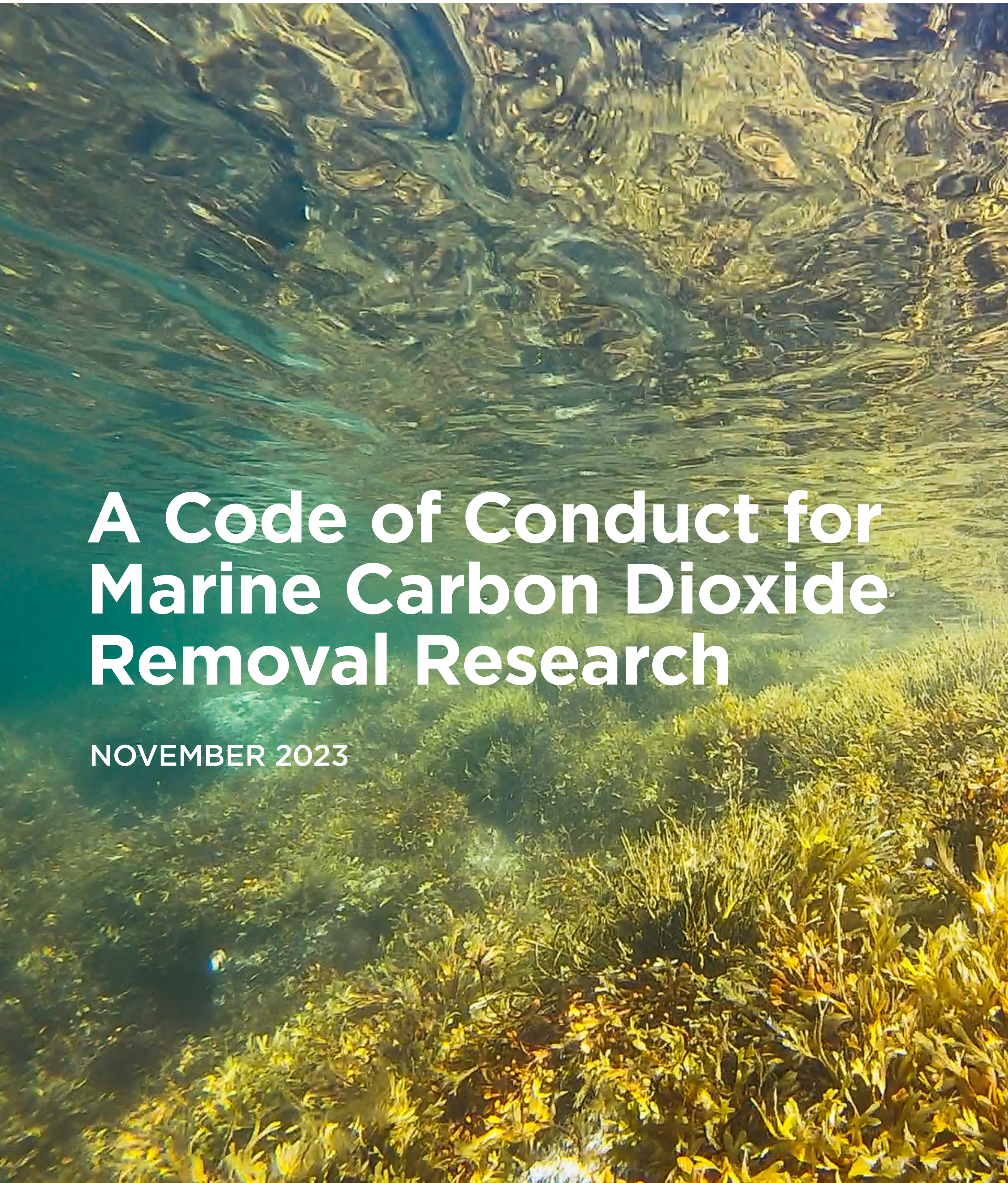

A Code of Conduct for Marine Carbon Dioxide Removal Research

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aspen institute

Authors

Dr. Miranda Boettcher

Dr. Fei Chai

Michael Conathan

Dr. Sarah Cooley

Dr. David Keller

Dr. Sonja Klinsky

Dr. Javier Lezaun

Dr. Phil Renforth

Dr. Michelle Scobie

Romany M. Webb

The authors would like to dedicate this work to the memory of our friend and colleague, Melanie Diaz. Her spirit was essential to the early stages of this project, and the tragic loss of someone so young and passionate about her work was felt deeply by all of us.

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INTRODUCTION

To keep planetary warming to 1.5˚C above pre-industrial levels, it is increasingly clear that active removal of atmospheric carbon dioxide will be required, alongside rapid, dramatic reductions in greenhouse gas emissions.[1] Multiple approaches for removing carbon dioxide from the atmosphere are being explored, including many using the ocean.[2] To date, marine carbon dioxide removal (mCDR), has received less attention than terrestrial carbon dioxide removal (CDR) approaches,[3,4] but its potential to contribute to net zero pathways has led to considerable investments in mCDR research.[5] Over two-thirds of our planet is covered by seawater and the ocean is the single largest regulator and driver of our climate and weather systems. The ocean is also already a potent carbon sink, estimated to have absorbed roughly a quarter of fossil carbon dioxide emissions since 1850.[6] mCDR approaches are poised to broaden the portfolio of CDR measures greatly, and some of them appear to have the potential for high effectiveness at large scales.

1 Intergovernmental Panel on Climate Change, AR6 Synthesis Report: Climate Change 2023. https://www.ipcc.ch/report/ar6/syr/

2 National Academies of Science, Engineering, and Medicine, "A Research Strategy for Ocean-Based Carbon Dioxide Removal and Sequestration," 2021. https://nap.nationalacademies.org/catalog/26278/a-research-strategy-for-ocean-based-carbon-dioxide-removal-and-sequestration

3 Keller, D. P., Brent, K., Bach, L. T., & Rickles, W. (2021). Editorial: The Role of Ocean-Based Negative Emission Technologies for Climate Mitigation. Frontiers in Climate, 3, 94. https://doi.org/10.3389/fclim.2021.743816

4 Babiker, M., G. Berndes, K. Blok, B. Cohen, A. Cowie, O. Geden, V. Ginzburg, A. Leip, P. Smith, M. Sugiyama, F. Yamba, 2022: Cross-sectoral perspectives. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.005

5 NASEM, *Supra* note 2.

6 Friedlingstein, P. et al., "Global Carbon Budget 2022," Earth System Science Data, Vol. 14, issue 11, 2022. Available at: https://essd.copernicus.org/articles/14/4811/2022/

However, the ocean encompasses our least explored and most poorly understood ecosystems. This means that the consequences of mCDR research, especially *in situ* field trials, can be difficult to predict. Many mCDR techniques have not been tested in the ocean and thus the short and long-term risks, harms and benefits of research are often not fully known or knowable (i.e., there are likely to be both foreseeable and unforeseeable outcomes). Stakeholders with diverse value sets may be impacted—positively or negatively—as practitioners and researchers launch and begin to scale up their activities in the natural environment outside controlled laboratory settings. Given the diverse environmental, social, cultural, economic and political dimensions of human relationships with the ocean, different communities may have very different views about whether, how, when, and where mCDR activities can and should occur. What may be an acceptable way to engage with the ocean in one community, may be understood very differently in another. Adding further complication, existing international, national, and subnational governance frameworks often do not provide sufficient guidance for making decisions about mCDR research, especially regarding field trial studies.

Recognizing the complexities inherent in the advent of mCDR research, beginning in late 2022, the Aspen Institute's Energy & Environment Program convened a group of nine leading experts from interdisciplinary backgrounds to develop a Code of Conduct that could begin to address these issues. This group recognizes that it will be no easy task to implement just, inclusive, and equitable solutions with the urgency required to address the existential crisis of climate change. Yet the reality that a perfect solution is functionally impossible to achieve must not prevent us from striving to get as close as possible.

Scope and Goals of This Code of Conduct

As the climate crisis intensifies, so do questions about how to balance the urgency of realizing the potential benefits of CDR against the risk of negative unintended consequences of such activities. Many argue that an all-hands-on-deck approach is the only way to avoid the worst consequences of climate change, so the risks of CDR generally and mCDR specifically are justified. Others have suggested that investing in CDR may create a so-called "moral hazard" by reducing the urgency of cutting greenhouse gas emissions.[7] Still others point out that too often large-scale human endeavors have resulted in severe unintended and unacceptable consequences.

Given the clear need to inform societal decision-making on the role mCDR can play in solving the climate crisis, it is imperative that researchers begin to answer questions about its effectiveness and impacts. Yet overly hasty development of new ocean-based climate interventions risks harm to communities and ecosystems and could jeopardize public perception of the field as a whole.[8] In addition, the harms, risks and benefits of mCDR efforts are unlikely to be evenly distributed, which raises the stakes of decision-making in this context. Unabated, climate change could have a devastating impact on global ecosystems and human populations, and the impacts of mCDR should be contemplated in this context. However, the ecosystems and human populations that might benefit from a reduction in the risks of climate change will not be entirely the same as those that could be affected by mCDR research. This code of conduct exclusively applies to mCDR research and does not attempt to put any affiliated risk in the context of the risk of delaying climate action. The code's purpose is to ensure that the impacts of mCDR research activities themselves are adequately understood and accounted for as they progress.

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7 Anderson, K. and Peters, G., "The trouble with negative emissions," *Science*, 14 Oct 2016. Available at: https://www.science.org/doi/10.1126/science.aah4567

8 Bellamy, R., et al., "Public perceptions of geoengineering research governance: An experimental deliberative approach," *Global Environmental Change*, Vol. 45, July 2017. Available at: https://www.sciencedirect.com/science/article/pii/S0959378016302230

This code of conduct sets out a framework for decision-making about mCDR research and the affiliated planning and scoping activities. It is not intended to endorse or oppose any mCDR practice or project but rather to inform the deliberations that will be needed in any project in this complex decision context. Its goal is to provide a roadmap of processes, procedures, and activities that project leads should follow to ensure that decisions regarding whether, when, where, and how to conduct mCDR research are informed by relevant ethical, scientific, economic, environmental, and regulatory considerations. Throughout the code, the term 'project leads' is used to refer to researchers, funders, developers, regulators, community stakeholders, and any others who have or contribute to decision-making obligations in any given mCDR effort, while recognizing that the exact configuration of those individuals will vary in each case. The code also occasionally uses the term "project participants" to refer to a slightly larger group of individuals who are involved in projects, but may not have broad decision-making authority.

