).

75 *Id.* § 1314.

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

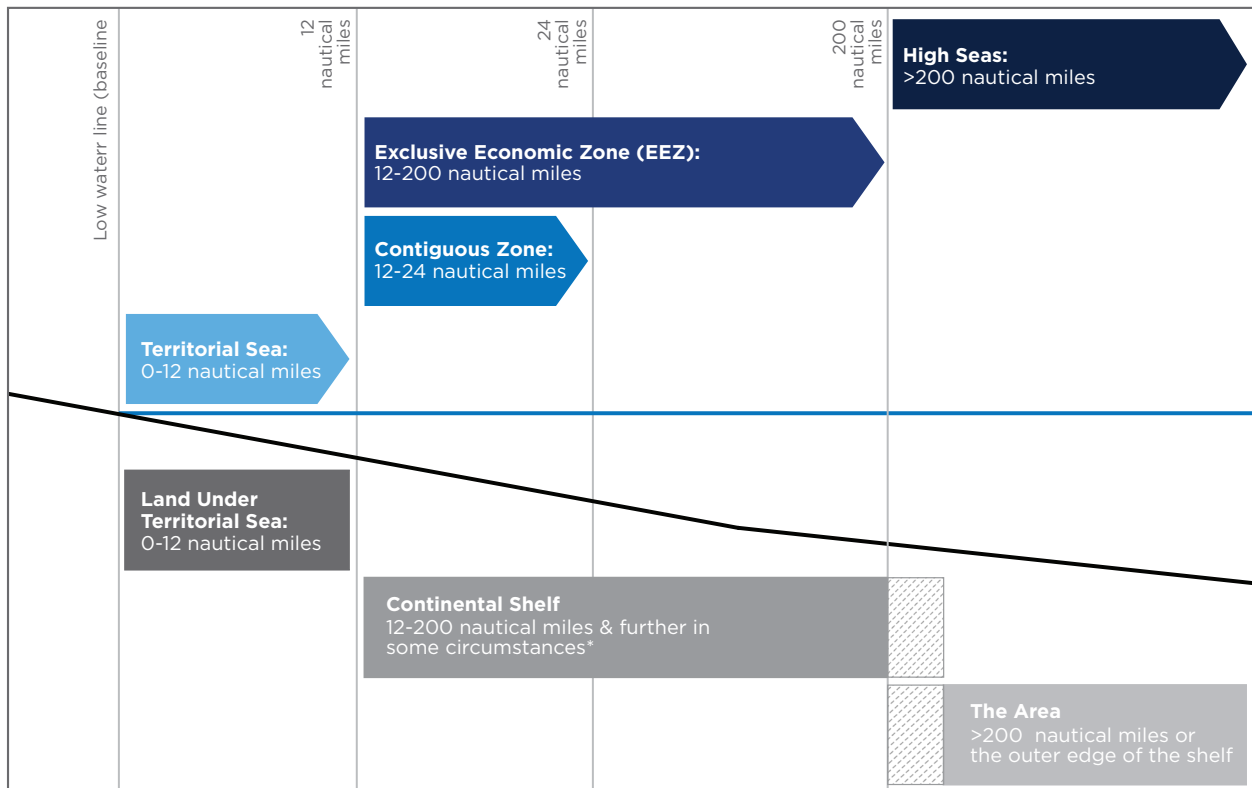
77 See *e.g.*, N.Y. Env’tl. Conservation Law § 13-0302 (stating that “all the right, title and interest in which the people of the state of New York have in and to the lands under water of Gardiner’s and Peconic bays in the county of Suffolk, except underwater lands within one thousand feet of the high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

78 43 U.S.C. § 1331.

- sixty n.m. from the foot of the continental shelf; or
- beyond the shelf foot where the sediment thickness is one percent of the distance thereto.⁷⁹

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 1: Offshore Zones Identified in UNCLOS



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

79 UNCLOS, *supra* note 57, Art. 76(1) & (4).

80 *Id.* Art. 76(5).

4. INTERNATIONAL LEGAL FRAMEWORK FOR ARTIFICIAL UPWELLING AND DOWNWELLING

Ocean-based activities are governed by various international agreements, as well as principles of customary international law. At the outset, it is important to note that international agreements are only binding on countries that have consented to them, whereas customary international law comprises universal standards that are binding on all countries.

There are currently no international agreements specifically governing AU / AD, but several instruments contain provisions that could apply to research or commercial-scale operations. The most directly relevant are 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”). Various principles of customary international law, including the so-called “no harm rule,” could also apply to AU / AD projects. The relevant agreements and rules, and their application to AU / AD, are discussed in this Part.

4.1 Relevant International Agreements

4.1.1 United Nations Convention on the Law of the Sea

Often described as the “constitution of the oceans,” UNCLOS defines countries’ rights and responsibilities with respect to the management and use of offshore areas. UNCLOS was first adopted in December 1982 and entered into force in November 1994.⁸¹ In the following years, two separate agreements dealing with implementation of specific provisions of UNCLOS were adopted—(1) the Seabed Mining Agreement, adopted in July 1994,⁸² and (2) the Straddling Fish Stocks Agreement, adopted in August 1995.⁸³ In June 2015, the United Nations General Assembly agreed to develop a new agreement under UNCLOS on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction (commonly referred to as the “Biodiversity Beyond National Jurisdiction Agreement”).⁸⁴ However, at the time of writing, the text of that agreement had not been finalized.

UNCLOS has been ratified or otherwise adopted by 167 countries and the European Union, but even countries that are not parties to UNCLOS recognize many of its provisions as forming part of customary international law and thus abide by them.⁸⁵ The Seabed Mining Agreement

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

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

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

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

85 See generally, Angelle C. Smith, *Frozen Assets: Ownership if Arctic Mineral Rights Must be Resolved to Prevent the Really Cold War*, 41 GEO. WASH. INT’L L. REV. 651, 657 (2011).

and Straddling Fish Stocks Agreement do not have the same universal acceptance. At the time of writing, there were 150 parties to the Seabed Mining Agreement,⁸⁶ and 91 parties to the Straddling Fish Stocks Agreement.⁸⁷ The U.S. is a party to the Straddling Fish Stocks Agreement only.

Various provisions of UNCLOS could apply to AU / AD and other ocean CDR projects.⁸⁸ Most notably, projects that are conducted for the purposes of research would be subject to Part XIII of UNCLOS, which establishes rules for “marine scientific research” (“MSR”).

UNCLOS does not include a definition of MSR. However, the term is commonly understood to encompass any scientific investigation of the marine environment, including studies of the seabed, water column, and atmosphere above the water.⁸⁹ Several legal scholars have concluded that “projects aimed at demonstrating or testing ocean CDR techniques would qualify [as MSR] if conducted “in situ” in the ocean.”⁹⁰ Thus, for example, projects that involve the temporary installation of pipes in the ocean to determine the feasibility and efficacy of AU / AD would likely be considered MSR.⁹¹ So too would other activities aimed at identifying areas suitable for AU / AD (e.g., the collection and testing of samples to assess water temperature, density, and nutrient concentration and the in situ measurement of wave, wind, and other meteorological conditions).⁹² This is the case regardless of whether the research activities are undertaken to facilitate the testing of pipes or their commercial-scale deployment because UNCLOS does not distinguish between basic research, conducted solely for the purpose of increasing scientific knowledge, and more applied research, conducted to inform or facilitate commercial activities.⁹³

Part XIII of UNCLOS recognizes that each Coastal Country has “the right to regulate, authorize, and conduct” MSR within its territorial sea and EEZ.⁹⁴ Both coastal and landlocked countries also have a right to conduct MSR on the high seas. Countries may only conduct MSR in the territorial sea and EEZ of another country with that country’s consent.⁹⁵ UNCLOS directs that “coastal [countries] shall, in normal circumstances, grant their consent for” MSR

86 United Nations, *supra* note 55.

87 *Id.*

88 For a discussion of the application of UNCLOS to other ocean CDR techniques, see ROMANY M. WEBB, REMOVING CARBON DIOXIDE THROUGH OCEAN ALKALINITY ENHANCEMENT: LEGAL CHALLENGES AND OPPORTUNITIES (2021), <https://perma.cc/QMJ2-VDZH>; KOREY SILVERMAN-ROATI ET AL., REMOVING CARBON DIOXIDE THROUGH SEAWEED CULTIVATION: LEGAL CHALLENGES AND OPPORTUNITIES (2021), <https://perma.cc/9ZDH-MSPE>.

89 See generally, Patricia Birnie, *Law of the Sea and Ocean Resources: Implications for Marine Scientific Research*, 10 INTL. J. MARINE & COASTAL L. 229, 241-42 (MSR is “any form of scientific investigation, fundamental or applied, concerned with the marine environment”); Tim Stephens & Donald R. Rothwell, *Marine Scientific Research in THE OXFORD HANDBOOK OF THE LAW OF THE SEA* (Donald R. Rothwell et al., eds, 2015) (MSR involves study of the ocean and marine environment as occurs in, for example, “physical oceanography, marine chemistry and biologic, scientific ocean drilling and coring, geological and geophysical research and other activities that have a scientific purpose”).

90 2021 NASEM Report, *supra* note 12, at 43.

91 See generally, Proelss & Hong, *supra* note 27, at 373.

92 *Id.* See also KERRYN BRENT ET AL., GOVERNANCE OF MARINE GEOENGINEERING: SPECIAL REPORT 19 (2019), <https://perma.cc/RPC3-WGXC>.

93 Brent et al., *supra* note 92, at 19.

94 UNCLOS, *supra* note 57, Art. 245 & 246.

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

in their territory “in order to increase scientific knowledge of the marine environment for the benefit of all mankind.”⁹⁶ Notably, however, coastal countries may “withhold their consent” if a research project is “of direct significance for the exploration and exploitation of natural resources, whether living or non-living” (among other things).⁹⁷ The terms “exploration” and “exploitation” are not defined in UNCLOS “exploration” or “exploitation,” but at least one commentator has argued that recovery of resources for commercial purposes is a form of resource exploitation.⁹⁸ Some AU / AD research could interfere with navigation and thereby impair the recovery of fish, seaweed, and other ocean resources. Where this occurs, a country may view AU / AD research as having “direct significance for the . . . exploitation of natural resources,” and refuse to permit the research in its territory.

Where a country obtains permission to conduct AU / AD research in another’s territory, it must provide the host country with a description of the nature and objectives of the research, how and where it will be conducted, and the expected start and end dates.⁹⁹ The host country has the right to participate or be represented in the research and can request access to research data and results.¹⁰⁰ The research results must also be “made internationally available through appropriate national and international channels.”¹⁰¹ This could help to enhance the transparency of AU / AD research. Importantly, however, the requirement to make research results available does not apply where a country conducts AU / AD research within its own territory or on the high seas.

All MSR, regardless of where it occurs, must be conducted in accordance with “appropriate scientific methods” and in a manner that does not “unjustifiably interfere with other legitimate uses” of the ocean.¹⁰² Any equipment used in MSR must “not constitute an obstacle to established international shipping routes”¹⁰³ and must ordinarily be removed at the conclusion of the research project.¹⁰⁴ AU / AD research may require the installation of pipes and pumps, both of which would likely be considered “equipment”¹⁰⁵ and thus need to be deployed outside of shipping routes in areas where the potential for interference with other uses (e.g., fishing) are minimized.

AU / AD research projects and commercial-scale operations would also need to comply with Part XII of UNCLOS, which imposes a general obligation on countries to “protect and preserve the marine environment.” Under Article 206 of UNCLOS, before undertaking any

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

97 *Id.* Art. 246(5)(a). Article 246(5)(b) also grants coastal countries the discretion to withhold consent if the project involves “the introduction of harmful substances into the marine environment,” which may apply to certain ocean CDR activities like ocean fertilization and ocean alkalinity enhancement.