For the purpose of this code "research" means an activity undertaken in the marine environment for the primary purpose of advancing scientific understanding of mCDR techniques. Research projects may involve the development, testing, evaluation, and demonstration of mCDR techniques. Although this document does include some indications of how the principles and guidelines set out in this Code may apply to lab research and modeling activities (see Box 1: Laboratory, Mesocosm, and Modeling Research and Appendix B), the primary focus of the Code is on field study research activities (also referred to as "field trials") undertaken in the marine environment. The spatial and temporal scope of mCDR research activities can vary greatly. The larger and longer the planned research project, the more significant the potential risks, and thus the more care must be taken in applying the principles and guidelines outlined in this code. Deployment of mCDR techniques, where the primary purpose is not advancement of scientific understanding, is not covered by this code.

The authors recognize that this work has been completed at a point in time when many uncertainties remain about how the oceanic carbon cycle functions in tandem with all the other unknown functions and systems of the global ocean, and about what climate change may mean for this vital planetary ecosystem. As such, any recommendations about future actions use inherently imperfect and non-exhaustive information, and must be revisited in future years as additional baseline research is completed. This report is intended to be an iterative, living document that will be regularly reviewed and updated. For more on the future of this work, see Appendix A.

As the world pursues diverse, dynamic, and effective climate solutions, works such as this one, which aims to find a balance between rapid development on the one hand and careful consideration of unforeseen eventualities on the other, are required. Such a balance will contribute meaningfully to heading off the worst impacts of climate change while safeguarding fundamental marine ecosystems and their vital contributions to a life-sustaining planet.

The Need for a Code of Conduct for mCDR Research

> "By encouraging researchers to assess, minimize, and publicize the impacts of their experiments, a code of conduct could reduce the harm done by field experiments. And by promoting principles that would encourage the growth of a rigorous body of research—such as rules requiring the disclosure of funding or the peer review and publication of results—a code of conduct could help researchers transparently and honestly determine the efficacy of ocean-based CDR technologies, which they must do if those technologies are to play a meaningful role in climate mitigation."
>
> — R. Loomis, S. Cooley, J. Collins, S. Engler, L. Suatoni, "A Code of Conduct Is Imperative for Ocean Carbon Dioxide Removal Research," Frontiers in Marine Science, May 2022.

Many mCDR projects are currently being developed in laboratory and modeling studies, and some have begun field trials of their proposed mCDR solutions. Additionally, academic researchers are investigating many aspects of different mCDR pathways, including the social and governance issues they may raise. All of this provides valuable data on the potential efficacy, feasibility, risks, harms and benefits of mCDR activities. These data can inform future decision-making regarding further research and development and potential future implementation of practices and methodologies. Closely coordinated laboratory, modeling, and field studies are essential steps in scoping upscaling and deployment and could also provide grounds on which to abandon a particular mCDR pathway.

While all forms of mCDR research carry risks (see Box 1: Laboratory, Mesocosm, and Modeling Research), field trials in particular have the potential for unintended or unanticipated environmental, social, ethical, and geopolitical consequences because they involve activities in the natural environment. While initial, small-scale field trials may carry lower levels of risk and are necessary to determine viability of concepts, as these projects scale up, the degree of risk increases. Introducing new substances or altering the ocean's biogeochemistry could have unforeseen effects on marine ecosystems, including impacts on marine life, biodiversity, and ecosystem functioning, with ensuing consequences for human life and livelihoods. These risks need to be carefully considered before conducting or scaling up field trials. This is essential to inform decisions about whether particular field trials should take place and the design of those trials to ensure that risks are minimized and benefits maximized.

Field trials involving significant environmental alterations may also raise ethical concerns. It is crucial for project leads to engage in discussions about the potential impacts, both positive and negative, on communities and ecosystems that may be particularly vulnerable to harmful outcomes from research activities. These may include existing resource users such as fishing communities, or historically disenfranchised populations such as Indigenous populations. Consideration should also be given to ensuring the equitable distribution of any positive outcomes that may arise from field trials. Stakeholders' reactions to field trials provide an additional source of information about public acceptance of these practices and inform governance needs.

Because field trials involve activities in the ocean—a shared resource—their governance and regulation is highly complex. While there is a large body of international law governing ocean-based activities, the regulation of individual field trials will often fall to national or subnational governments (see Code of Conduct section I.A. below). This can create opportunities for "forum shopping," with researchers pursuing research in countries or regions that have less stringent regulatory oversight mechanisms and enforcement capacities. This in turn can result in a race to the bottom that historically has led to exploitation of less-developed countries. It is important to avoid repeating past mistakes and ensure that all nations, especially those in the global south, have meaningful opportunities to effectively participate in and oversee mCDR research.

Establishing proper frameworks to oversee, understand, and manage mCDR field trials is essential to ensure responsible and transparent testing, minimize risks, and avoid uncontrolled experimentation that could harm marine and coastal ecosystems, cultural value structures, or even cause setbacks to future deployment of mCDR research projects. These factors and more have led to calls for a code of conduct to provide clear guidance to project leads as they approach mCDR research.[9]

BOX 1: Laboratory, Mesocosm, and Modeling Research

Laboratory, mesocosm, and modeling research falls largely outside the scope of this code of conduct, since they do not carry immediate or direct social and environmental risks. However, such work often provides the intellectual foundation for many aspects of mCDR, and as such it has long-term implications for both social and environmental outcomes. Decisions embedded throughout the research process shape what risks, harms, and benefits can be identified for discussion by stakeholders. For instance, deciding what conceptual frameworks to use, which variables to include and how to parametrize them, and the resolution or scale at which modeling outputs are meaningful radically influences which types of positive or negative outcomes can be considered, and how well the distribution of these is understood. Over time, these research assumptions and experimental designs can 'lock in' particular ways of thinking about any given form of mCDR and can be used to systematically exclude from view alternate ways of thinking, along with potential risks, harms and benefits.

Given their relevance in decision-making process, and their inherent limitations in representing intangible risks or culturally specific considerations, research assumptions and simulated outcomes need to be subjected to processes of public communication and deliberation very similar to those outlined in this Code of Conduct for outdoor field research practices. A series of methodologies for participatory research can support these processes as part of a broader social contract for mCDR research and development and in conjunction with parallel developments in other domains of climate action. This work of engagement is particularly relevant when researchers advise policymakers to support decisions concerning further development or experimental deployment of mCDR methods.

The authors recommend further exploration and development of a code of conduct for modeling activities. For additional details on how the foundational principles of this code of conduct could apply to modeling activities, see Appendix B.

9 Loomis, R. et al., "A Code of Conduct Is Imperative for Ocean Carbon Dioxide Removal Research," Frontiers in Marine Science, May 2022. https://www.frontiersin.org/articles/10.3389/fmars.2022.872800/full#B19

History of This Code of Conduct

In 2021 the Aspen Institute's Energy & Environment Program began an effort to address calls for a Code of Conduct for mCDR with the publication of "Guidance for Ocean-Based Carbon Dioxide Projects."[10] That report, created by a multidisciplinary group of 25 individuals from geographically diverse backgrounds, identified sets of questions that required further attention in order to explore how to develop governance structures, scientific research, and community engagement to manage this emerging field. This work picks up where that project left off and represents the first attempt to create a code of conduct specifically for mCDR research activities that project leads and other key stakeholder groups can reference as they begin to move from the lab into the natural environment, or, in some cases, scale up operations or ongoing experiments.

In developing the code of conduct, the authors focused on issues relating to three, often overlapping, areas of focus: 1) social and environmental considerations; 2) establishment of sufficient governance structures; and 3) development of adequate monitoring, reporting, and verification mechanisms to determine how much carbon dioxide is being removed from the atmosphere and durably stored, and to track any other potential environmental impacts or co-benefits that result from mCDR research activities.

It begins with a brief look at other, similar codes of conduct that exist or are in development to ground this work in the context of existing and developing literature. It then turns to the intended uses of, and values underpinning the code of conduct, before defining the practices and processes that were considered in its development. Finally, the code itself is broken into three parts, reflecting the three key stages in project development: Planning and Scoping; Execution of Research; and Conclusion of Research.

Codes of conduct support research that can affect human or environmental welfare

Research codes of conduct provide community-wide guidelines within which a range of stakeholders in the research ecosystem are encouraged to operate when investigating questions that may impact humans or the non-human environment.[11] Codes of conduct can provide blueprints to help project leads build effective relationships that center trust and the consideration of a wide range of harms, risks and benefits. This can, in turn, enhance the well-being of those potentially affected by research while also benefiting the development of research more generally. A code of conduct can help project leads and other stakeholders identify considerations and steps that might otherwise be overlooked, either intentionally or accidentally, and ensure that a diversity of views is reflected in decision-making. Although codes of conduct typically do not impose mandatory requirements or enforcement measures, they are regularly used as tools to encourage and incentivize imposition of a broad suite of values and norms by "establish[ing] sets of norms and best practices, encouraging responsible research among public and private actors.[12] They can be particularly effective in guiding funders to prioritize their support for research activities that adhere to these guidelines.

10 Aspen Institute Energy & Environment Program, "Guidance for Ocean-Based Carbon Dioxide Removal Projects," 2021. Available at: https://www.aspeninstitute.org/publications/ocean-carbon-dioxide-removal/

11 Loomis et al., 2022. *Supra* note 9.

12 Hubert A. M. (2021). A Code of Conduct for Responsible Geoengineering Research. Glob. Policy 12 (supp.1), 82–96. https://onlinelibrary.wiley.com/doi/full/10.1111/1758-5899.12845

Importantly, codes of conduct can provide an equal footing for project leads and enable collective, publicly legitimate decision-making. Research activities that do not obtain or maintain consent to operate from impacted stakeholders may be more difficult, or even impossible, to successfully complete and can undermine future research and development efforts.[13] Additionally "policymakers could use an [mCDR] code of conduct as a starting point for future regulations that are managed by institutions accountable to the public.[14] Notably, codes of conduct are different from, and typically less prescriptive and detail-oriented than other forms of guidance such as best practice guides (see Box 2, Best Practice Guides for mCDR Research).

Several codes of conduct have been developed, including for climate engineering generally and specifically for solar geoengineering.[15] Some organizations working in the mCDR space have created sets of guiding principles[16,17] or industry-based pledges,[18] and some individual operators have developed their own internal best practices guides.[19] Others have developed principles to guide research into specific mCDR approaches.[20] While each of these efforts incorporates components that are addressed in this document, this work is intended to address the ongoing call for a code of conduct that encompasses multiple mCDR practices and provide guidance specifically for mCDR field trials that are beginning to be conducted and may very well expand in number and scope in coming years.