98 See e.g., Chuxiao Yu, *Implications of the UNCLOS Marine Scientific Research Regime for the Current Negotiations on Access and Benefit Sharing of Marine Genetic Resources in Areas Beyond National Jurisdiction*, 51 OCEAN DEV. & INT’L L. 1, 6 (2019).

99 UNCLOS, *supra* note 57, Art. 248.

100 *Id.* Art. 249.

101 *Id.* Art. 249(1)(e).

102 *Id.* Art. 240.

103 *Id.* Art. 261.

104 *Id.* Art. 249(1)(g).

105 See *generally*, Proelss & Hong, *supra* note 27, at 374 (arguing pipes used for artificial upwelling “meet the criteria of equipment”).

activity which “may cause . . . significant and harmful changes to the marine environment,” countries must “assess the potential effects” of the activity and publish the findings of that assessment.¹⁰⁶ While the need for an assessment must be determined on a case-by-case basis, given the risks associated with AU / AD, assessments are likely to be required for at least some research and many commercial-scale operations. Other international agreements (discussed in Part 4.1.4 below) provide further guidance on conducting assessments.

Part XII of UNCLOS further requires countries to “protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life.”¹⁰⁷ The Straddling Fish Stocks Agreement similarly directs countries to avoid adverse “impacts on . . . species, in particular endangered species,” and to “protect biodiversity in the marine environment.”¹⁰⁸ These requirements could have implications for the conduct of AU / AD projects. For example, research and commercial-scale operations may need to be conducted outside of sensitive areas to protect rare and fragile ecosystems and minimize species impacts.

Under both UNCLOS and the Straddling Fish Stocks Agreement, countries must also take steps to minimize pollution of the marine environment,¹⁰⁹ which could occur in some AU / AD projects. UNCLOS defines “pollution” 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.¹¹⁰

UNCLOS requires countries to “take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as to not cause damage by pollution,” including measures “designed to minimize to the fullest extent . . . pollution from . . . installations and devices operating in the marine environment.”¹¹¹ The pipes and other equipment used in AU / AD could be a source of pollution, for example, if they disintegrate or otherwise fail while in the ocean. This could result in the release of plastic, metal, and/or other materials into the ocean which could harm marine species or hinder other marine activities (e.g., shipping and fishing).¹¹² Where this occurs, UNCLOS would require the country with jurisdiction over the AU / AD project to:

- take all necessary measures to minimize the adverse impacts of the project and ensure

106 UNCLOS, *supra* note 57, Art. 206. See also *id.* Art. 205 (specifying requirements for the publication of assessment reports).

107 *Id.* Art. 194(5).

108 Straddling Fish Stocks Agreement, *supra* note 83, Art. 5(f)-(g).

109 UNCLOS, *supra* note 57, Art. 194(1); Straddling Fish Stocks Agreement, *supra* note 83, Art. 5(f).

110 UNCLOS, *supra* note 57, Art. 1(1)(4).

111 *Id.* Art. 194(2) & (3)(d).

112 2021 NASEM Report, *supra* note 12, at 103 (noting that equipment failures “could introduce significant plastic, metal, and/or concrete pollution” into the ocean).

that it does not cause damage to other states or their environments;¹¹³

- notify affected countries and competent international authorities of any imminent or actual damage from the project;¹¹⁴ and
- study the risks and effects of the project and publish the results of that study.¹¹⁵

According to UNCLOS, countries that fail to fulfil the above requirements “shall be liable in accordance with international law.”¹¹⁶ The 2001 United Nations Resolution on the Responsibility of States for Internationally Wrongful Acts sets out the legal consequences for countries that engage in “internationally wrongful acts.” According to Article 2 of the Resolution, a country commits an “internationally wrongful act” where it engages in “conduct consisting of an action or omission” that is “attributable to the [country] under international law” and “[c]onstitutes a breach of an international obligation” of the country.¹¹⁷ Articles 12 and 13 of the Resolution further clarify that a country breaches an international obligation when it acts in a way that “is not in conformity with what is required of it” under an international obligation by which it is bound.¹¹⁸ Under Article 30 of the Resolution, where such a breach occurs, the country must cease the offending conduct and “offer appropriate assurances and guarantees of non-repetition.”¹¹⁹ The country must also make “full reparation” for any injuries¹²⁰ 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).¹²¹

4.1.2 Convention on Biological Diversity

Adopted in June 1992, the CBD aims to promote “the conservation of biological diversity, [and] the sustainable use of its components.”¹²² The CBD entered into force in December 1993 and, at the time of writing, had been ratified or otherwise accepted by 195 countries and the

113 UNCLOS, *supra* note 57, Art. 194, 196, 202-209, & 211-212.

114 *Id.* Art. 198. In an Advisory Opinion on seabed mining, the International Tribunal for the Law of the Sea noted that states have an obligation to conduct environmental impact assessments during consultations and notifications before a project is undertaken. *Responsibilities and obligations of States with respect to activities in the Area*, Advisory Opinion 1, 10, 51 (February 1, 2011). Similar reasoning may be applied to require ocean CDR projects to conduct environmental impact assessments during consultation and notification.

115 UNCLOS, *supra* note 57, Art. 204-206.

116 *Id.* Art 235(1).

117 Resolution Adopted by the United Nations General Assembly, Responsibility of States for Internationally Wrongful Acts, A/RES/56/83 (Jan. 28, 2002) Art. 2.

118 *Id.* Art. 12-13.

119 *Id.* Art. 30.

120 The resolution defines “injury” to “include any damage, whether material or moral, caused by [a country’s] internationally wrongful act.” See *id.* Art. 31(2).

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

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

European Union.¹²³ The U.S. had signed, but not ratified, the CBD at the time of writing.¹²⁴

Article 3 of the CBD recognizes that countries have “the sovereign right to exploit their own resources pursuant to their own environmental policies” but must “ensure that activities within their jurisdiction or control do not cause damage to the environment of other [countries] or of areas beyond the limits of national jurisdiction.”¹²⁵ 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.”¹²⁶ 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.”¹²⁷ For projects that could have transboundary effects, parties must “[p]romote . . . notification, exchange of information and consultation” with potentially affected countries.¹²⁸ 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.¹²⁹ Parties should also have in place “national arrangements for emergency responses” to projects that represent a “grave and imminent danger to biological diversity.”¹³⁰

Provided the above requirements are met, the CBD would not prevent countries from undertaking or authorizing AU / AD projects.¹³¹ The Conference of the Parties to the CBD has adopted a series of non-binding decisions recommending that countries avoid engaging in “ocean fertilization” and other “climate-related geo-engineering activities.” There is, however, some uncertainty as to whether and when those decisions will apply to AU / AD projects.

4.1.2(A) CBD Decisions on Ocean Fertilization and Marine Geoengineering

In a 2008 decision, the Conference of the Parties:

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

¹²³ Convention on Biological Diversity, *List of Parties*, <https://perma.cc/ZY3W-9PC3> (last visited Jan. 19, 2021).

¹²⁴ *Id.* Article 18 of the Vienna Convention on the Law of Treaties provides that a country that has signed, but not ratified, a treaty is “obliged to refrain from acts which would defeat the object and purpose of a treaty . . . until it shall have made its intent clear not to become a party to the treaty.” This has been interpreted as requiring signatories to avoid acts that would make it more difficult or impossible for other parties to comply with the relevant agreement. Some researchers have argued that this requirement forms part of customary international law and thus applies to countries that are not party to the Vienna Convention (including the U.S.). However, even if this is the case, the obligation only applies until the country has signaled “its intent . . . not to become a party to the treaty.” The U.S. has arguably done this by failing to ratify the CBD for nearly thirty years (despite having signed it in 1993). See generally, Curtis A. Bradley, *Treaty Signature*, in *THE OXFORD GUIDE TO TREATIES 208* (Duncan B. Hollis ed., 2012).

¹²⁵ CBD, *supra* note 122, Art. 3.

¹²⁶ CBD, *supra* note 122, Art. 7(c).

¹²⁷ *Id.* Art. 14(1)(a).

¹²⁸ *Id.* Art. 14(1)(c).

¹²⁹ *Id.* Art. 14(1)(d).

¹³⁰ *Id.* Art. 14(1)(e).

¹³¹ 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).

. . . and a global, transparent and effective control and regulatory mechanism is in place for these activities.¹³²

The 2008 decision includes an exemption for “small scale research studies within coastal waters,” which may be “authorized if justified by the need to gather specific scientific data . . . [and] subject to a thorough prior assessment of the potential impacts of the research studies on the marine environment.”¹³³ According to the 2008 decision, authorized research projects should “be strictly controlled,” and not undertaken for any “commercial purpose.”¹³⁴

The term “ocean fertilization” was not defined in the 2008 decision and there is some uncertainty as to whether the term captures AU / AD. Within the scientific community, “ocean fertilization” is often defined as the “[a]ddition of micronutrinets (e.g., iron) and/ or macronutrients (e.g., phosphorus or nitrogen) to the surface ocean . . . [to] increase photosynthesis by marine phytoplankton.”¹³⁵ This definition arguably would not encompass AU / AD because they do not involve the addition of nutrients to ocean waters. Some in the international community have, however, adopted a broader definition of “ocean fertilization” which could encompass AU / AD. Most notably, in a separate resolution also adopted in 2008, the parties to the London Convention and Protocol defined “ocean fertilization” to mean “any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans.”¹³⁶ That could encompass AU / AD which, as discussed in Part 2 above, aims to increase uptake of carbon dioxide in the ocean by stimulating phytoplankton growth. It should, however, be noted that the London Convention / Protocol definition has not been formally adopted or approved by the Conference of the Parties to the CBD. Moreover, less than half of the parties to the CBD are also party to the London Convention / Protocol, so there is nothing to suggest that the definition adopted under the latter instruments has broad acceptance among parties to the CBD.

Regardless of whether AU / AD is treated as a form of ocean fertilization under the 2008 CBD decision, it would likely be covered by a second decision, which was adopted by the CBD Conference of the Parties in 2010 to regulate “geoengineering activities.”¹³⁷ The 2010 decision “invites 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.”¹³⁸ The guidelines recommends 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-

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

133 *Id.*

134 *Id.*

135 2021 NASEM Report, *supra* note 12, at 2.

136 Resolution LC-LP.1(2008) on the Regulation of Ocean Fertilization, Art. 2 (Oct. 31, 2008) [hereinafter “2008 LC / LP Resolution”].

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

138 *Id.*

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.)¹³⁹

That recommendation was reaffirmed by the Conference of the Parties to the CBD in 2012¹⁴⁰ and again in 2016.¹⁴¹

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.”¹⁴² The Secretariat to the CBD subsequently determined, and the Conference of the Parties agreed, that geoengineering should be defined more broadly to include any “[d]eliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and its impacts.”¹⁴³ That definition could encompass the deployment of commercial-scale AU / AD systems for the purpose of mitigating climate change. It may not, however, encompass smaller-scale AU / AD research. In any event, even if the 2010 decision does apply to AU / AD projects, it is unlikely (on its own) to prevent approval of those projects because it is non-binding and merely “invites” countries to “consider” the guidelines provided.

4.1.3 London Convention and Protocol

The London Convention was adopted in November 1972 and entered into force in August 1975. The London Convention aims to “promote the effective control of all sources of pollution of the marine environment,” particularly those resulting from the “dumping” of “waste or other matter” at sea.¹⁴⁴ In November 1996, the parties to the London Convention adopted a new protocol, which is intended to update the Convention and will replace it if ratified by all contracting parties.¹⁴⁵ The London Protocol sets more ambitious goals than the London Convention, aiming to “protect and preserve the marine environment from all sources of pollution,” and to “prevent, reduce and where practicable eliminate pollution caused by dumping” of “waste or other matter.”¹⁴⁶

139 *Id.* Art. 8(w).