It is important to recognize that individuals with the resources and capacity to undertake mCDR may not be the same individuals whose lives and livelihoods could be affected positively or negatively by mCDR activities. The latter group may lack the scientific expertise, political agency, or resources to participate effectively in decision-making regarding research activities. As has been made clear by the growing body of knowledge on climate justice, those with the least decision-making agency are also those at most risk from both the impacts of climate change and the unintended consequences of attempts to combat it.[21] Loomis et al. (2022) note that to avoid further exacerbating the already-inequitable impacts of climate change, mitigation methods must pursue biodiversity and support social equity, and research codes of conduct can help ensure that these goals can be upheld through the solutions development process.[22]

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13 For example, see outcomes from attempts to pursue solar radiation management activities in the early part of this decade as discussed here: https://www.nytimes.com/2021/04/02/climate/solar-geoengineering-block-sunlight.html

14 Loomis et al., 2022, *Supra* note 9. See also: Hubert, A., 2021, *Supra* note 12.

15 Examples include: American Geophysicists' Union, "Ethical Framework for Climate Intervention," 2023. Available at: https://www.agu.org/learn-about-agu/about-agu/ethics/ethical-framework-for-climate-intervention; Hubert et al. 2017, Hubert et al. 2021, *Supra* note 12; NASEM 2021, *Supra* note 2.

16 Ocean Visions, "Principles Guiding Our Work on Carbon Dioxide Removal & the Ocean," May 2022. https://oceanvisions.org/oceancdr-principles/

17 Reykjavik Protocol, "A set of supplier best practices to responsibly grow the nature-deployed credit industry, to reduce uncertainties, and to reduce conflicts of interest," 2023. Available at: https://www.reykjavik-protocol.com/

18 Carbon Business Council, "Oath to Restore the Earth." Available at: https://www.carbonbusinesscouncil.org/restoretheearth

19 See e.g., Planetary Technologies, Code of Conduct, https://www.planetarytech.com/about/code-of-conduct/

20 Buesseler, K., Leinen, M., Ramakrishna, K., "Removing carbon dioxide: First do no harm," Nature June 2022. Available at: https://pubmed.ncbi.nlm.nih.gov/35764800/

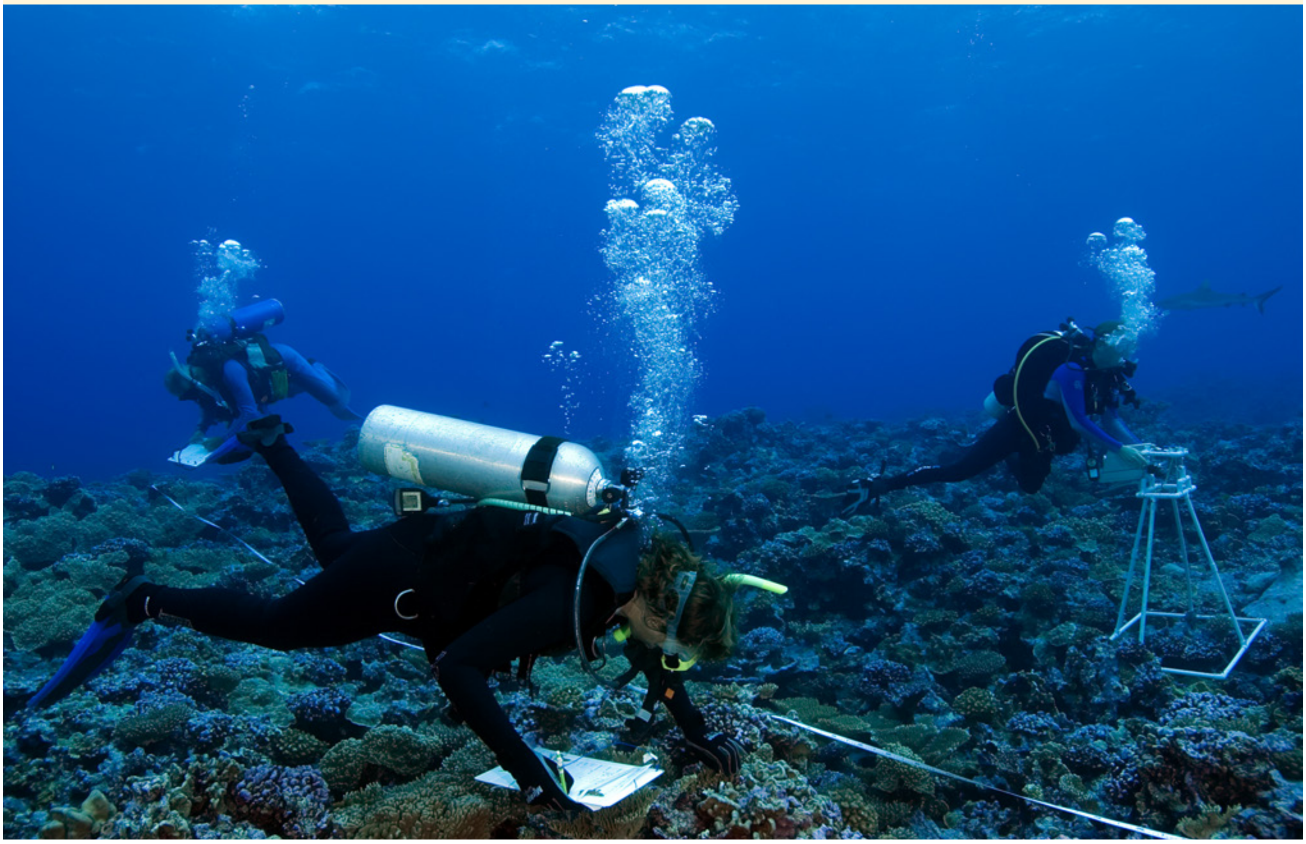
21 Intergovernmental Panel on Climate Change, Working Group II, "Climate Change 2022: Impacts, Adaptation, and Vulnerability." Available at: https://www.ipcc.ch/report/ar6/wg2/

22 Loomis et al., 2022. *Supra* note 9.

BOX 2: Best Practice Guides for mCDR Research

Various groups within the mCDR community, including several research consortia, have developed or are in the process of developing best practice guides for mCDR research. The form and content of these guides differ in several important respects. Some set out very general, high level principles for conducting research, while others provide much more granular instructions on how to approach different stages in the research process. An example of the latter is the *Guide to Best Practices for Ocean Acidification Research and Data Reporting*, which was first published in 2011 to provide "guidelines and standards for ocean acidification research.[23] A new *Guide to Best Practices for Ocean Alkalinity Research* (OAE Guide) was under development at the time of writing.[24] The OAE Guide is intended to promote responsible research into OAE and, to that end, will include recommendations for conducting laboratory, mesocosm and field experiments, as well as modeling. It also discusses the legal and social frameworks in which research occurs and offers recommendations for effectively engaging with those frameworks.

This code of conduct differs from, but is intended to complement, these and other best practice guides. This code applies to all mCDR techniques rather than a subset and lays out more general principles that are intended to guide the planning and scoping, execution, and conclusion of research activities. In addition to following the principles set out here, project leads should consult best practice guides for more detailed advice on specific research activities.



23 European Commission, "Guide to Best Practices for Ocean Acidification Research and Data Reporting," Directorate-General for Research and Innovation, 2011. Available at: https://www.iaea.org/sites/default/files/18/06/oa-guide-to-best-practices.pdf

24 Oschlies, A., et al., "Guide to Best Practices in Ocean Alkalinity Enhancement Research," State of the Planet, 2023. Available at: https://sp.copernicus.org/articles/special_issue1269.html

SCIENTIFIC AND GOVERNANCE UNDERPINNINGS OF mCDR

The IPCC defines CDR as “technologies, practices, and approaches that remove and durably store carbon dioxide from the atmosphere.”[25] Most mCDR methodologies are intended to work by increasing the ocean’s ability to do this through a process referred to as air-sea carbon dioxide gas exchange. A 2021 report from the U.S. National Academies of Science, Engineering, and Medicine (NASEM) explains that “there are several physical, geochemical, and biological processes that are known to influence air-sea carbon dioxide gas exchange and ocean carbon storage.”[26]

25 IPCC AR6 Working Group III: CDR Factsheet. Available at: https://www.ipcc.ch/report/ar6/wg3/downloads/outreach/IPCC_AR6_WGIII_Factsheet_CDR.pdf

26 NASEM, 2021, *Supra* note 2.

BOX 3: mCDR APPROACHES

Coastal and mCDR approaches aim to manipulate or enhance biological, chemical, and/or physical pathways that already exist in the ocean's natural state (see Fig. 1 and Fig. 2). These are grouped into the following four general categories.

Biological carbon sink enhancement: Proposed biological methods for removing carbon dioxide from the upper ocean mostly focus on increasing photosynthesis and (notionally) carbon transport into the deep sea via the biological carbon pump or by increasing the permanent burial of carbon in coastal sediments through the management of coastal vegetated ecosystems, commonly referred to as blue carbon. Examples include: macroalgae cultivation and sinking, nutrient or iron fertilization, recovery of coastal ecosystems and blue carbon.

Chemical carbon sink enhancement: Proposed chemical methods for increasing mCDR have mostly focused on increasing the alkalinity of seawater, a process sometimes referred to as ocean alkalinity enhancement, enhancing chemical weathering, or ocean alkalinization. These approaches generally aim to reduce surface sea-water partial pressure of carbon dioxide thereby allowing more atmospheric carbon dioxide to dissolve in seawater and be stored as bicarbonate or carbonate ions, increasing seawater's carbon storage capacity. Examples include: ocean alkalinity enhancement and electrochemical approaches.

Physical carbon sink enhancement: Ideas have been proposed to enhance the physical carbon pump by artificially increasing the rate at which surface water is transported to the deep ocean, since this is the solubility pump process that most limits the rate at which carbon is stored in the deep ocean. Examples include: artificial upwelling and downwelling.

Other approaches: There are also other approaches that seek to increase the removal and storage of carbon dioxide. Cultivating marine macroalgae to harvest for the creation of biofuels, followed by using carbon capture and storage methods when fuels are combusted is an example of a hybrid approach. Another approach is carbon dioxide stripping, where carbon dioxide is extracted from seawater and subsequently stored (e.g., in a geological formation).

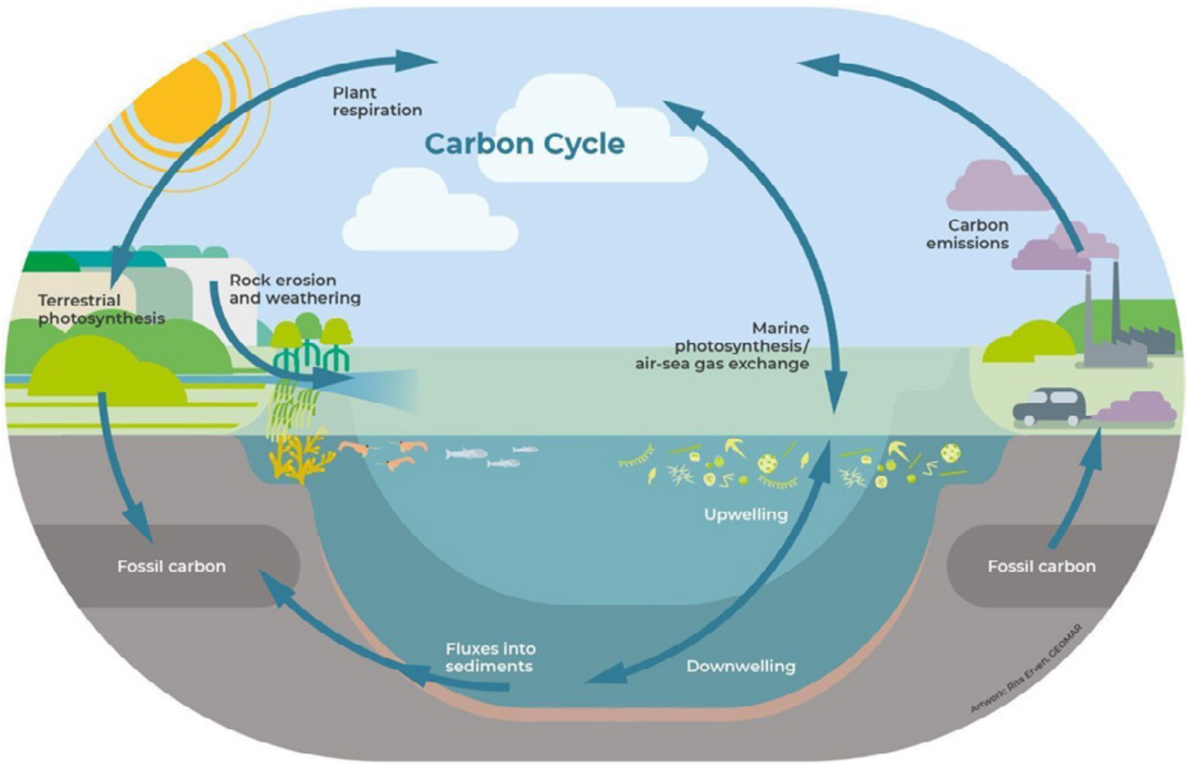


Figure 1. The natural carbon cycle. (Credit: Rita Erven, GEOMAR)

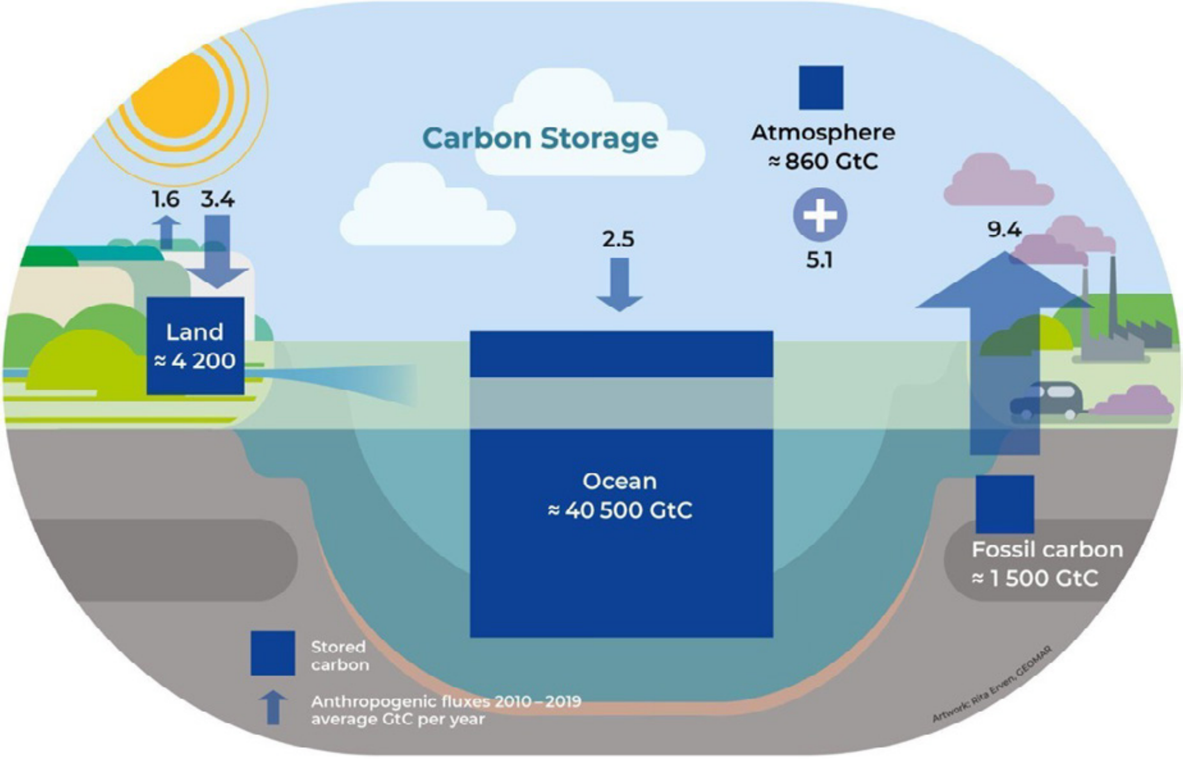


Figure 2. Processes for carbon storage. (Credit: Rita Erven, GEOMAR)

mCDR approaches currently being researched leverage at least one of these processes. Each process involves numerous factors that contribute to uncertainty about exactly how much carbon dioxide can be absorbed, and whether and how it might then be stored for sufficient time to make these practices effective and additional. Furthermore, monitoring and verifying both carbon removal and environmental side effects may be difficult given existing observational capabilities. There are currently no widely agreed upon standards for monitoring, reporting, and verification of mCDR activities.[27]

Existing marine policy

According to the NASEM's Research Strategy report, there is "no single, comprehensive legal framework specific to ocean CDR" research.[28] Developing an effective governance framework for mCDR is essential, but may be challenging, at least in the short-term, for a variety of reasons. Perhaps most significantly, the ocean is a shared resource, with around 60% of ocean waters falling outside the authority or control of any one country. As such, establishing and enforcing legally-binding rules to control in-ocean research necessarily requires a high level of coordination and cooperation between countries, which can be difficult to achieve. As an example, while a new international agreement dealing with the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction (the so-called "BBNJ treaty") was recently adopted, it took nearly twenty years for the text of that treaty to be agreed, and it has yet to enter into force. The slow pace of development of international law is particularly problematic given the rapidly growing interest in mCDR. Indeed, mCDR is an emerging field of study, wherein the "speed of scientific and technological innovation often leaves government and the public reacting to events rather than

27 NASEM 2021, *Supra* note 2.
28 *Ibid.*

responsibly governing new possibilities.[29] Any attempt to develop a more forward-looking legal framework could "be quickly surpassed by new knowledge or invention."[30]

Despite the lack of a comprehensive legal framework specific to mCDR research, various legal norms and principles can help to guide decisions regarding the conduct of research projects. Previous studies have identified a number of legal instruments—existing across international, national, and subnational levels—that could apply to mCDR research.[31] One notable international example is the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter ("London Protocol").[32] In 2013, the parties to the London Protocol adopted an amendment, which is intended to govern certain "marine geoengineering activities" involving "the placement of matter into the sea from vessels, aircraft, platforms or other man-made structures at sea.[33] The amendment sets out a framework for permitting ocean fertilization research but could, in the future, be expanded to apply to other mCDR approaches.[34]

The 2013 amendment to the London Protocol has not yet entered into force and thus is not legally binding. In order for it to become legally binding, the 2013 amendment must be ratified by two-thirds of its parties, and even then, it would only apply to party states.[35] This threshold seems unlikely to be met in the near future. Indeed, in the decade since the amendment was adopted, only 6 of the 53 parties have ratified the amendment. Moreover, by its terms, the amendment will only apply to ocean fertilization projects. There is considerable uncertainty as to whether and how the amendment might be applied to other mCDR techniques.

In the face of all these scientific and regulatory uncertainties, development of a Code of Conduct that can illuminate a pathway to responsible research for researchers, developers, funders, communities, regulators, and all other stakeholders is critical.

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29 European Commission, Global Governance of Science 12 (2009), https://op.europa.eu/en/publication-detail/-/publication/74f6f66b-d6f0-4100-b052-89d1c1265871

30 *Ibid*.

31 *See e.g.*, Romany M. Webb et al., Ocean Carbon Dioxide Removal for Climate Mitigation: The Legal Framework (Edward Elgar Publishing, 2023) (discussing the treatment of ocean CDR under international law and the domestic laws of seven countries).

32 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters (adopted 7 November 1996, entered into force 24 March 2006) [hereinafter "London Protocol"].

33 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 (18 October 2023).

34 *Id.* Annex 4. See also IMO Doc. LC/SG 44/16, para. 3.6 (identifying several "marine geoengineering" activities that "the London Protocol parties might wish to consider for listing in the next Annex 4 of the Protocol"); IMO Doc. LC 44/5, para 5 (listing four "marine geoengineering" activities—including ocean alkalinity enhancement and seaweed cultivation—that should be subject to "priority evaluation" for inclusion in Annex 4 of the Protocol).

35 London Protocol, *Supra* note 32, at Art. 21.

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CODE OF CONDUCT

Foundational Principles of this Code of Conduct

Due to the diversity of considerations shaping mCDR decision-making, this code integrates insights from several ethical and philosophical perspectives. Some scientific research has historically been conducted in ways that harmed individuals and communities for economic, social, or scientific gains, and this continues today. Harmful and extractive practices also continue outside of research, and they are even enshrined in policies and regulations. To overturn the precedent of research that harms communities and exacerbates power imbalances, this code relies on the work of Kyle Whyte, a Potawatomi environmental philosopher, and others to articulate principles for mCDR research that develop and maintain good relationships including trust, consent, reciprocity and accountability.[36] However, because mCDR research is also inherently about innovation, we have also specifically drawn on guidance from the literature on Responsible Research and Innovation (RRI).[37,38] Key ideas from within this approach include inclusivity, anticipation, reflexivity and responsiveness.

36 Whyte, K. (2019) Too late for indigenous climate justice: Ecological and relational tipping points. WIREs Climate Change. Available at: https://wires-onlinelibrary-wiley-com.ezproxy1.lib.asu.edu/doi/full/10.1002/wcc.603

37 Owen, R. et al., "A Framework for Responsible Innovation," April, 2013. https://onlinelibrary.wiley.com/doi/10.1002/9781118551424.ch2

38 Stilgoe, J. et al., "Developing a Framework for Responsible Innovation," Research Policy, Nov. 2013. https://www.sciencedirect.com/science/article/pii/S0048733313000930

Development of this code of conduct has also been informed by various legal principles that have been developed over time to govern activities that could pose risks to the environment. These include, for example, the obligation under customary international law on States to take steps to prevent and control transboundary environmental harms.[39] Various international legal instruments, including the Convention on Biological Diversity, call for ex-ante environmental review of risky activities and emphasize the need for notification and consultation with potentially affected countries and other stakeholders.[40] The UN Declaration on the Rights of Indigenous Peoples additionally requires the "free, prior, and informed consent" of Indigenous peoples for activities in their territories,[41] and the UN Convention on the Law of the Sea declares that the seabed in international waters is "the common heritage of [hu]mankind.[42] The new BBNJ Treaty further states that countries should "act as stewards of the ocean in areas beyond national jurisdiction on behalf of present and future generations by protecting, caring for and ensuring responsible use of the marine environment.[43] This code provides guidance that is consistent with and builds on these and other general legal principles.