140 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 CBD Decision”].

141 Report of the Conference of the Parties to the Convention on Biological Diversity on the Work of its Thirteen Meeting, Decision XIII/4, Art. 14 (2016).

142 2010 CBD Decision, *supra* note 137, at footnote 3.

143 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 CBD Decision, *supra* note 140, Art. 5.

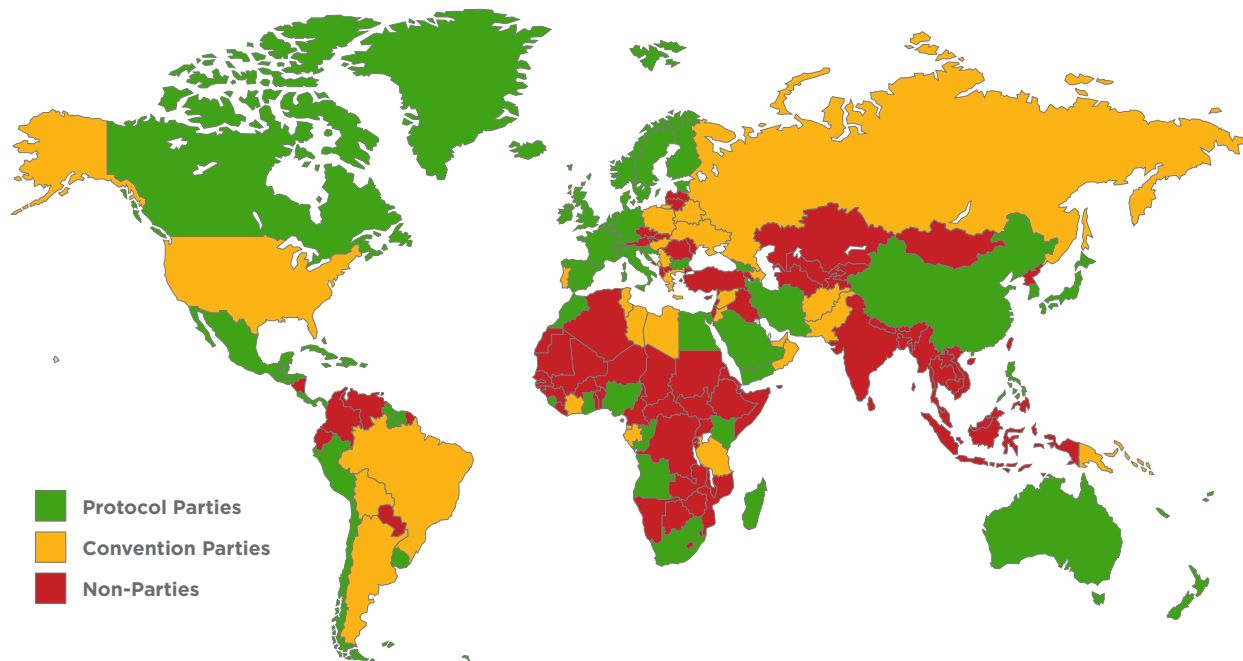
144 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972 [hereinafter “London Convention”], Art. I-II.

145 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.

146 *Id.*

At the time of writing, there were eighty-seven parties to the London Convention, and fifty-three parties to the London Protocol (see Figure 2 and Table 1).¹⁴⁷ 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.¹⁴⁸

Figure 2: Parties to the London Convention and London Protocol¹⁴⁹



147 International Maritime Organization, *Map of Parties to the London Convention/Protocol*, [https://perma.cc/qqg4-dy7h](https://perma.cc/QQG4-DY7H) (last updated Feb. 22, 2019).

148 Env'tl. Prot. Agency, *Ocean Dumping: International Treaties*, [https://perma.cc/9ksu-756n](https://perma.cc/9KSU-756N) (last updated Feb. 28, 2019).

149 *Id.*

Table 1: Contracting Parties to the London Protocol

Angola	France	Marshall Islands	South Africa
Antigua and Barbuda	Guatemala	Mexico	Spain
Australia	Georgia	Morocco	Suriname
Barbados	Germany	New Zealand	Sweden
Belgium	Ghana	Netherlands	Switzerland
Bulgaria	Guyana	Nigeria	Tonga
Canada	Iceland	Norway	Trinidad and Tobago
Chile	Ireland	Peru	United Kingdom
China	Islamic Republic of Iran	Philippines	Uruguay
Congo	Italy	Republic of Korea	Vanuatu
Denmark	Japan	Saint Kitts and Nevis	Yemen
Egypt	Kenya	Saudi Arabia	
Estonia	Luxembourg	Sierra Leone	
Finland	Madagascar	Slovenia	

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.¹⁵⁰ Parties to the London Convention must prohibit the dumping of eight substances listed in Annex I to the Convention (“prohibited substances”),¹⁵¹ but can permit the dumping of other (non-prohibited) substances.¹⁵² 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”).¹⁵³

Both the London Convention and London Protocol define “waste or other matter” broadly to include “material of any kind, form or description.”¹⁵⁴ In both instruments, “dumping” is defined to mean the “deliberate disposal of waste or other matter at sea from vessels, aircraft,

150 London Convention, *supra* note 144, Art. VII; London Protocol, *supra* note 145, Art. 10

151 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.

152 London Convention, *supra* note 144, Art. IV.

153 London Protocol, *supra* note 145, 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.

154 London Convention, *supra* note 144, Art. III; London Protocol, *supra* note 145, Art. I.

platforms, or other man-made structures.”¹⁵⁵ 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.¹⁵⁶

4.1.3(A) Treatment of AU / AD Projects under the London Convention and Protocol

Scholars have expressed differing opinions on whether AU / AD involves “dumping” that must be permitted under the London Convention and Protocol. Some argue that, because AU / AD merely “involve the transfer of water/nutrients from one part of the ocean to another, rather than the introduction of new matter,” they do not involve “dumping” within the terms of the London Convention and Protocol.¹⁵⁷ Others, however, note that AU / AD require the installation of pipes and other equipment in the ocean and argue that the act of installation could constitute “dumping” under the London Convention and Protocol.¹⁵⁸

Whether AU / AD projects involve “dumping” will ultimately need to be assessed on a case-by-case basis by the country under whose jurisdiction the projects occur. In our view, however, most projects are unlikely to involve dumping.

As noted above, the London Convention and Protocol apply to the dumping of all “waste or other matter,” with that term defined broadly to encompass structures, containers, and other bulky items.¹⁵⁹ As such, there is little doubt that pipes and other equipment used in AU / AD projects would qualify as “waste or other matter” covered by the London Convention and Protocol. Under both instruments, dumping requires the “deliberate disposal” of waste or other matter, but neither instrument includes a definition of “disposal.”¹⁶⁰ In general parlance, the term “disposal” is used to refer to the act of getting rid of or abandoning something that is no longer useful,¹⁶¹ which does not occur in AU / AD projects. Rather, in such projects, pipes and other equipment are temporarily placed in the ocean for the purpose of cycling water and thereby increasing uptake of carbon dioxide from the atmosphere. At the end of the project, the equipment is removed, and thus it cannot be said to be abandoned or disposed of in the ocean.

155 London Convention, *supra* note 144, Art. III; London Protocol, *supra* note 145, Art. I.

156 London Convention, *supra* note 144, Art. III; London Protocol, *supra* note 145, Art. I.

157 See e.g., Brent et al., *supra* note 92, at 38 & 46.

158 See e.g., Chris Vivian, Remarks at the National Academies of Sciences, Engineering, and Medicine Workshop on Ocean-based CDR Opportunities and Challenges (Feb. 25, 2021) (slides available at <https://www.nationalacademies.org/event/02-25-2021/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration-workshop-series-part-4>). But see Proelss & Hong, *supra* note 27, at 380 (“Given that the pipes are introduced into the marine environment ‘for a purpose other than mere disposal thereof,’ their deployment cannot be regarded as dumping”).

159 Annexes to the London Convention and Protocol list “vessels[,] platforms and other man-made structures,” “containers,” and other “bulky items” as examples of “water or other matter.” See London Convention, *supra* note 144, Annex II; London Protocol, *supra* note 145, Annex I.

160 London Convention, *supra* note 144, Art. III(1(a)); London Protocol, *supra* note 145, Art. 1(4.1).

161 Merriam-Webster Dictionary, *Dispose*, <https://perma.cc/A9PL-7GKQ> (last visited Mar. 9, 2022); Cambridge Dictionary, *Dispose*, <https://perma.cc/KHG5-8ZKQ> (last visited Mar. 9, 2022). The meaning of “disposal” has been the subject of extensive discussion by U.S. courts interpreting domestic statutes such as the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Liability Act. See generally, Jeffrey M. Gaba, *Solid Waste and Recycled Materials under RCRA: Separating Chaff from Wheat*, 16 *Ecology* L.Q. 623 (1989); Eric Lode, *What Constitutes Solid Waste Subject to Regulation under Resource Conservation and Recovery Act* (42 U.S.C.A. §§ 6901 et seq.), 83 A.L.R. Fed. 2d 235.

Recognizing the difference between disposal and placement, the London Convention and Protocol expressly provide that the term “dumping” does not include “the placement of matter [in the ocean] for a purpose other than mere disposal thereof, provided that such placement is not contrary to the aims of” the Convention or Protocol.¹⁶² As explained above, both instruments aim to prevent pollution of the marine environment, which is unlikely to occur as a result of the placement of pipes in the ocean for AU / AD projects. A project-by-project assessment would, however, need to be undertaken.

Even if a particular AU / AD project were found to involve “dumping,” which we consider unlikely, parties to the London Convention and Protocol likely could permit the project, at least in some circumstances. Parties to the London Convention can permit the dumping of any material other than the prohibited substances listed in Annex I to the Convention. The only potentially relevant prohibited substance is “persistent plastics and other persistent synthetic materials . . . which may float or may remain in suspension in the sea in such a manner as to interfere materially with fishing, navigation, or other legitimate uses of the sea.”¹⁶³ Parties to the London Convention could not permit the dumping of pipes with these characteristics, but could permit the dumping of other types of pipes (e.g., made from biodegradable materials). Similarly, parties to the London Protocol could also likely permit the dumping of pipes as the list of allowed substances in Annex I to the Protocol includes “man-made structures,” which is likely to encompass pipes.¹⁶⁴

4.1.3(B) London Convention / Protocol Resolutions on Ocean Fertilization

In 2008, the parties to the London Convention and Protocol adopted a non-binding resolution, which declares that “the scope of the . . . Convention and Protocol includes ocean fertilization activities.”¹⁶⁵ The 2008 resolution draws a distinction between ocean fertilization projects that involve “legitimate scientific research” and other (non-research) projects. According to the 2008 resolution:

- **Legitimate scientific research projects** “should be regarded as [involving the] placement of matter for a purpose other than mere disposal thereof.”¹⁶⁶ As such, research projects will fall outside the definition of “dumping,” provided they are not contrary to the aims of the London Convention and Protocol. The country under whose jurisdiction a research project occurs must determine whether it (1) has proper scientific attributes to qualify as legitimate scientific research and (2) poses risks to the marine environment that make it contrary to the aims of the London Convention and Protocol.¹⁶⁷ In 2010, the parties to the London Convention / Protocol adopted an

162 London Convention, *supra* note 144, Art. III(1(b)); London Protocol, *supra* note 145, Art. 1(4.2).

163 London Convention, *supra* note 144, Annex I(4).

164 London Protocol, *supra* note 145, Annex 1(1.4).

165 2008 LC / LP Resolution, *supra* note 136.

166 *Id.* Art. 3.

167 A country has jurisdiction over a research project if occurs within offshore areas under the country’s jurisdiction (i.e., the territorial sea and EEZ) or is performed using vessels or aircraft that are registered, or were loaded, within the country’s territory.

“assessment framework” to guide countries in making these determinations.¹⁶⁸ 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.”¹⁶⁹

- **Non-research projects** “should be considered as contrary to the aims of the [London] Convention and Protocol” and thus treated as dumping for the purposes of those instruments.¹⁷⁰ As a result, non-research projects will be subject to the terms of the London Convention and Protocol, both of which require permits to be obtained before ocean dumping can be carried out (see Part 4.1.3(A) above).

There is some uncertainty as to whether the 2008 resolution applies to AU / AD. As noted above, the 2008 resolution is targeted at “ocean fertilization activities,” which are generally understood within the scientific community as activities involving the addition of nutrients to ocean water to stimulate phytoplankton growth.¹⁷¹ However, the 2008 resolution defines “ocean fertilization” more broadly to mean “any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans,”¹⁷² which could encompass AU / AD.¹⁷³

If AU / AD is considered a form of “ocean fertilization,” research projects occurring under the jurisdiction of a party to the London Convention or Protocol would be subject to the 2008 resolution, as well as the 2010 assessment framework. The country with jurisdiction over an AU / AD project would need to evaluate whether it involves “legitimate scientific research” and is or is not contrary to the aims of the London Convention and Protocol. Non-research projects would need to comply with applicable permitting requirements in the London Convention and Protocol (see Part 4.1.3(A) above).

4.1.3(C) London Protocol Amendment on Ocean CDR

In 2013, the Parties to the London Protocol agreed to an amendment, which would codify the above approach to assessing ocean fertilization projects.¹⁷⁴ 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

¹⁶⁸ Resolution LC-LP.2(2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (Oct. 14, 2010) [hereinafter “2010 LC / LP Resolution”].

¹⁶⁹ *Id.*

¹⁷⁰ 2008 LC / LP Resolution, *supra* note 136, Art. 8.

¹⁷¹ See e.g., 2021 NASEM Report, *supra* note 12, at 31.

¹⁷² 2008 LC / LP Resolution, *supra* note 136, Art. 2. The definition excludes “conventional aquaculture, or mariculture, or the creation of artificial reefs.”

¹⁷³ Vivian, *supra* note 158.

¹⁷⁴ Resolution LP .4(8), Amendment to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 to Regulate Marine Geoengineering (Oct. 18, 2013) [hereinafter “2013 LP Amendment”].

subcategory of an activity may be authorized under a permit.¹⁷⁵

While the article refers generally to “marine geoengineering activities,” annex 4 only lists “ocean fertilization,” thus limiting the scope of the amendment.¹⁷⁶ Under annex 4, countries cannot permit ocean fertilization projects, unless they are found to constitute “legitimate scientific research.”¹⁷⁷ 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.¹⁷⁸

Like the 2008 resolution, the 2013 amendment defines “ocean fertilization” broadly to mean “any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans,”¹⁷⁹ which could encompass AU / AD.¹⁸⁰ The amendment applies to any ocean fertilization activities that involve “the *placement* of matter into the sea” (emphasis added),¹⁸¹ which arguably occurs in AU / AD projects (i.e., because pipes and other equipment are placed in the water).¹⁸² Nevertheless, the 2013 amendment has limited effect on AU / AD projects because it has not yet taken effect, and thus is not legally binding. Under the terms of the London Protocol, amendments do not enter into force until ratified by two-thirds of the parties to the Protocol.¹⁸³ To date, just six of the fifty-three parties to the London Protocol have ratified the 2013 amendment, which is well below the two-thirds threshold required.¹⁸⁴

Table 2: Treatment of AU / AD Projects Under the London Convention, London Protocol, 2008 Resolution, and 2013 Amendment

	London Convention	London Protocol	2008 Resolution	2010 Amendment
Legally binding on the U.S.	Yes. The U.S. is a party to, and thus bound by, the London Convention.	No. The U.S. is not a party to, and thus not bound by, the London Protocol.	No. The resolution is not legally binding on any country.	No. The amendment has not yet entered into force. Even when it does, the amendment will only affect the London Protocol, to which the U.S. is not a party.

continued on next page

175 *Id.* Annex 1, Art. 1.

176 *Id.*

177 *Id.*

178 *Id.*

179 *Id.*

180 See *supra* Part 4.1.2(A).

181 2013 LP Amendment, *supra* note 185, Annex I, Art. 1.

182 See *supra* Part 4.1.2(A).

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

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

continued from previous page

	London Convention	London Protocol	2008 Resolution	2010 Amendment
Applicable to AU/AD projects	Unlikely. AU / AD arguably do not involve “dumping” as defined in the Convention because they do not involve the deliberate disposal of materials.	Unlikely. AU / AD arguably do not involve “dumping” as defined in the Protocol because they does not involve the deliberate disposal of materials.	Unlikely. AU / AD arguably do not involve “dumping” as defined in the Protocol because they do not involve the deliberate disposal of materials.	Likely. The definition of “ocean fertilization” in the amendment appears broad enough to encompass AU. The amendment applies where there is a “placement of matter into the sea” which arguably occurs in AU.
Requirements for AU / AD projects (if applicable)	Must be permitted by national authorities in the country with jurisdiction over the project. Permits cannot be issued for projects that involve the dumping of “persistent plastics and other persistent synthetic materials.” Permits could be issued for AU / AD projects that do not use plastic pipes or other plastic or synthetic materials.	Must be permitted by national authorities in the country with jurisdiction over the project. Permits could be issued for AU / AD projects, provided the pipes and other equipment used qualify as “man-made structures.”	Subject to review by relevant national authorities in the country with jurisdiction over the project under the 2010 assessment framework. May need to be permitted (depending on findings of review).	Must be permitted by relevant national authorities in the country with jurisdiction over the project. Permits can only be issued for “legitimate scientific research.”

4.1.4 Other Potentially Relevant International Agreements

Other international agreements with potential relevance to AU / AD research and commercial-scale operations include:

- The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*** (“ENMOD”): ENMOD was adopted in December 1976 and entered into force in October 1978.¹⁸⁵ At the time of writing, there were 78 parties to ENMOD, each of which had agreed “not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects.”¹⁸⁶ ENMOD defines “environmental modification techniques”

¹⁸⁵ United Nations, *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*, STATUS OF TREATIES, <https://perma.cc/YH6D-N23T> (last updated Mar. 28, 2022).

¹⁸⁶ *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques*, May 18, 1977, Art. I.

as those intended to change, “through the deliberate manipulation of natural processes, the dynamics, composition or structure of the Earth.” This definition could include AU / AD, which involve manipulating natural processes for sequestering carbon dioxide in the oceans, and thereby change the composition of both the ocean and the atmosphere. However, ENMOD would not apply to the use of such techniques for peaceful purposes, including to mitigate climate change.

- ***The International Convention for the Prevention of Pollution from Ships*** (“MARPOL”): MARPOL was adopted in November 1973, entered into force in October 1983, and had 160 parties at the time of writing.¹⁸⁷ MARPOL aims to prevent marine pollution due to operational or accidental releases from ships.¹⁸⁸ It includes six technical annexes, each dealing with a different source of pollution. Of particular relevance of AU / AD, Annex V prohibits “the disposal into the sea of all plastics.”¹⁸⁹ Certain pipes and other equipment used in AU / AD could be made of plastic. However, as discussed in Part 4.1.3 above, the plastic equipment used in AU / AD is arguably not “disposed of” in the ocean. Whereas disposal typically involves the permanent abandonment of materials that are no longer useful, any plastic AU / AD equipment would be temporarily placed in the ocean for the purpose of cycling water and thereby increasing uptake of carbon dioxide from the atmosphere. While there is a risk of plastic equipment disintegrating or being lost in the ocean, that is unlikely to violate the prohibition on the disposal of plastic at sea in Annex V of MARPOL. The Annex specifically states that the prohibition does not apply to “[t]he accidental loss” of materials “resulting from damage to . . . equipment, provided that all reasonable precautions have been taken before and after the occurrence of the damage, to prevent or minimize the accidental loss.”¹⁹⁰
- ***The Convention Concerning the Protection of World Cultural and Natural Heritage*** (“World Heritage Convention”): The World Heritage Convention was adopted in November 1972 and entered into force in December 1975. The 194 parties to the World Heritage Convention must identify important cultural and natural heritage sites within their territory and “do all [they] can” to protect and conserve those sites.¹⁹¹ This could have implications for the approval and conduct of AU / AD projects in the vicinity of, or that could otherwise affect, cultural or natural heritage sites.
- ***The Convention on the Conservation of Migratory Species of Wild Animals*** (“Convention on Migratory Species”): The Convention on Migratory Species was adopted in June 1979 and entered into force in November 1983.¹⁹² At the time of writing, there were 131 parties to the Convention on Migratory Species, each of which had agreed to “endeavour [sic] to provide immediate protection for migratory species”

187 INTL. MARITIME ORGANIZATION, STATUS OF TREATIES (2019), <https://perma.cc/9SMG-DWWG>.

188 International Convention for the Prevention of Pollution from Ships, Nov. 2, 1973.

189 *Id.*, Annex V, Reg. 3.2.

190 *Id.* Annex V, Reg. 7.1.2.

191 Convention Concerning the Protection of World Cultural and Natural Heritage, 1037 U.N.T.S. 151, Nov. 16, 1972, Art. 4.

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

that are endangered and “conclude agreements covering the conservation and management of migratory species” that have an unfavorable conservation status or a conservation status that would benefit from international cooperation.¹⁹³ The parties have adopted a number of resolutions, decisions, and concerted actions aimed at coordinating international action to protect migratory marine species.¹⁹⁴ Marine species covered by these provisions include marine mammals and fish,¹⁹⁵ so AU / AD project developers would need to ensure their activities do not threaten those species’ habitat.

- ***The Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters*** (“Aarhus Convention”): The Aarhus Convention was adopted in June 1998 and entered into force in October 2001.¹⁹⁶ The forty-seven European and Asian parties¹⁹⁷ to the Convention agree to “guarantee . . . rights of access to information, public participation in decision-making, and access to justice in environmental matters.”¹⁹⁸ To that end, the parties must ensure that the public is informed of, and consulted about, proposed activities that “may have a significant effect on the environment.”¹⁹⁹ Whether a particular AU / AD project may have significant environment effects would need to be determined on a case-by-case basis. The government entity approving any environmentally-significant project would need to comply with various procedural obligations set out in the Aarhus Convention, including (among other things):
 - The government entity must take steps to “encourage” the project proponent “to identify the public concerned, to enter into discussions, and to provide information” about the project before applying for approval.²⁰⁰
 - The government entity must to publish information and allow members of the public to submit “comments, information, analyses, or other opinions” about the project.²⁰¹ Any submissions must be given due consideration by the government entity²⁰² and requests for information must be responded to within one month of submission.²⁰³

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

194 UN ENVIRONMENT PROGRAMME, CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS, PROGRESS REPORT ON RELEVANT ACTIVITIES UNDERTAKEN WITHIN THE FRAMEWORK OF THE CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS (CMS) FOR THE UNITED NATIONS OPEN-ENDED INFORMAL CONSULTATIVE PROCESS ON OCEANS AND THE LAW OF THE SEA (Undated), <https://perma.cc/JVF7-ZLL4>.