The eight principles described here are interconnected, and the order in which they are listed is not intended to connote a ranked priority or importance.

- **Awareness of power imbalances** is a foundational principle which recognizes that all research activities take place in contexts which may be characterized by historical and/or contemporary power imbalances. These power imbalances can result in harms, risks and/or benefits being both perceived and experienced unevenly. Power imbalances can occur at all scales, from within communities to across nations, between generations, and across time, in which case inequalities can accumulate. There are also implicit power imbalances between humans and non-humans which must be taken into consideration when weighing research decisions (see Box 4: Applying the CoC Principles to Non-Humans).
- **Inclusiveness** requires the development and use of a research process in which a wide range of individuals, communities, and types of knowledge should be involved in planning, implementing and evaluating the success of the mCDR research. This includes the integration of people with a full range of subject expertise along with other forms of knowledge, such as local knowledge. Care should be taken to avoid performative inclusivity in which there may be tokenism, "rubber stamping," or other representations of inclusion which are not imbued with actual decision-making authority. Inclusive processes are characterized by shared decision authority across a wide range of stakeholders to avoid exclusionary or exploitative research processes. These processes expand discussions of futures (see also the anticipation principle) that certain types of research may help shape—that is, the distinctive set of environmental, scientific, social and political developments that research activities may bring into being.[44]
- **Consent** is a direct manifestation of recognizing people's dignity. Seeking consent includes taking actions to ensure that diverse perspectives and philosophical values are integrated into decisions that will directly affect them and that they have substantial voice in decision processes. Granting consent is an affirmative choice, not an absence of objection and requires inclusive decision processes. Consent also requires transparency and education about the existence and uneven distribution of risks and benefits, uncertainties, and future implications of any decision

39 See generally, Declaration of the United Nations Conference on Environment and Development, UN Doc A/CONF.151/26/Rev. 1, Principle 2.

40 See e.g., Convention on Biological Diversity, 1760 UNTS 79, Art. 14.

41 United Nations Declarations on the Rights of Indigenous Peoples, A/RES/61/295, Art. 28 and 32 (2 October 2007).

42 United Nations Convention on the Law of the Sea, Title XI, Section 2.

43 Preamble, Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity in Areas beyond National Jurisdiction, A/CONF.232/2023/4*, June 19, 2023.

44 Stilgoe, J. et al., *Supra* note 38.

to the extent possible. Importantly, different legal and cultural contexts may have specific protocols for consent. For instance, many Indigenous nations may have consent processes over and above those required by colonial governments on their territories. For these reasons the UN Declaration on the Rights of Indigenous Peoples requires the "free, prior, and informed consent" of Indigenous Peoples for activities in their territories.[45] As previous studies have noted, "[r]esearch conducted without consent [from Indigenous communities] and outside of a collaborative framework can be a form of colonialism that can potentially harm Indigenous peoples."[46]

- **Reciprocity** stems from awareness that relationships are at the heart of any research project and that these relationships generate obligations of care, respect and consideration to each other and toward nature. Operationalizing reciprocity requires reflexivity and awareness of power imbalances so that researchers, funders, regulators and other stakeholders are aware of their own biases, their positionalities within the research, and likely distributions of benefits, harms and risks within the context of project operation. (See Awareness of Power Imbalances.)

  One component of reciprocity is the recognition that the imposition of a burden or risk on a group (of people or non-humans) may trigger special obligations to provide commensurate benefits or appropriate compensation. As such, reciprocity addresses many concerns stemming from environmental and climate justice contexts in which harms have been disproportionately borne by those who have been excluded from decision processes and to whom obligations of care, respect and consideration were not met.

- **Reflexivity** refers to the practice of critically examining one's own actions, commitments, and assumptions. It involves recognizing the limitations of any specific type of knowledge, including scientific knowledge, and acknowledging that different perspectives on an issue may exist. Since individuals are embedded in larger systems, reflexivity involves scrutinizing the underlying value systems and theories held by diverse stakeholders in the context of historical and contemporary power imbalances within social patterns and governance structures. When integrated through a research process, reflexivity becomes a more transparent, inclusive activity in which all of those involved make their underlying assumptions public and open for dialogue. Reflexivity can be greatly supported through inclusive decision processes which set up conditions for dialogue, mutual learning, and shared reflexive enquiry.[47]

- **Responsiveness and Trust** are tightly linked to consent and anticipation in situations of uncertainty, or during research processes focused on new ideas or innovations. Trust requires repeated demonstrations of respect for consent, combined with responsiveness to concerns from diverse stakeholders as they emerge through the research process. Responsiveness means that the actual concerns and experiences raised by stakeholders are openly considered as a research project progresses and actual changes may be made in accordance with these concerns. Responsiveness would also include adequately responding to signals from ecological monitoring, such as by altering experimental design to avoid harm or to enhance a benefit. Understanding diverse concerns and collectively finding ways of addressing these will require inclusive decision processes.

  Substantial differences in viewpoints may occur across communities rooted in people's varying perceptions, risk tolerance, sensitivity to risks and benefits, values and worldviews, personal experiences, and historical and contemporary community experiences with research, governing

45 United Nations Declarations on the Rights of Indigenous Peoples, A/RES/61/295, Art. 28 and 32 (2 October 2007).

46 NASEM 2021, *Supra* note 2.

47 Wynne, B., "Lab Work Goes Social, and Vice-Versa: Strategising Public Engagement Processes," Science and Engineering Ethics, 2011. https://link.springer.com/article/10.1007/s11948-011-9316-9; von Schomberg, R., "A Vision of Responsible Research and Innovation," 2013. https://onlinelibrary.wiley.com/doi/10.1002/9781118551424.ch3; and Stilgoe, J. et al., supra note 38.

authorities, and marginalization, including through colonialism.[48] These differences will inform how different people and groups experience mCDR activities and evaluate ecological and social harms, risks and benefits. Project leads alone are not responsible for determining how best to address diverse concerns because they will not fully understand all perspectives and are likely shielded from immediate harms or risks of the research. Instead, identifying appropriate responses as research processes evolve is a shared obligation with all stakeholders. Dedicating time, energy, and resources including funding to responsiveness is important as once lost, trust is difficult to regain.

- **Accountability** is the recognition that depending on the scale and scope of their research, project participants may have a range of obligations to diverse actors beyond themselves, and that failing to meet these obligations carries consequences, and that those involved in such projects should take responsibility for their actions. Just as researchers are accountable to funders, there may be additional very specific obligations arising from laws and regulations or formal agreements with communities for which research teams are accountable. For example, a research group may have agreed to hire local staff, observe particular protocols, or have made other specific arrangements which must be honored. Project participants may also share generalized accountability to the broader public, future generations, or non-humans (see Box 4: Applying the CoC Pprinciples to Non-Humans).
- **Anticipation and Precaution:** Anticipation requires that everyone involved in or affected by proposed research activities actively envisage what sorts of futures might result, and transparently discuss their assumptions about which of these futures, if any, may be considered both scientifically feasible and socially and environmentally desirable. Anticipation processes that are participatory and inclusive (i.e., including researchers and affected stakeholders) will broaden the range of imaginable futures, and thus enable the co-production of research plans that balance precaution with enabling the benefits that may arise from the generation of new knowledge.

  A common principle often used when anticipating future effects of research is precaution. The precautionary principle states that "[w]here there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[49] Some have argued that the precautionary principle requires mCDR to be restricted or even prohibited, because it poses unknown but potentially significant risks to the environment.[50] However, it could also be argued the precautionary principle requires full investigation of all possible options for addressing climate change, including mCDR. Cooley et al. (2023) conclude "one could argue that the precautionary principle gives us reasons both to pursue CDR in general and to prefer approaches whose non-carbon-cycle effects are reversible or benign."[51] The divergence highlights the challenges associated with using the precautionary principle to assess mCDR research,[52] and reinforces the need for researchers and affected stakeholders to actively envisage the potential future risks and benefits of each research project and co-produce research plans that reflect these.

48 Cooley, S. et al., "Sociotechnical Considerations about Ocean Carbon Dioxide Removal," Annual Review of Marine Science, Vol. 15, 41–66, January 2023. Available at: https://www.annualreviews.org/doi/10.1146/annurev-marine-032122-113850

49 Rio Declaration on Environment and Development, 31 ILM 874 (13 June 1992).

50 *See e.g.*, Hubert, A.M., 2021, supra note 11. This view is reflected in the Assessment Framework for Scientific Research Involving Ocean Fertilization that was adopted in 2010 by the parties to the London Convention and Protocol. The framework states: "[i]f the risks and/or uncertainties [associated with a proposed ocean fertilization project] are so high as to be deemed unacceptable, with respect to the protection of the marine environment, taking into account the precautionary approach, then a decision should be made to seek revision of or reject the proposal." See Resolution LC-LP.2(2021) on the Assessment Framework for Scientific Research Involving Ocean Fertilization, cl. 4.3 (14 October 2020).

51 Cooley et al. Ann. Revs. Mar. Sci. 2023. *Supra* note 48.

52 For further discussion of the challenges associated with use of the precautionary principle in the context of CDR, see UK House of Commons Science and Technology Committee, The Regulation of Geoengineering: Fifth Report of Session 2009–10 (2010), p. 34–35.

BOX 4: Applying the CoC Principles to Non-Humans

The consideration of non-humans—other species or natural entities such as rivers or forests—is central to this code of conduct, although how the principles are applied to humans and non-humans would vary. For instance, some principles, such as consent, would be difficult to apply directly to relationships with non-humans without generating special institutional arrangements, such as forms of guardianship. However, the other principles are more easily applied to non-humans. For instance, concerns about ecological and/or social harms, risks and benefits would inform how the principles of precaution and anticipation would be used. Commitments to principles such as responsiveness and trust and awareness of power imbalances also directly include consideration of non-humans. For example, responsiveness includes an obligation to effectively use and act upon emergent data about ecological and social harms, risks and benefits; while recognizing the power humans have over non-humans in mCDR contexts warrants special consideration for non-humans in decision processes.

The interpretation of other principles, such as reciprocity and inclusivity would depend on how those using the code think about their relationships with non-humans. For example, mCDR research conducted within a western science paradigm will tend to assume clear delineations between living and non-living entities, but these categorizations are not universally shared as seen in cases like the Whanganui River which was granted personhood in New Zealand, or in other rights of nature initiatives. Multiple worldviews feature reciprocity between human and non-human beings. Similarly, a purpose of highlighting inclusivity is that it creates opportunities for multiple worldviews and forms of expertise about non-humans to be brought into decision processes, including by communities who may have been excluded from decision-making in research processes in the past.