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

196 United Nations Economic Commission for Europe, *About the Convention*, AARHUS CONVENTION, <https://perma.cc/R9HN-WAAM> (last visited Oct. 27, 2021).

197 United Nations Economic Commission for Europe, *Map of Parties*, AARHUS CONVENTION, <https://perma.cc/AP3D-7QKK> (last visited Oct. 27, 2021).

198 Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, 2161 U.N.T.S. 447, June 25, 1998, Art. 3.

199 *Id.* Art. 6.

200 *Id.* Art. 6(5).

201 *Id.* Art. 6(2) & (6)-(7).

202 *Id.* Art. 6(8).

203 *Id.* Art. 4.

- ***The Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean*** (Escazú Agreement): The Escazú Agreement was adopted in March 2018 and entered into force in April 2021. There were 24 signatories and 12 ratifying parties to the Escazú Agreement at the time of writing.²⁰⁴ Similar to the Aarhus Convention, the Escazú Agreement commits its parties to ensuring the rights of access to environmental information, public participation in the environmental decision-making process, and access to justice in environmental matters.²⁰⁵
- ***The Antarctic Treaty***: Adopted in December 1959, the Antarctic Treaty entered into force in June 1961, and had fifty-four parties at the time of writing.²⁰⁶ The Antarctic Treaty provides for “[f]reedom of scientific investigation in Antarctica,” defined as the “area south of 60° South Latitude.”²⁰⁷ The parties to the Antarctic Treaty agreed to cooperate on scientific research and, to that end, exchange “information regarding plans for scientific programs in Antarctica” and “scientific observations and results from Antarctica” to the “greatest extent feasible and practicable” (among other things).²⁰⁸ Additional requirements are imposed by the Protocol on Environmental Protection to the Antarctic Treaty, which was adopted in October 1991 and entered into force in January 1998.²⁰⁹ The protocol requires parties to undertake an environmental review of proposed research projects to evaluate “their possible impacts on the Antarctic environment and dependent and associated ecosystems and on the value of Antarctica for the conduct of scientific research.”²¹⁰ Projects must be planned and conducted so as to “limit adverse impacts on the Antarctic environment and dependent and associated ecosystems” and avoid
 - (i) adverse effects on climate or weather patterns;
 - (ii) significant adverse effects on air or water quality;
 - (iii) significant changes in the atmospheric, terrestrial . . . , glacial or marine environments;
 - (iv) detrimental changes in the distribution, abundance or productivity or species or populations of species of fauna and flora;
 - (v) further jeopardy to endangered or threatened species or populations of such species; or
 - (vi) degradation of, or substantial risk to, areas of biological, scientific, historic, aesthetic or wilderness significance.”²¹¹

204 Observatory on Principle 10 in Latin America and the Caribbean, *Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean*, <https://perma.cc/4HTY-PDYL> (last visited Mar. 28, 2022).

205 *Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean*, April 3, 2018, Art. 1.

206 Secretariat of the Antarctic Treaty, *The Antarctic Treaty*, <https://perma.cc/Q4HF-ZL8K> (last visited Oct. 27, 2021).

207 Antarctic Treaty, 402 U.N.T.S. 71, Art. II & VI.

208 *Id.* Art. II & III.

209 Secretariat of the Antarctic Treaty, *The Protocol on Environmental Protection to the Antarctic Treaty*, <https://perma.cc/65AW-JQF9> (last visited Oct. 27, 2021).

210 Protocol on Environmental Protection to the Antarctic Treaty, Art. 3(2)(c) & 8.

211 *Id.*, Art. 3(2)(a)-(b).

These requirements would apply to AU / AD research projects conducted by a party in the Antarctic region.

The U.S. is a party to, and thus bound by, ENMOD, the World Heritage Convention, the Antarctic Treaty, and Annexes I, II, III, V, and VI of MARPOL. The U.S. is not a party to, and thus not bound by, the other agreements listed in Part 4.1.4.

4.2 Relevant Principles of Customary International Law

Research into, and deployment of, AU / AD systems could implicate the so-called “no harm” rule of customary international law. As articulated in the 1992 Declaration of the United Nations Conference on the Environment and Development, the no harm rule requires each country “to ensure that activities within their jurisdiction or control do not cause damage to the environment of other [countries] or of areas beyond the limits of national jurisdiction.”²¹² The International Tribunal for the Law of the Sea described the rule as imposing an obligation of “due diligence” on countries to “exercise best possible efforts” or “do the utmost” to avoid or minimize transboundary environmental damage.²¹³ What constitutes best efforts will depend on the circumstances.²¹⁴ At a minimum, however, countries must closely oversee activities that could cause transboundary environmental damage (e.g., by adopting and strictly enforcing relevant domestic laws).²¹⁵ In this regard, the International Court of Justice (“ICJ”) has stated that the due diligence obligation “entails not only the adoption of appropriate rules and measures, but also a certain level of vigilance in their enforcement and the exercise of administrative control applicable to public and private operators, such as the monitoring of activities undertaken by such operators.”²¹⁶ Thus, to fulfil their obligation under the no harm rule, countries should ensure they have adequate domestic laws and take other measures to prevent any adverse environmental impacts from AU / AD projects.

The ICJ has also recognized that countries have a procedural obligation, under customary international law, to “undertake an environmental impact assessment where there is a risk that [a] proposed . . . activity may” cause “significant” transboundary environmental damage.²¹⁷ There is no agreed upon definition of what constitutes “significant” damage. However, the International Law Commission has interpreted the term as requiring damage that is more than

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

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

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

215 *Id.* at 111 – 116. See also *Pulp Mills Case*, *supra* note 223, at 187 & 197.

216 *Pulp Mills Case*, *supra* note 223, at 197.

217 *Id.* at 204.

merely “detectable,” but not necessarily “serious” or “substantial.”²¹⁸

Prior to undertaking or authorizing a project that has the potential to cause transboundary environmental damage, the responsible country must conduct a preliminary assessment to determine whether there is a risk of significant damage.²¹⁹ If the country finds that a project poses a risk of significant damage, it must undertake a more comprehensive environmental impact assessment. Under international law, the country must complete the assessment prior to the commencement of the project, but otherwise has broad discretion in conducting the assessment.²²⁰ In this regard, the ICJ has observed that international law does not “specify the scope and content of an environmental impact assessment” and thus “it is for each [country] to determine in its domestic legislation or in the authorization for the project, the specific content of the environmental impact assessment required in each case.”²²¹ The U.S. and many other countries do, however, have domestic laws governing the conduct of environmental impact assessments. Many countries’ laws require consultation with potentially affected parties and the general public during the environmental impact assessment. Where the environmental impact assessment confirms that a project could cause significant transboundary environmental harm, the relevant country must notify and consult with other potentially affected countries and relevant international organizations.²²²

218 INTERNATIONAL LAW COMMISSION, DRAFT ARTICLES ON PREVENTION OF TRANSBOUNDARY HARM FROM HAZARDOUS ACTIVITIES, WITH COMMENTARIES 152 (2001), <https://perma.cc/7BB3-B4MM>.

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

220 Pulp Mills Case, *supra* note 223, at 205.

221 *Id.*

222 Certain Activities Case, *supra* note 230, at 707.

5. U.S. LAWS GOVERNING ARTIFICIAL UPWELLING AND DOWNWELLING

The U.S. has jurisdiction over offshore areas extending 200 n.m. from its coast, and further in some circumstances.²²³ Under international law, the U.S. has full “sovereign rights” within that area, including rights to explore, exploit, conserve, and manage natural resources.²²⁴ The U.S. is also 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.²²⁵ This part discusses key U.S. federal and state laws that could apply to AU / AD in areas under U.S. jurisdiction.

5.1 Projects in U.S. Federal Waters

As discussed in Part 2, AU / AD projects would require the installation of vertical pipes and other equipment (e.g., pumps and associated power sources), which may be moored into the seabed or free floating above it. Federal government approval would be required to moor equipment to the seabed of the OCS (i.e., typically extending 3 to 200 nautical miles from the coast). In the OCSLA, Congress declared that “the subsoil and seabed of the [OCS] appertain to the United States and are subject to its jurisdiction, control, and power of disposition.”²²⁶ The courts have held that, while the U.S. federal government does not own the OCS in fee simple, it does have “paramount rights” to it.²²⁷ As such, any use or occupancy of the OCS by others—e.g., to moor pipes for use in AU / AD projects—must be permitted by the federal government through a lease, right-of-way, or similar instrument.

In the OCSLA, Congress authorized the Department of the Interior (“DOI”) to issue leases and rights-of-way over the OCS for certain activities relating to energy and mineral development. DOI could, under the OCSLA, issue OCS leases authorizing the mooring of renewable energy generating facilities to power AU / AD systems. However, leases could not be issued for the mooring of AU / AD pipes or other equipment, at least where that equipment is not deployed with renewable generating facilities.

All AU / AD systems that are moored to the OCS must also be permitted by the U.S. Army Corps of Engineers (“ACE”). ACE could issue permits for AU / AD systems regardless of whether they incorporate renewable energy facilities. There is some uncertainty as to whether an ACE-issued permit would be sufficient, by itself (i.e., absent a DOI-issued lease), to authorize the mooring of AU / AD systems on the OCS. Experience with wind energy development on the OCS suggests that ACE permits could be used to authorize the temporary mooring of AU / AD systems for research purposes, but not their long-term deployment for commercial purposes; the latter would require both a permit from ACE and a lease from DOI. Since DOI can only issue leases for AU / AD systems incorporating

²²³ See *supra* Part 3.1.

²²⁴ UNCLOS, *supra* note 57, Art. 56(1)(a).

²²⁵ *Id.* Art. 56(1)(b).

²²⁶ 43 U.S.C. § 1332(1).

²²⁷ *U.S. v. California*, 332 U.S. 19 (1947).

renewable generating facilities, the deployment of other systems requiring use of the seabed is effectively prohibited under current law.

5.1.1 OCS Leases and Rights-of-Way

Under section 8(p)(1) of the OCSLA, DOI's Bureau of Ocean Energy Management ("BOEM") can issue leases and rights-of-way over the OCS for activities that:

- (A) support the exploration, development, production, or storage of oil or natural gas . . . ;
- (B) support transmission 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].²²⁸

BOEM has interpreted subsection (C) above as authorizing it to issue leases for the "construct[ion], operat[ion], or maintain[ance of] any facility to produce, transport, or support generation of electricity or other energy product derived from a renewable energy resource."²²⁹ BOEM regulations define "renewable energy" broadly to mean "energy resources other than oil and gas and minerals," including (but not limited to) "wind, solar, and ocean waves, tides, and currents."²³⁰

Pursuant to subsection (C), BOEM could issue leases authorizing the installation of offshore wind turbines, solar panels, or tidal generating facilities that are intended to generate electricity for use in AU / AD systems. It is, however, unclear whether such leases would also authorize the installation of other equipment (e.g., pipes and pumps) that is not used to generate electricity but forms part of the AU / AD system. Under BOEM regulations, facilities installed under renewable energy leases must be used for:

- "commercial activities . . . associated with the generation, storage, or transmission of electricity or other energy product . . . intended for distribution, sale, or other commercial use;" or
- other activities "that support, result from, or relate to the production of energy from a renewable energy source."

It could be argued that AU / AD pipes and pumps that are deployed with an offshore renewable generating facility are "relate[d] to the production of energy from a renewable energy source" because they use the energy produced by the facility. On that view, a BOEM-issued lease would authorize the installation of a complete AU / AD system, including the pipes, pumps, and renewable generating facility. A contrary view could also be taken, however.

²²⁸ 43 U.S.C. § 1337(p)(1).

²²⁹ 30 C.F.R. § 585.104

²³⁰ *Id.* § 585.112.

Under the OCSLA, BOEM is only authorized to issue leases for activities that “produce or support production, transportation, or transmission of energy” from renewable sources, which AU / AD pipes and pumps arguably do not do. BOEM could, therefore, take the view that the installation of pipes and pumps cannot be authorized through renewable energy leases.

BOEM does not have authority to issue leases for AU / AD projects that do not involve any renewable energy development (e.g., because they do not require an energy source). Absent such a lease, project developers likely could not use the OCS to moor structures, with one possible exception discussed in Part 5.1.2 below. In the future, however, Congress could amend the OCSLA to allow the issuance of OCS leases for AU / AD systems that do not incorporate renewable energy generating facilities.

5.1.1(A) Process for Obtaining Leases Under the OCSLA

Where an AU / AD project incorporates a renewable energy facility, the project developer could apply to BOEM for a lease. BOEM must issue leases through a competitive auction process unless BOEM determines that there is no competitive interest in the area to be leased.²³¹ On receiving a lease application, BOEM must publish a notice in the Federal Register, seeking expressions of interest in the area.²³² If one or more expressions of interest are received, BOEM must auction leases,²³³ otherwise leases must be issued on a non-competitive basis.²³⁴

Before issuing a lease, BOEM must evaluate the effect of leasing on the human, marine, and coastal environments and develop measures to mitigate any adverse effects.²³⁵ BOEM must also conduct an environmental review under the National Environmental Policy Act (“NEPA”) and consult with other federal, state, and local government agencies as follows:

- NEPA requires federal agencies, including BOEM, to prepare an environmental impact statement (“EIS”) for any major federal action “significantly affecting the quality of the human environment.”²³⁶ The requirement applies whether the federal agency itself undertakes the action, funds the action, or authorizes it (e.g., via a lease or permit).²³⁷ The EIS must assess the natural, economic, social, and cultural resource effects of the action, and the agency is required to release relevant documents to the public and consider their input.²³⁸
- Under the Endangered Species Act (“ESA”),²³⁹ BOEM must consult with the Fish and Wildlife Service (“FWS”) before issuing any lease or taking any other action that

231 43 U.S.C. § 1337(p)(3). See also 30 C.F.R. Part 585, Subpart B. For a more detailed discussion of BOEM’s leasing process, see ROMANY M. WEBB & MICHAEL B. GERRARD, *Sequestering Carbon Dioxide Undersea in the Atlantic: Legal Problems and Solutions*, 36 UCLA J. ENV’T. L. & POL’Y 1, 17-21 (2018).

232 30 C.F.R. §§ 585.210 & 585.230.

233 *Id.* §§ 585.220 & 585.231.

234 *Id.* §§ 585.212 & 585.231.

235 *Id.* § 585.211(b)(2).

236 42 U.S.C. § 4332(2)(C).

237 40 C.F.R. § 1508.18(a).

238 42 U.S.C. 4332(2)(C).

239 30 C.F.R. § 585.203.

may affect terrestrial or freshwater species, which have been listed as endangered²⁴⁰ or threatened^{241,242} BOEM must also consult with FWS to ensure activities do not harm seabirds under the Migratory Bird Treaty Act.²⁴³ 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”).²⁴⁴

- BOEM must ensure that activities authorized under a lease will not harm historic properties or religious sites of importance to American Indians. The National Historic Preservation Act requires federal agencies to consider the effect of any action they undertake or authorize on historic properties, including shipwrecks, sunken aircraft, and prehistoric archeological sites on the OCS.²⁴⁵ If a place of religious significance to American Indians may be affected, BOEM may also need to consult with Indian religious practitioners pursuant to the American Indian Religious Freedom Act.²⁴⁶
- BOEM must consult with other federal agencies with an interest in, and state and local governments affected by, issuance of the lease.²⁴⁷ Where BOEM’s issuance of a lease will affect²⁴⁸ 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.²⁴⁹ BOEM must submit a consistency determination to the relevant state,²⁵⁰ and, if the state objects to the determination, BOEM must work with it to address the objection.²⁵¹

240 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).

241 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).

242 *Id.* § 1536(a)(2).

243 *Id.* § 703(a).

244 *Id.* § 1855(b)(2).

245 54 U.S.C. §§306101-31. See also BOEM, *National Historic Preservation Act*, <https://perma.cc/UG5S-45TH> (last visited Mar. 28, 2022) (listing examples of historic properties on the OCS).

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

247 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).

248 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.” See 15 C.F.R. § 930.11(g).

249 16 U.S.C. § 1456(c).

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

251 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 15 C.F.R. § 930.43.

With a BOEM-issued lease in hand, the lessee has the right to install and operate facilities on a designated portion of the OCS,²⁵² subject to the lessee obtaining any necessary approvals from other agencies.²⁵³ The approvals required for each AU / AD project will depend on the specific design of the project and where it takes place.

5.1.2 ACE Permits for OCS Activities

All AU / AD systems that are moored or otherwise attached to the seabed of the OCS will require a permit from ACE under section 10 of the Rivers and Harbors Act (“RHA”) (as amended by section 4 of the OCSLA). Section 10 of the RHA prohibits “any obstruction . . . to the navigable capacity of any of the waters of the U.S.” unless authorized by ACE.²⁵⁴ For the purposes of the RHA, navigable “waters of the U.S.” include ocean waters, extending up to three n.m. from shore.²⁵⁵ While ACE does not have jurisdiction under the RHA over structures further offshore, section 4 of the OCSLA extends ACE’s “authority . . . to prevent obstruction to navigation . . . to [certain] artificial islands, installations, and other devices” on the OCS.²⁵⁶ Specifically, section 4 of the OCSLA grants ACE authority over “all artificial islands, and all installations and other devices permanently or temporarily attached to the seabed [of the OCS], which may be erected thereon for the purpose of exploring for, developing, or producing resources therefrom, or any such installation or other device (other than a ship or vessel) for the purpose of transporting such resources.”²⁵⁷ ACE has interpreted section 4 broadly, concluding that it has authority over all structures attached to the OCS, regardless of how those structures are used.²⁵⁸ That interpretation has been upheld by First Circuit Court of Appeals.²⁵⁹

Given the above, ACE could issue permits for AU / AD systems that are moored or otherwise attached to the seabed of the OCS, regardless of whether those systems integrate renewable energy facilities. In this respect, ACE’s permitting authority is somewhat broader than BOEM’s leasing authority, discussed in Part 5.1.1 above. It is unclear whether an ACE-issued permit would, by itself (i.e., absent a BOEM-issued lease), be sufficient to authorize AU / AD projects on the OCS. In *Alliance to Protect Nantucket Sound, Inc. v. U.S. Department of the Army*, the First Circuit Court of Appeals held that only an ACE-issued permit (and no BOEM-issued lease) was required to install a structure on the OCS where that structure did not “infringe on any federal property interest.”²⁶⁰ The case concerned a data tower which was to be temporarily installed on the OCS for no more than five years to collect information about

252 *Id.* § 585.200(a).

253 *Id.* For a more detailed discussion, see Webb & Gerrard, *supra* note 242, at 24-26.

254 33 U.S.C. § 403.

255 33 C.F.R. §§ 322.2 & 329.12(a).

256 43 U.S.C. § 1333(e).

257 *Id.* §§ 1333(a) & (e).

258 ARMY CORPS OF ENGINEERS, REGULATORY GUIDELINE LETTER 88-08, REGULATION OF ARTIFICIAL ISLANDS, INSTALLATIONS, AND STRUCTURES ON THE U.S. OUTER CONTINENTAL SHELF (1988), <https://perma.cc/H5YS-RJ3D> (“The legislative history of the OCSLA, as amended, indicates that Congress intended the Corps to regulate all . . . artificial islands, structures, etc. [on the OCS] regardless of the purpose they would serve”).

259 *Alliance to Protect Nantucket Sound, Inc. v. U.S. Dep’t of the Army*, 398 F.3d 105, 109 (1st Cir. 2005) (ACE “has authority to grant a Section 10 permit for all structures on the OCS, regardless of their function . . . [L]egislative history reveals, with exceptional clarity, Congress’s intent that Section 10 authority under OCSLA not be restricted to structures related to mineral development”).

260 *Id.* at 114.

wind resources in the area.²⁶¹ The court accepted ACE’s conclusion that the tower would have “negligible impact on property ownership.”²⁶² In the court’s view, it was “inconceivable . . . that permission to erect a single, temporary scientific device . . . which gives the federal government information it requires [to assess the feasibility of offshore wind energy development] could be an infringement on any federal property ownership interest in the OCS.”²⁶³ The court thus concluded that the tower could be authorized through an ACE-issued permit and did not require “additional Congressional authorization.”²⁶⁴

Applying the above reasoning, some AU / AD projects may be found not to infringe on federal property interests, and thus able to be authorized solely through an ACE-issued permit. This is particularly likely if AU / AD pipes and other equipment are to be installed temporarily, for a limited number of months or years, as part of a research project. The temporary nature of the installation and its use for research purposes were key factors in the court’s decision in *Alliance to Protect Nantucket Sound, Inc.*

5.1.2(A) Process for Obtaining Permits Under the RHA

Under the RHA, ACE issues general permits for categories of activities that “are substantially similar in nature and cause only minimal individual and cumulative environmental impacts.”²⁶⁵ Activities covered by general permits do not need to be specifically authorized by ACE. In some cases, the person engaging in the activity must notify ACE in advance, but that is not always required.²⁶⁶ All general permits are subject to conditions designed to ensure that the activities they authorize have minimal impacts on the marine environment and other users thereof. Thus, for example, activities performed under general permits must not take place in “waters . . . that serve as breeding areas for migratory birds” or have “concentrated shellfish populations,” must not “substantially disrupt the necessary life cycle movements of” aquatic species, and must cause no more than “minimal adverse effect on navigation.”²⁶⁷

At the time of writing, fifty-nine general permits were in effect.²⁶⁸ While none deal specifically with AU / AD, General Permit 5 (Scientific Measurement Devices) could apply to some research projects. General Permit 5 covers the installation of “devices whose purpose is to measure and record scientific data, such as staff gages, tide and current gages, meteorological stations, water recording and biological observation devices, water quality testing and improvement devices, and similar structures.”²⁶⁹ This would encompass equipment used to collect samples or other measurements needed to determine whether a particular area is suitable for AU / AD. It would not, however, cover AU / AD pipes, pumps, or related equipment. Thus, an individual permit would need to be obtained from ACE to install AU / AD pipes, pumps, and related equipment for research or commercial projects.

261 *Id.* at 107 & 114.

262 *Id.* at 114.

263 *Id.*

264 *Id.*

265 33 C.F.R. § 322.2(f)(1).

266 *See generally*, Reissuance and Modification of Nationwide Permits, 86 Fed. Reg. 2744, 2745 (Jan. 13, 2021).

267 ARMY CORPS OF ENGINEERS, 2021 NATIONWIDE PERMITS 47-48 (2021), <https://perma.cc/Q5ZB-RE4H>.

268 *Id.*

269 *Id.* at 6.