Code of Conduct

The goal of this code of conduct is to provide a roadmap of processes, procedures, and activities that project leads should follow to ensure that decisions regarding whether, when, where, and how to conduct mCDR research are informed by relevant ethical, scientific, economic, environmental, and regulatory considerations.

This code focuses on the responsibilities of those leading mCDR projects to ensure that projects are conducted in accordance with this code of conduct. However, this will also require active support, including financial, from the entire set of actors associated with mCDR including funders, other researchers, journals, regulators, and communities. The term 'project leads' is used to refer to researchers, funders, developers, regulators, community stakeholders, and any others who have or contribute to decision-making obligations in any given mCDR effort, while recognizing that the exact configuration of those individuals will vary in each case. Unless otherwise specified, the directives in each numbered principle below are addressed to project leads.

The code of conduct is organized around three main phases of mCDR research:

1. **Planning and Scoping**, which covers the period before a research project begins, and provides guidance on the process project leads should follow to determine whether, when, where, and how to conduct research, including issues relating to project design, considerations around impacts, identification of and engagement with stakeholders, siting, and permitting.
2. **Execution of Research**, which covers the period during which a research project is conducted, and addresses issues related to monitoring positive and negative project impacts, accountability, liability, reporting and transparency, oversight and identification of "showstoppers" that require project cessation or changes, and decisions about scaling up or scaling back operations.
3. **Conclusion of Research**, which covers the completion of a research project, and provides guidance on project moving to the next level of research and operation, communication of results and next steps including more evaluation and remediation of any adverse project effects, fair distribution of benefits, and decommissioning.

Although the code of conduct is structured around three 'idealized' research phases for clarity of reading, in practice there is often no clear linear progression or division between these phases. The research process is and should be iterative based on advancement of scientific understanding and technical capabilities, and issues addressed in one phase might need to be reconsidered during others.

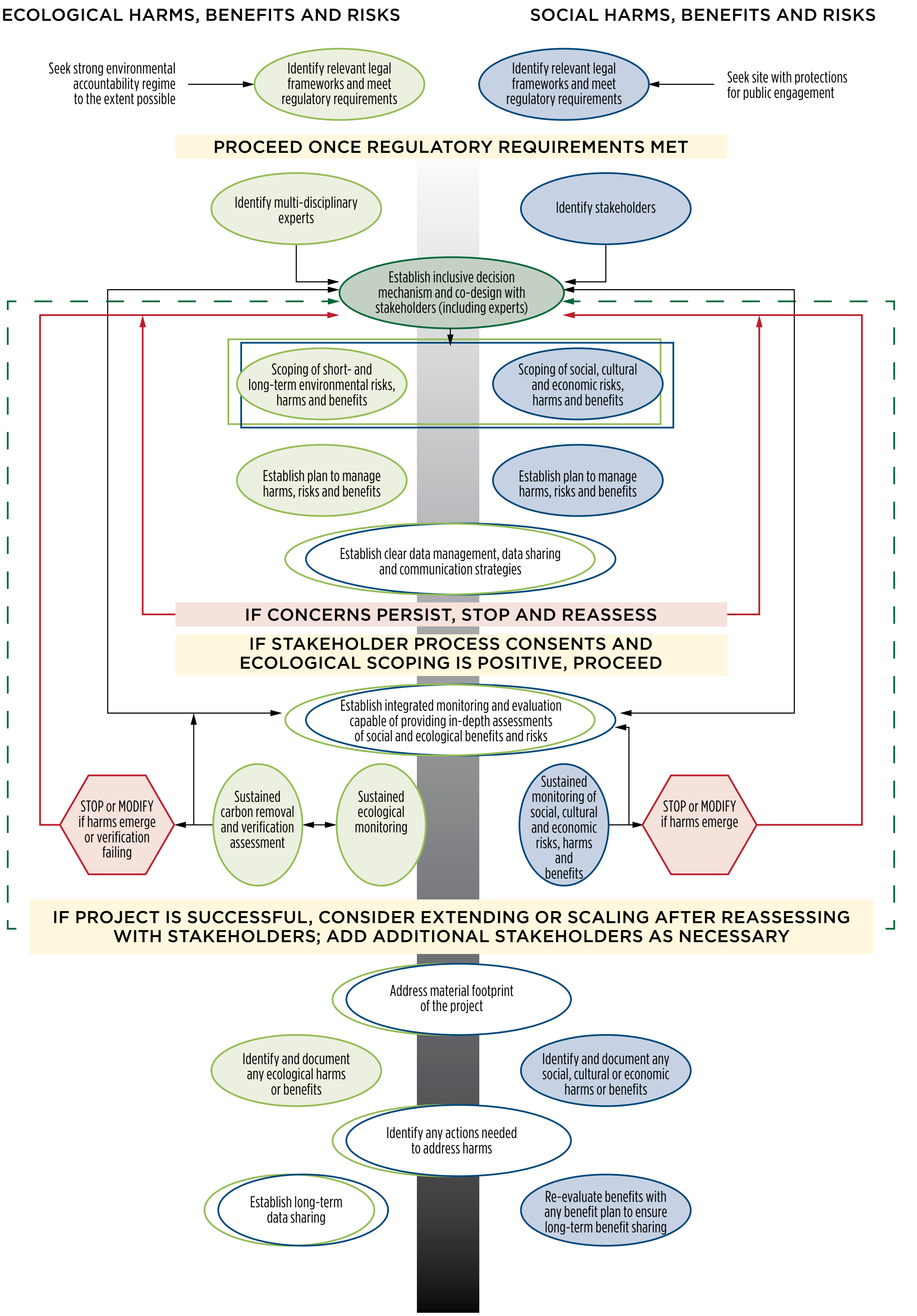

Figure 3. General timeline of process for mCDR research.

I. Planning and Scoping

This section covers activities and interactions that take place once a project is in preparation to move from a closed-loop or laboratory setting into the natural environment. As referenced in discussions about modeling (see Box 1: Laboratory, Mesocosm, and Modeling Research and Appendix B), there are also considerations that project leads should take into account even before a project reaches this stage, as those considerations can shape research at an even more fundamental level. However, this section of the code is intended to focus on decision-making related to selection of project location, method of execution, engagement with stakeholders, acquisition of funding, permitting, and other components of field work. Each of the areas and recommendations noted here should proceed simultaneously and iteratively.

I.A. ENGAGE FULLY WITH RELEVANT LEGAL FRAMEWORKS

There is currently no comprehensive legal framework specific to mCDR research, either at the international level, or domestically in most countries.[53] That does not, however, mean that mCDR projects operate in a legal vacuum.[54] mCDR projects must be conducted in accordance with all applicable laws and regulations and, in so far as possible, with scientific, environmental, and other principles that may not be legally binding but nevertheless represent best practice for ocean-based activities. This is important for a variety of reasons including, most notably, to build trust and ensure accountability.

There is a large body of international law governing ocean-based activities that could have implications for mCDR field trials and other research. Countries may also have domestic laws—e.g., governing the protection of marine resources and other environmental matters—that could apply to mCDR research in some circumstances. These domestic laws could exist at the national or subnational levels and Indigenous communities in different areas may also have their own legal frameworks (e.g., Native American tribes in the U.S.). Importantly, the laws may not specifically mention mCDR, but may nonetheless apply to mCDR research because it involves activities or has impacts the laws are designed to control. For example, research to test the efficacy of ocean alkalinity enhancement may require the discharge of ground alkaline materials into ocean waters from vessels—an activity that could be classified as "ocean dumping" under international agreements, such as the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter[55] (London Convention) and the London Protocol. Some mCDR research projects might also pose risks to marine life and thus be regulated under domestic species protection laws.

More generally, the United Nations' Rio Declaration on Environment and Development[56] and other international instruments lay out various environmental principles that mCDR project leads should be cognizant of, and work to uphold. For example:

- Principle 10 of the Rio Declaration emphasizes the need to ensure "all concerned citizens" have access to information, and can participate in decision-making, about environmental issues. More detailed requirements with respect to information sharing and public participation are set out in international agreements (including, but not limited to, the Aarhus and Espoo Conventions).

53 Some countries (e.g., Germany) have enacted laws specifically designed to regulate "marine geoengineering." However, even where such laws exist, they may not create a comprehensive legal framework applicable to all mCDR activities. *See e.g.*, Alexander Proelss and Robert C. Steenkamp, *Germany in* Ocean Carbon Dioxide Removal for Climate Mitigation: The Legal Framework (Romany M. Webb et al. eds., Edward Elgar Publishing, 2023).

54 NASEM, 2021. *Supra* note 2.

55 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters (adopted 29 December 1972, entered into force 30 August 1975) [hereinafter "London Convention"].

56 Rio Declaration on Environment and Development, UN Doc. A/CONF.151/26 (vol. I), 31 ILM 874 (1992).

- Principle 17 of the Rio Declaration calls for *ex ante* environmental review of "proposed activities that are likely to have a significant adverse impact on the environment." Under customary international law, countries have a procedural obligation to conduct an environmental impact assessment before undertaking or authorizing a project that poses a risk of "significant" transboundary environmental damage.[57] There is no agreed upon definition of what constitutes "significant" damage, but the International Law Commission has interpreted the term as requiring damage that is more than merely "detectable," but not necessarily "serious" or "substantial."[58] Some mCDR research projects may, depending on the nature and scale of activities involved, present such risks.
- According to Principle 19 of the Rio Declaration, countries must provide "prior and timely notification and… information" about activities that could have significant adverse transboundary effects, and consult with other countries "at an early stage and in good faith." This requirement is further elaborated in international agreements, such as the Convention on Biological Diversity and United Nations Convention on the Law of the Sea. Countries also have a responsibility, under customary international law, 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," including the high seas.[59] Again, depending on their nature and scale, some mCDR research projects might pose risks to resources of the high seas.

I.A.1. Identify and adhere to applicable international and domestic laws.

For the most part, international law only imposes obligations on countries and not individuals within those countries. For example, the London Convention and Protocol require countries to establish domestic permitting regimes for ocean dumping, but does not directly regulate private individuals engaged in dumping. Those individuals are, instead, regulated under countries' domestic laws which may vary. For example, not all countries are party to the London Convention and Protocol and, even those that are, may not have implemented them in the same way domestically. Given this, individuals planning an mCDR research project may be tempted to focus solely on the applicable domestic law, and ignore international law. However, various principles set out in international law can help to guide the planning and conduct of mCDR research, and thus supplement domestic legal requirements.