On receiving an application for an individual permit, ACE must issue a public notice, soliciting comments and other information from interested stakeholders.²⁷⁰ ACE must consider any comments and information received when deciding whether to issue an individual permit.²⁷¹ ACE must base its decision on an evaluation of the probable impact of the activity to be permitted on the public interest.²⁷² This requires “a careful weighing” of all relevant factors, including:

economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership and, in general, the needs and welfare of the people.²⁷³

ACE must consider the need for the activity and balance its likely benefits against its detrimental effects.²⁷⁴ If the activity will take place in an area with recognized historic, cultural, scenic, conservation, recreational, or similar values, ACE must consider its likely effects on those values.²⁷⁵ ACE must also complete any necessary environmental reviews under NEPA,²⁷⁶ consult with FWS and NMFS to minimize impacts on species,²⁷⁷ and work with the relevant coastal state(s) to ensure consistency with any management plan(s) adopted under the CZMA.²⁷⁸

5.1.3 Other Considerations

Various other federal laws could also apply to AU / AD projects in federal waters. For example, the National Marine Sanctuaries Act (“NMSA”) would apply to the projects conducted in or near any area designated as a marine sanctuary by the Secretary of Commerce. Under the NMSA, activities in marine sanctuaries must be permitted by the National Oceanic and Atmospheric Administration (“NOAA”),²⁷⁹ and must not “destroy, cause the loss of, or injure” any living or non-living resource that contributes to the conservation, recreational, ecological, historical, educational, cultural, archeological, scientific, or aesthetic value of the sanctuary.²⁸⁰

All structures and equipment installed in connection with AU / AD projects must be appropriately marked to enable vessels to navigate around them. The U.S. Coast Guard (“USCG”) oversees the marking of structures under the aids to navigation program.²⁸¹

270 33 C.F.R. § 325.2(a)(2).

271 *Id.* § 325.2(a)(3).

272 *Id.* § 320.4(a)(1).

273 *Id.*

274 *Id.* § 320.4(a)(2).

275 *Id.* § 320.4(e).

276 *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.

277 *Id.* §§ 320.4(c) & 325.2(b)(5).

278 *Id.* §§ 320.4(h) & 325.2(b)(2).

279 33 U.S.C. § 1436(1). *See also id.* § 1432(8) (defining “sanctuary resource”).

280 33 U.S.C. § 1436(1). *See also id.* § 1432(8) (defining “sanctuary resource”).

281 *See generally*, U.S. Coast Guard, Aids to Navigation Manual Administration (2005), <https://perma.cc/NEY7-2PVC>.

Pursuant to that program, any person wanting to install a fixed or floating structure that restricts, endangers, or interferes with navigation must apply to USCG authorization to mark the structure.²⁸² Prior to granting such authorization, USCG must conduct any necessary environmental and other reviews and consultations, for example under NEPA, the ESA, and CZMA. Where authorization is granted, USCG specifies the required markings, which ordinarily must remain in place until the structure is removed.²⁸³

AU / AD projects that require the installation of structures that extend above the surface of the water (e.g., wind turbines) may be subject to additional marking and other requirements imposed by the Federal Aviation Administration (“FAA”). FAA regulations require notice for the construction of any structure extending more than 200 feet in the air.²⁸⁴ If the FAA determines that the structure may result in obstruction or interference with the navigable airspace, the agency must conduct a study to determine the extent of the adverse impact and options for mitigating that impact.²⁸⁵ Wind turbines specifically may be required to meet white paint and synchronized red light requirements.²⁸⁶

Construction of AU / AD systems in federal waters may also raise supply chain considerations. Under the Jones Act, vessels transporting cargo from one U.S. point to another U.S. point must be built in the U.S., and owned and crewed by U.S. citizens.²⁸⁷ U.S. Customs and Border Protection (“CBP”) is responsible for determining what maritime activity falls under the Jones Act. In the past, CBP has taken the view that oil rigs attached to the seabed of the U.S. OCS are U.S. points and thus can only be serviced by U.S. ships if the ship departs from a U.S. port.²⁸⁸ Notably, however, CBP has determined that rigs not attached to the seabed (e.g., mobile offshore drilling units) are not U.S. points, and thus can be served by foreign vessels.²⁸⁹ CBP may draw a similar distinction between moored and floating AU / AD systems. If moored systems are considered U.S. points for the purposes of the Jones Act, building out the infrastructure for AU / AD projects may require investment both in the projects themselves and likely in U.S.-flag ships capable of carrying supplies to build and service them.

While the construction of AU / AD systems would involve the placement of materials (e.g., pipes and pumps) in ocean waters, it would not, in our view, trigger application of the ocean dumping provisions in the Marine Protection, Research, and Sanctuaries Act (“MPRSA”).²⁹⁰ Enacted to fulfil the U.S.’s obligations under the London Convention, the MPRSA regulates “the dumping of all types of materials into ocean waters” within twelve n.m. of the U.S. coast, and further in some cases.²⁹¹ For the purposes of the MPRSA, “dumping” is defined to mean

282 33 C.F.R. §§ 64.03, 64.04, & 64.21.

283 *Id.* § 64.23.

284 14 C.F.R. § 77.9.

285 49 U.S.C. § 44718(b).

286 FAA, *Wind Turbine FAQs*, <https://perma.cc/9XCF-3U3H> (last updated Oct. 18, 2021).

287 46 U.S.C. § 50101.

288 JOHN FRITTELLI, CONG. RESEARCH SERV., R45725, SHIPPING UNDER THE JONES ACT: LEGISLATIVE AND REGULATORY BACKGROUND 9 (2019), <https://perma.cc/9VGY-HRX8>.

289 *Id.*

290 33 U.S.C. § 1401 et seq.

291 *Id.* § 1401(b).

“any disposition of material.”²⁹² Notably, however, the definition expressly excludes:

the construction of any fixed structure or artificial islands [and] the placement of any device in ocean waters or on or in the submerged lands beneath such waters, for a purpose other than disposal, where such construction or placement is otherwise regulated by Federal or State law or occurs pursuant to an authorized Federal or State program.²⁹³

The pipes and other equipment used in AU / AD are likely to be considered “fixed structures” or “devices” that are placed in the ocean “for a purpose other than disposal.” While the term “disposal” is not defined in the MPRSA, it is generally used to refer to the act of getting rid of something that is no longer useful.²⁹⁴ That is not the purpose behind installing AU / AD pipes and other equipment in ocean waters. On the contrary, the equipment is intended to be used to cycle water, with the aim of increasing uptake of carbon dioxide by the ocean. The installation of the equipment is governed by other federal laws and programs (e.g., the OCSLA leasing and RHA permitting programs for moored structures and the USCG’s aids to navigation program for floating structures), and thus exempt from the MPRSA.

AU / AD projects in federal waters also would not require water discharge permits under the Federal Water Pollution Control Act (commonly known as the Clean Water Act (“CWA”)).²⁹⁵ The CWA prohibits the “discharge of any pollutant” to navigable waters from a point source, unless the discharger holds a permit issued under the National Pollutant Discharge Elimination System (“NPDES”).²⁹⁶ The CWA defines “navigable waters” to include the U.S. “territorial sea” but, importantly, adopts a different definition of the “territorial sea” to the one used in international law.²⁹⁷ Whereas international law provides that each country’s territorial sea extends to twelve n.m. from its coastline,²⁹⁸ under the CWA, the U.S. territorial sea is defined as “the belt of the seas measured from the line or ordinary low water along . . . the coast . . . and extending seaward a distance of three miles.”²⁹⁹ Three miles is equivalent to approximately 2.6 n.m. Federal waters generally begin three n.m. from the coast (except off Texas and the west coast of Florida, where federal waters begin nine n.m. from the coast), and thus the CWA does not apply to discharges within federal waters. (It should be further noted that, even if AU / AD projects were conducted in waters subject to the CWA (e.g., state waters), they would not require NPDES permits because they do not involve any discharge of “pollutants,” as that term is defined in the CWA. This is discussed further in Part 5.2.)

²⁹² *Id.* § 1402(f).

²⁹³ *Id.*

²⁹⁴ Merriam-Webster Dictionary, *Dispose*, <https://perma.cc/92EM-BZXB> (last visited Mar. 28, 2022); Cambridge Dictionary, *Dispose*, <https://perma.cc/6DWT-JGGG> (last visited Mar. 28, 2022).

²⁹⁵ 33 U.S.C. § 1251 et seq.

²⁹⁶ *Id.* §§ 1311(a) (providing that, subject to certain exceptions, “the discharge of any pollutant by any person shall be unlawful) & 1342(a)(1) (authorizing the EPA Administrator to issue permits authorizing the discharge of pollutants). See also *id.* §§ 1362(16) (defining “discharge” to mean “a discharge of a pollutant”) & 1362(12) (defining “discharge of a pollutant” to mean “(A) any addition of any pollutant to navigable waters from any point source, (B) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft”).

²⁹⁷ *Id.* § 1362(7).

²⁹⁸ UNCLOS, *supra* note 57, Art. 2-3.

²⁹⁹ 33 U.S.C. § 1362(8).

5.2 Projects in State Waters

Coastal states have primary jurisdiction over offshore waters and submerged land within three n.m. of their coasts, except in parts of the Gulf of Mexico, where the jurisdiction of Texas and Florida extends nine n.m. from the coast.³⁰⁰ The seabed underlying state waters is generally owned by the relevant coastal state but, in some areas, may be under municipal ownership.³⁰¹ Private parties wanting to use the seabed to moor AU / AD systems may require a lease or other authorization from the state or municipal owner.³⁰² In Delaware, for example, the “construction . . . of any structure on, in, under, or over” the seabed underlying state waters requires a lease from the state Department of Environmental Control.³⁰³ Similarly, in Massachusetts, the state Department of Environmental Protection must license use of the seabed.³⁰⁴ In some other states (e.g., Connecticut and Texas), use of the seabed is overseen by the state energy agency or land office.³⁰⁵ The requirements and process for obtaining a seabed lease or license differ between states.

In addition to obtaining a lease or license to use of the seabed, persons wanting to install AU / AD systems in state waters may also require other permits from local, state, and/or federal government entities. Again, local and state permitting requirements vary, and may ultimately depend on the specific design of each AU / AD project, including precisely where it is located. For example, some states impose additional requirements on development in wetlands and other sensitive environments, which could have implications for AU / AD in some areas. Several states have enacted “little NEPA” statutes that require agencies to conduct environmental reviews of activities they propose to undertake, fund, or permit.³⁰⁶

Due to their potential to interfere with navigation, all AU / AD projects in state waters will require a permit from ACE under the RHA. The RHA prohibits “[t]he creation of any obstruction . . . to the navigable capacity of any waters of the U.S.,” including state waters, unless the obstruction is “affirmatively authorized by Congress.”³⁰⁷ In the RHA, Congress empowered ACE to issue permits for activities that “modify” state waters, including by installing “structures” therein.³⁰⁸ ACE regulations define “structure” broadly to include “any obstacle or obstruction” to navigation, which would encompass AU / AD pipes and other

300 See *supra* Part 3.2.1.

301 For example, in parts of New York, local governments own the submerged land under state waters pursuant to Colonial patents. See *generally*, *Town of Oyster Bay v. Commander Oil Corp.*, 96 N.Y.2d 566, 572 (N.Y. 2001) (holding that the Town of Oyster Bay “owns the underwater land beneath Oyster Bay by virtue of a colonial patent”).

302 See *generally*, *Webb & Gerrard, supra* note 242, at 53-57.

303 7-7500-7504 DEL. ADMIN. CODE §§ 1-2.

304 310 MASS. CODE REGS. §§ 9.03-9.05.

305 See *e.g.*, CONN. GEN. STAT. § 22a-361 (providing for the issuance of certificates, authorizing use of the submerged land underlying state waters, by the Connecticut Department of Energy and Environment); TEX. NAT. RES. CODE §§ 33.101 - 33.106 (authorizing the Texas General Land Office to lease the submerged land underlying state waters).

306 NEPA.gov, States and Local Jurisdictions with NEPA-like Environmental Planning Requirements, <https://perma.cc/4DG8-GEDJ> (last visited Mar. 28, 2022). Examples include the California Environmental Policy Act, the New York State Environmental Quality Review Act, and similar acts in several other coastal states.

307 33 U.S.C. § 403. See *also* 33 C.F.R. § 329.12 (clarifying that “[t]he navigable waters of the United States over which Corps of Engineers regulatory jurisdiction extends includes all ocean and coastal waters within a zone three geographic (nautical) miles from the baseline”).

308 33 U.S.C. § 403; 33 C.F.R. § 322.3.

equipment. The process for obtaining permits from ACE is discussed in Part 5.1.2 above. Many states have their own permitting programs for offshore structures. These tend to be in addition to the federal permit requirements.

AU / AD pipes and other equipment installed in state waters would also be subject to the requirements of the federal aids to navigation program. As discussed in Part 5.1.3 above, under that program, any person wanting to install a fixed or floating structure that interferes with navigation must apply to USCG for authorization to mark the structure.³⁰⁹

AU / AD projects in state waters would not, in our view, require NPDES permits under the CWA. As discussed in Part 5.1.3 above, under the CWA, a NPDES permit is required to discharge pollutants into navigable waters of the U.S., including ocean waters within three miles of the U.S. coast.³¹⁰ For the purposes of the CWA, a pollutant is “discharged” when it is added to navigable waters from a “point source,” defined as “any discernible, confined and discrete conveyance, including . . . any pipe.”³¹¹ The pipes used in AU / AD projects would likely be considered “discrete conveyances” and thus “point sources” under the CWA. The pipes are not, however, used to add pollutants to navigable waters. Under the CWA, the term “pollutant” is defined to mean “dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharge into water.”³¹² The pipes used in AU / AD projects would not discharge or add any such pollutants to ocean waters. The sole purpose of the pipes is to move water from the deep ocean to the surface; there is no discharge or addition of other, foreign or polluting materials.

5.3 Projects Implicating Tribal Rights

Some AU / AD projects, particularly those impacting fish or fish habitat, may implicate tribal rights. Native American tribes have secured rights to protect their property and way of life through several treaties with the U.S. government, which have, in turn, been recognized through congressional legislation and judicial decisions. Several treaties secure the rights of Native Americans to fish in historical fishing waters. For instance, the 1855 Treaty of Point Elliott states: “The right of taking fish at usual and accustomed grounds and stations is further secured to said Indians in common with all citizens of the Territory.”³¹³ The geographic scope of the fishing rights is not specified in the treaties, but the Washington Supreme Court recognized that they would extend to areas ceded to the United States by the tribes, and those areas “actually used” and occupied by tribes for an extended period of time.³¹⁴ As recognized by the 9th Circuit, tribal rights to take fish create an implied duty on the part of state and federal governments to avoid damage to fish habitat.³¹⁵

309 33 C.F.R. §§ 64.03, 64.04, & 64.21.

310 33 U.S.C. §§ 1311(a), 1342(a)(1), 1362(7)-(8), 1362(12), and 1362(16).

311 *Id.* § 1362(14).

312 *Id.* § 1362(6).

313 Treaty with the Dwamish, Suquamish, etc., (commonly known as Treat of Point Elliot), art. 5, Jan. 22, 1855, 12 Stat. 927.

314 *State v. Buchanan*, 138 Wash. 2d 186, 207 (1999).

315 See Richard Du Bey, Andrew S. Fuller & Emily Miner, *Tribal Treaty Rights and Natural Resource Protection: The Next Chapter United States v. Washington - The Culverts Case*, 7 AM. INDIAN L. REV. 54, 55 (2019).

AU / AD projects could, in some circumstances, impact the ability of tribes to take fish from historically-recognized ocean fishing areas. Where this is the case and the projects require permits from U.S. federal agencies, those agencies must consult with the tribes affected prior to issuing permits. Executive Order 13175 states: “Each agency shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.”³¹⁶ Policies that have tribal implications are “regulations, legislative comments or proposed legislation, and other policy statements or actions that have substantial direct effects on one or more Indian tribes”³¹⁷ Permits granted by federal agencies for AU / AD projects that may implicate treaty rights, such as those to take fish in historical fishing areas, may thus require consultation with tribes. NOAA has prepared guidelines for such consultations, which detail the procedures for initiating consultation, responding to requests for consultation, and determining consultation structure.³¹⁸

316 Exec. Order No. 13175, 65 F.R. 67249 § 5(a) (2000).

317 *Id.* § 1(a).

318 NOAA, NOAA PROCEDURES FOR GOVERNMENT-TO-GOVERNMENT CONSULTATION WITH FEDERALLY RECOGNIZED INDIAN TRIBES AND ALASKA NATIVES (2013).

6. CONCLUSION

Cutting future carbon dioxide and other GHG emissions is essential, but may not be sufficient by itself, to avoid catastrophic climate change. The IPCC has concluded that, to limit global warming to 1.5°C above pre-industrial levels, emissions must reach net-zero around mid-century.³¹⁹ According to the IPCC, for that to happen, it will be necessary to deploy CDR technologies.³²⁰ One such technology is AU / AD, which uses large, vertical pipes to cycle water between the surface and deep ocean. The goal is to upwell cooler, nutrient rich water from depth to the surface, where it will stimulate the growth of phytoplankton that uptake carbon dioxide from the atmosphere, and downwell warmer, carbon dioxide-saturated water from the surface to depth. This should, in theory, result in carbon dioxide being taken out of the atmosphere and sequestered in the deep ocean.

Depending on where and how they are conducted, AU / AD projects could be subject to a variety of international and domestic (U.S.) laws. At the international level, potentially applicable instruments include UNCLOS, the CBD, and the London Convention and Protocol. None of those instruments were, at the time they were adopted, intended to regulate AU / AD. However, each includes general provisions governing ocean-based activities, which could apply to AU / AD. Moreover, the parties to the CBD and London Convention and Protocol have adopted specific rules for activities involving “ocean fertilization,” the definition of which could encompass AU / AD in some circumstances. Importantly, however, the ocean fertilization rules are not legally binding.

There are similarly no U.S. laws dealing specifically with AU / AD but, again, projects could be subject to general environmental and other laws governing ocean-based activities. In the U.S., jurisdiction over ocean-based activities is shared among coastal states and the federal government. Persons wanting to use areas of the seabed under state jurisdiction to moor AU / AD systems will generally require a state-issued lease and/or other approvals. Federal government approval will be required to deploy AU / AD systems that are moored to the OCS. The key requirements are listed in Appendix A.

³¹⁹ Skea et al., *supra* note 7, at SPM-30.

³²⁰ *Id.* at SPM-47.

APPENDIX A: PERMITTING REQUIREMENTS TABLE

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

Table A1: Minimum Permitting Requirements for Water-Based Activities Undertaken in Connection with Artificial Upwelling and Downwelling Projects in U.S. Waters

Activity	Location	Approval Required	Issuing Agency	Criteria for Issuance
<p>Construction / operation of structures attached to the seabed (e.g., moored pipes and other equipment)</p>	<p>U.S. state waters</p>	<p>State lease (or similar) authorizing occupation of state submerged land</p>	<p>Varies (often state land management agency)</p>	<p>Varies. Some states require an environmental review and consultation with local governments, Native American tribes, and other stakeholders prior to lease issuance.</p>
		<p>State construction approval</p>	<p>Varies (often state environmental agency)</p>	
		<p>Permit under the RHA</p>	<p>ACE</p>	<p>A general permit may be available for certain research activities. Most projects are, however, likely to require individual permits. Before issuing an individual permit, ACE must evaluate the probable effect of construction on the public interest. Environmental review and consultation with government, tribal, and other stakeholders* may be required.</p>
		<p>Authorization under the Aids to Navigation Program</p>	<p>USCG</p>	<p>USCG must confirm that the structure is appropriately marked and meets other regulatory requirements. Environmental review and consultation with government, tribal, and other stakeholders* may be required.</p>
		<p>Documentation under NEPA</p>	<p>ACE / USCG</p>	<p>ACE / USCG must conclude that an environmental review is not required under NEPA and issue documentation to that effect or conduct the required environmental review and publish the findings. An environmental review is required under NEPA where a federally-authorized activity significantly affects the human environment.</p>
		<p>Consistency determination under the CZMA</p>	<p>Varies (often state environmental agency)</p>	<p>The state must be satisfied that the federal action is consistent “to the maximum extent practicable” with the enforceable policies of any state coastal management plan adopted under the CZMA.⁶</p>

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Activity	Location	Approval Required	Issuing Agency	Criteria for Issuance
<p>Construction / operation of structures attached to the seabed (e.g., moored pipes and other equipment)</p>	<p>U.S. federal waters</p>	<p>Federal lease authorizing occupation of federal submerged land#</p>	<p>BOEM</p>	<p>Leases can only be issued for activities specified in the OCSLA. BOEM must consider the effect of leasing on the human, marine, and coastal environments. Environmental review and consultation with government, tribal, and other stakeholders* may be required.</p>
		<p>Permit under the RHA</p>	<p>USACE</p>	<p>A general permit may be available for certain research activities. Most projects are, however, likely to require individual permits. Before issuing an individual permit, ACE must evaluate the probable effect of construction on the public interest. Environmental review and consultation with government, tribal, and other stakeholders* may be required.</p>
		<p>Authorization under the Aids to Navigation Program</p>	<p>USCG</p>	<p>USCG must confirm that the structure is appropriately marked and meets other regulatory requirements. Environmental review and consultation with government, tribal, and other stakeholders* may be required.</p>
		<p>Documentation under NEPA</p>	<p>BOEM / ACE / USCG</p>	<p>BOEM / ACE / USCG must conclude that an environmental review is not required under NEPA and issue documentation to that effect or conduct the required environmental review and publish the findings. An environmental review is required under NEPA where a federally-authorized activity significantly affects the human environment.</p>
		<p>Consistency determination under the CZMA</p>	<p>Varies (usually state environmental agency)</p>	<p>The state must be satisfied that the federal action is consistent “to the maximum extent practicable” with any state coastal management plan adopted under the CZMA.⁶</p>

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Activity	Location	Approval Required	Issuing Agency	Criteria for Issuance
Construction / operation of floating structures (not attached to the seabed) (e.g., floating pipes and other equipment)	U.S. state waters	State construction approval	Varies (often state environmental agency)	Varies. Some states require an environmental review and consultation with governments, tribal, other stakeholders.
	Authorization under the Aids to Navigation Program	USCG	USCG must confirm that the structure is appropriately marked and meets other regulatory requirements. Environmental review and consultation with government, tribal, and other stakeholders* may be required.	
	Documentation under NEPA	USCG	USCG must conclude that an environmental review is not required under NEPA and issue documentation to that effect or conduct the required environmental review and publish the findings. An environmental review is required under NEPA where a federally-authorized activity significantly affects the human environment.	
	Consistency determination under the CZMA	Varies (often state environmental agency)	The state must be satisfied that the federal action is consistent “to the maximum extent practicable” with the enforceable policies of any state coastal management plan adopted under the CZMA. [^]	
	U.S. federal waters	Authorization under the Aids to Navigation Program	Authorization under the Aids to Navigation Program	USCG must confirm that the structure is appropriately marked and meets other regulatory requirements. Environmental review and consultation with government, tribal, and other stakeholders* may be required.
	Documentation under NEPA	USCG	USCG must conclude that an environmental review is not required under NEPA and issue documentation to that effect or conduct the required environmental review and publish the findings. An environmental review is required under NEPA where a federally-authorized activity significantly affects the human environment.	
	Consistency determination under the CZMA	Varies (often state environmental agency)	The state must be satisfied that the federal action is consistent “to the maximum extent practicable” with any state coastal management plan adopted under the CZMA. [^]	

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

A BOEM-issued lease may not be required for the temporary installation of pipes and other equipment as part of a research project

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

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