Project leads will need to engage with legal experts early in the planning process to identify potentially applicable domestic laws. The domestic laws that apply to mCDR research will depend on a variety of factors, including but not necessarily limited to the following:

a. The physical location in which the activity will take place and, in particular, whether it occurs in ocean waters under the jurisdiction of a specific country (e.g., the countries' territorial sea or exclusive economic zone) or on the high seas.

b. If the research will be conducted using a vessel or aircraft, the country where that vessel is registered or "flagged."

c. The nationality of the individuals involved in the research project, particularly if operating on the high seas. Some countries have enacted domestic laws that regulate the conduct of their nationals on the high seas.

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57 ITLOS Advisory Opinion at 111-116; Case Concerning Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgement, I.C.J. Rep. 2010 at 187 & 197 (April 2010).

58 International Law Commission (ILC). (2001). Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, with Commentaries. https://legal.un.org/ilc/texts/instruments/english/commentaries/9_7_2001.pdf

59 Declaration of the United Nations Conference on Environment and Development, Principle 2, UN Doc. A/CONF.151/26/Rev. 1, June 3–14, 1992.

I.A.2. Seek out areas with more robust legal frameworks to ensure projects will be compliant with environmental principles.

Researchers will, of course, need to consider a range of factors when deciding where and how to conduct mCDR research projects. Some types of research may need to be conducted in certain locations, for example, where water temperatures or pH levels are within defined ranges. When choosing between multiple locations with the desired characteristics, project leads should consider the legal frameworks that would apply to projects in each location, and prioritize locations with more robust legal requirements and oversight of environmental interventions and technology development. While it may be tempting for researchers to choose the path of least resistance and design projects to avoid legal requirements and oversight, doing so may undermine accountability and thus trust, and ultimately engender opposition to mCDR research.

I.A.3. View legal requirements as a floor rather than a ceiling.

While various laws could apply to mCDR resarch, those laws were, in most cases, designed with other activities in mind. At the international level, for example, the London Convention and Protocol were adopted long before mCDR was being widely discussed. In the case of the London Protocol, the parties have adopted an amendment dealing specifically with “marine geoengineering,” but that amendment has not yet entered into force and is thus not legally binding. Regulating mCDR activities under general environmental laws that were designed for other activities presents significant challenges. Research suggests that, in some cases, existing general laws may not adequately address the unique risks that mCDR resarch could pose to marine environments and communities.[60] As such, compliance with existing legal requirements is necessary, but may not always be sufficient, to ensure mCDR projects are conducted in a just and responsible way that furthers the principles identified above.[61] Researchers should be mindful of this fact and go beyond minimum legal requirements (e.g., with respect to project assessment, environmental impact assessments, stakeholder engagement, risk management, etc.) where the principles of this code would require them to do so.

I.A.4. Be mindful of and coordinate with all present and (to the extent practicable) future ocean users, including non-humans, to consider how the proposed activity might impact those users.

While often perceived as an “open space” devoid of activity, the ocean is in fact extensively used by both human and non-human actors. Demands on the ocean are increasing, in part due to the growing interest in developing ocean-based climate solutions, such as offshore renewable energy. There is also greater scientific understanding of the complexities and interrelationships between ocean systems and coasts. The possibility of interactions between mCDR research projects and other current and potential future ocean-based activities should be closely scrutinized and carefully managed. In areas where marine spatial plans have been developed to manage different ocean uses, project leads should consult existing local, regional, and national plans and contribute to future planning efforts. Project leads should also be cognizant of relevant developments at the international level, such as the use of area-based management tools envisioned under the BBNJ Treaty.

60 See generally, Webb, R. M., et al., *Ocean Carbon Dioxide Removal for Climate Mitigation: The Legal Framework* (Edward Elgar Publishing, 2023), quote at p.244.

61 See Reykjavik Protocol, *Supra* note 17.

I.B. CO-DEVELOP ALL RESEARCH AS DICTATED BY SCALE AND SCOPE

Co-development entails the active involvement of multiple impacted stakeholders in the research process (see Fig. 4). Co-developing research upholds principles of inclusiveness, consent, reciprocity, reflexivity, responsiveness and trust, and anticipation and precaution. Proulx et al. note that “[h]aving communities participate from the outset and guide the research can increase the likelihood of mCDR implementations that are compatible with environmental justice, and avoid mCDR implementations that would exacerbate environmental injustice.”[62] (See Box 5: Stakeholder Identification Process.) Furthermore, research co-design offers additional benefits of targeting research efforts more effectively (both for field-based and laboratory-based activities), energizing the work, developing stronger trust, and yielding durable benefits and insights.[63] Enabling affected stakeholders to participate in the definition and scope of scientific research also upholds their rights to justice and environmental decision making recognized under 15(1)(b) of the International Covenant on Economic, Social and Cultural Rights[64] and Principle 10 of the Rio Declaration.[65] By ensuring that community concerns and other potential problems can be identified and addressed early on in the process, co-development of research may also reduce the risk of future litigation and other surprises that could derail the project.

BOX 5: Stakeholder Identification Processes

The range of stakeholders included will vary depending on the location, scale and nature of the research. Very small scale, short, low risk projects will require a less robust stakeholder engagement process than those with a larger spatial scale, longer duration or that pose greater risks. If a research project is scaled up in any dimension, the initial stakeholder engagement process may need to be augmented.

The importance of stakeholder processes flows from the full set of principles of this code of conduct. The purposes of inclusive decision processes are a) to ensure that research activities take as wide a range of social and ecological concerns into account as possible, including those that the research team itself may not have thought of, b) to ensure that research activities are considered acceptable by those who would bear any harms or risks before they are conducted, and c) that there is continued shared responsibility for evaluating research as it develops. Because non-humans cannot represent themselves directly, stakeholder groups should include those with specialized knowledge of impacts on non-humans, which would include local and Indigenous knowledge in addition to multi-disciplinary expertise. For instance, a community or group of subject experts may express concerns about a particular bay, beach or reef area, or about a specific species, ecosystem, or human-species interaction that may otherwise have been overlooked without this specialized insight.

Accordingly, when establishing stakeholder groups, efforts should be made to identify those who: are directly impacted; have specialized knowledge of the place, mechanism, technique, regulatory arena, or ecosystem being targeted; adjacent marine or terrestrial activity users; and relevant regulatory entities. An initial task of stakeholder engagement may be to use this group to identify any missing stakeholders and the adequacy of representation will have to be revisited if projects shift (see Fig. 3).

62 See generally, MaryJane Proulx et al., *Indigenous Traditional Knowledge and Ocean Observing: A Review of Successful Partnerships*, Frontiers in Marine Science 8:703938 (2021).

63 Moser, S. “Can Science on Transformation Transform Science? Lessons from co-design,” Current Opinion in Environmental Sustainability, Vol. 20, June 20216. Available at: https://www.sciencedirect.com/science/article/pii/S1877343516300665

64 International Covenant on Economic, Social and Cultural Rights (adopted 16 December 1966, entered info force 3 January 1976) 993 UNTS 3.

65 Rio Declaration on Environment and Development, UN Doc. A/CONF.151/26 (vol. I), 31 ILM 874 (1992).

I.B.1. Project funders must ensure that resources are available for co-design processes.

Creative inclusive decision processes that facilitate co-design require resources. Funders must factor the cost of activities intended to ensure the inclusion of stakeholder perspectives into their investment in a given project, and allow for a timeline that reflects reasonable diligence towards these activities.[66] For example, in the natural sciences, calls for research proposals that require transdisciplinary research and co-development and budgets should include adequate resources to do so. In some circumstances, resources also may be needed to compensate community members for their time. This is especially common when working with Indigenous communities, particularly if elders or knowledge keepers are included.

1.B.2. Establish inclusive decision-making processes.

Effectively ensuring accountability, trust, consent and reciprocity will require the establishment of inclusive decision processes that are free from coercion and include all stakeholders. Decision-making processes must take into account the best available knowledge from the full range of disciplinary insights relevant to the research. This includes not only scientific expertise but also local and Indigenous knowledge, practitioner and regulator perspectives, and technical expertise. Failing to include a diversity of those affected will reduce their ability to raise concerns that may prevent the project from proceeding, and increase the likelihood that important potential outcomes will not be identified or addressed through the research process.

The appropriate model of engagement for any given project will depend on the scale, scope, and levels of uncertainty and/or risks of the project. The form of the inclusive process may need to change, for instance, as research is scaled up or moved closer to deployment. Examples might include forms of stakeholder advisory councils; stakeholder workshops with follow-up mechanisms; the appointment of external advisors; public forums or hearings or any other mechanism that shares decision authority over research projects. In some jurisdictions, processes for marine spatial planning offer a framework to discuss mCDR activities in conjunction with other uses of marine spaces.[67] Including some actors, such as non-humans and future generations, may be more difficult but can also be achieved through various means, such as employing guardianship councils or ombudspeople with the mandate to represent future or non-human interests, or by running models under diverse scenario parameters, among other ways. Project leads should actively seek to understand the nature of the power imbalances which are shaping physical or conceptual elements of the research project, including decision-making, when the scale of the project justifies such consideration.

I.B.3. Co-produce benefit and compensation mechanisms with stakeholders before project implementation and ensure they are periodically reviewed by stakeholders.

When benefits are envisioned as part of a project, a benefit sharing plan that outlines the objectives, stakeholders, and mechanisms for equitable benefit distribution should be formulated before the beginning of a project, and periodically reviewed during its execution. This plan should be developed in collaboration with all relevant parties, including local communities, researchers, and funding organizations. Stakeholders who will be impacted should be actively involved in

66 For example, see methods and formats for project co-design included in Satterfield, T., Nawaz, S., and Boettcher, M.: Social Considerations and Best Practices for Engaging Publics on Ocean Alkalinity Enhancement, State Planet Discuss. [preprint], https://doi.org/10.5194/sp-2023-3, in review, 2023. https://doi.org/10.5194/sp-2023-3

67 Lezaun, J. (2021). Hugging the shore: tackling marine carbon dioxide removal as a local governance problem. *Frontiers in Climate*, 3, 684063.

articulating what counts as a "benefit," which may include material, economic, social, environmental, and cultural benefits, and how they will be allocated. The plan should address the distribution and duration of benefits and the mechanisms for resolving disputes about the distribution of benefits (see Box 6, Harms, Risks, and Benefits).[68] Efforts should be made to ensure that the accrual of any benefits (including revenue, technology transfer, and knowledge sharing) from the planned research activity will not create or further entrench inequality or injustice, and that mechanisms are in place to ensure appropriate redress of any harms caused. (See subsection III.B below.)

I.B.4. Clearly communicate anticipated research outcomes with stakeholders.

As part of the co-design process, project teams should clearly and publicly communicate what they concretely hope to get out of the proposed research activity. This includes communicating immediate knowledge gains and what they envisage as the longer-term contribution of this new knowledge to future mCDR activities and climate mitigation writ large. There should be opportunities for other stakeholders to also contribute to these goals as articulation of these may require altering the project somewhat. Project leads will need to understand what active consent processes are appropriate and required in any given situation.

I.B.5. Situate research planning within local, traditional and Indigenous knowledge and practice.

Many studies have shown that "[r]esearch conducted without consent [from Indigenous communities] and outside of a collaborative framework can be a form of colonialism that can potentially harm Indigenous peoples."[69,70] In particular, for near shore projects, restrictions on access to "coastal and marine resources that have traditionally been open access and an important source of livelihoods" should be carefully scrutinized.[71] In the past, coastal blue carbon projects (e.g., involving mangrove restoration) have "been critiqued for pushing out traditional users," resulting in "traditional management systems being replaced, and communities losing their ability to change their management strategies in response to environmental change" or other factors.[72] Care must be taken to avoid repeating these mistakes in the mCDR context. It is thus crucial to acknowledge historical and present day contexts, and to co-develop research plans within the context of local, traditional and Indigenous socio-ecological relationships and using diverse Indigenous knowledges as may be relevant. Doing so can ensure a broader perspective on environmental impacts, help to ensure reciprocity and build trust between researchers and stake-holders, and avoid creating or perpetuating historical and/or contemporary power imbalances.[73]

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68 Other resources provide more detailed guidance on developing benefit sharing plans for CDR projects and provide examples from other sectors. *See e.g.*, U.S. Dept. of Energy, "Guidance for Creating a Community Benefits Plan for Regional Direct Air Capture Hubs," 2022, available at: https://www.energy.gov/oced/articles/community-benefits-plan-guidance; Fraser, C., "Community and Labor Benefits in Climate Infrastructure: Lessons for Equitable, Community-Centered Direct Air Capture Hub Development," 2023, https://www.dataforprogress.org/memos/community-and-labor-benefits-in-climate-infrastructure; Eisenson, M. & Webb, R. M., "Expert Insights on Best Practices for Community Benefits Agreements," 2023,. Available at: https://scholarship.law.columbia.edu/sabin_climate_change/206/

69 Datta, R. "Decolonizing both researcher and research and its effectiveness in Indigenous research," *Research Ethics*, Vol. 14, Issue 2, September 2017. Available at: https://journals.sagepub.com/doi/10.1177/1747016117733296

70 NASEM, 2021. *Supra* note 2.

71 *Ibid.*, at 62.

72 *Ibid.*

73 Satterfield, T., et al., *Supra* note 66.

I.C. IMPLEMENT CLEAR AND TRANSPARENT RESEARCH PROCESSES THROUGHOUT

I.C.1. Prior to the execution of a research project, create a data management plan to explain what type of data is anticipated from the project and how it might be collected, monitored, shared, and archived.

A data management plan should typically provide information on the type, format and scale of the data, it should reference methods of data collection, explain how the data will be stored and curated, consider data security and provisions for access and sharing, and consider long-term preservation and archiving. The contents of data management plans could be shaped by the requirements of the funder, or co-created with stakeholders.

I.C.2. Design research projects to have planned strategies for communication and dissemination of results, including to non-academic audiences, beyond involved stakeholders.

Even highly co-designed projects will need to communicate to wider publics and non-involved stakeholders. Messages must use accessible language and appropriate modalities, including efforts to provide clarification and response or pushback to deliberate dissemination of misinformation. In some situations, non-written modalities such as video, public meetings, radio or other means may be preferable. Communications strategies should be flexible to accommodate changes in the research project, but should include communications at the onset of the project, throughout its execution and particularly highlighting early results, and following the project completion.

I.D. IDENTIFY AND COMMUNICATE POTENTIAL SOCIAL AND ENVIRONMENTAL OUTCOMES

Due to the variety of mCDR approaches, the different locations in which they could be pursued, and the diverse groups that might be impacted, we do not provide a comprehensive list of all outcomes of potential concern in this code. Rather, project leads will need to assess social and environmental outcomes on a case-by-case basis, taking into account the specifics of their project. Inclusive and iterative processes will be required to fully scope outcomes before projects are started, and can also inform the establishment of decision protocols to determine when risks or harms warrant ending a research project.[74] The processes used should account for uncertainties associated with mCDR and be responsive to developments in the science (see Box 6: Harms, Risks, and Benefits). Project leads should be mindful of the full range of risks, harms and benefits associated with any project and the fact that they will be defined differently by different stakeholders (see Box 5: Stakeholder Identification Processes).

74 *Ibid.*

BOX 6: Harms, Risks and Benefits

Understanding what environmental and social harms, risks and benefits are, their magnitude, and how they are likely to be distributed is crucial to conducting responsible research, even in the face of myriad uncertainties. Diverse stakeholders, including researchers themselves, will define specific harms, risks and benefits differently in any given project because they will value different aspects of the project.

Harms are known, negative consequences of actions. For instance, a harm might be the destruction of a particular piece of land required for the research activity (such as a beach or part of the seabed floor). Harms may be unavoidable for some kinds of research but could be reduced if identified in advance, and may be seen as acceptable in the context of the larger purpose, goals, and potential benefits from the research process.

Risks are uncertain negative consequences of actions. For example, risks may include possible harm to a particular ecosystem or species, such as a potential reduction in abundance. Risks may vary by likelihood or likely intensity in scope, duration or severity. If identified in advance efforts to reduce risk likelihood or intensity can be built into research design. Risk tolerance will be a central part of any decision process.

Benefits can be known or uncertain positive consequences of action. It is important that different kinds of benefits be clearly distinguished and communicated. Some benefits may be direct and certain, for instance immediate financial payments for use of materials or access, while others may be indirect, diffuse, or uncertain such as long-term emission reductions or possible long-term financial pay-outs through a carbon market. Because different stakeholders will define benefits differently, care should be taken to ensure that benefits are defined as such by the intended beneficiaries of them.

I.D.1. Take a systems approach to scoping in order to anticipate the full range of harms, risks, and benefits and any interactions that may emerge amongst them.

Bearing in mind the complexity of natural systems and social relationships in and across ocean areas and uses, including across ocean-terrestrial boundaries, taking a systems approach is essential. In a systems approach, scoping is conducted to understand how impacts in one domain may affect other systems in other domains. The following four categories can be a useful guide for scoping risks, harms and benefits:

- **Environmental:** including impacts that are both proximate and distant in nature, and ecosystems along the land-ocean continuum;
- **Sectoral:** including fisheries, integration with human settlements, coastal zone health, recreational uses, or transportation;
- **Socio-cultural:** including diverse understandings of sacred or socially important spaces, culturally significant practices (for instance harvesting traditional foods), aesthetics, understandings of wellbeing, or relationships with particular organisms or with the ocean itself; and
- **Financial-material:** including financial, physical, and intangible infrastructure such as data, technology, or built assets, and in-kind contributions from the local community or environment.

I.D.2. Clearly identify and communicate the duration, location, and spatial scale of any research activity and its outcomes.

The longevity and severity of outcomes may fundamentally change how stakeholders evaluate benefits, risks or harms. For example, stakeholders may judge temporary disruption of the seafloor during construction of a research apparatus differently from permanent displacement of a species' spawning grounds by the apparatus. Consent processes should include information about the proposed duration of any research activity and its potential positive or negative outcomes, including whether or not negative outcomes will be permanent or can be corrected after the fact.

The location and spatial scale of research outcomes must also be considered. This is especially important to ensure that all those who might be affected by a research project, and thus should be included in decision-making about it, are identified and engaged. Changing the scale of a project may involve very different Indigenous communities, depending on the locations of their contemporary or historical territories. Importantly, public perceptions about mCDR activities may not 'scale up' in a linear fashion. Because the range of stakeholders involved and the set of environmental and social risks, harms and benefits would change as research is scaled up, consent processes will need to be revisited with shifts in scale, location or duration. Public support or consent for an activity at one scale should not be assumed for activity at another.

I.D.3. Differentiate between direct and indirect outcomes.

When developing research, project leads should clearly differentiate between the direct impacts the project is intended to have, and any unintended or indirect impacts, and be careful to not scale research projects too quickly and too far beyond the scale and knowledge base provided by previous research. Careful attention to language is central, for instance, being specific when describing potential, claimed, actual, direct, and indirect impacts.

As part of this effort, there should be explicit identification of carbon-related and non-carbon-related impacts of research. For some stakeholders, non-carbon-related outcomes of mCDR, such as the potential for improved marine health or local job creation, may be of primary importance. If research has been co-developed, important elements, goals, and sensitivities should already have been identified. Any project outcomes that could affect stakeholder priorities or core values should be clearly communicated.

Finally, identification and differentiation of benefits should inform the creation of appropriate data collection and monitoring systems. For example, if a project was claiming the potential to generate revenue in a carbon market, the project should establish a means for assessing the extent to which this is or is not occurring. Research protocols should include efforts to scope potential outcomes and establish and clearly communicate appropriate testing for any outcomes they are expecting without over-promising based on theoretical outcomes. These protocols should quantify side effects wherever possible and be informed by anticipation and precaution, for example by exploring an expanded range of possible outcomes, using scenarios and other means to manage uncertainty.

I.D.4. Identify and differentiate amongst risk-bearers and beneficiaries of research activities.

Risks, harms, and benefits will not be evenly distributed. Accordingly, care should be taken to identify specifically who will be impacted and how. Such groups could include people who are outside the scope of the research, future generations, non-humans, or other stakeholders who may or may not have a direct voice in decision-making processes.[75] If direct risk-bearers are identified who have not been included in decision-making processes, it is a signal that these processes should be augmented because they do not have sufficient representation to entail consent.

75 Options for representing the perspectives of non-humans and future generations include the appointment of ombudspoeple or guardianship. For more information on these options, see: González-Ricoy, Iñigo, and Axel Gosseries. 2016. Institutions for Future Generations. Oxford University Press.

Since what constitutes a risk or benefit is a judgment, special attention should be paid to the definition of both categories by those experiencing them. Not all intended benefits may be seen as such by purported beneficiaries. Identifying what potential benefits or risks are will require early and upfront engagement with beneficiaries and risk bearers.

One tool worth considering, particularly as research increases in scale, would be for project leads to post bonds in advance of initiating a project in order to ensure funding would be available to remediate any adverse impacts resulting from research activities.

I.D.5. Acknowledge historically rooted inequities, which are frequently ongoing.

Scoping processes should also include consideration of how each specific mCDR project will address issues related to historic climate and other inequities and ensure accrual of any benefits, including revenue, from the project will not further entrench inequity.

I.D.6. Acknowledge and address uncertainties.

Any project will inevitably have uncertainties, but decisions will still need to be made. The nature, scope, and assumptions shaping the identification of uncertainties needs to be clearly communicated to all stakeholders, consistent especially with principles of awareness of power imbalances, inclusiveness, consent, reflexivity, responsiveness and trust, and anticipation and precaution. The way uncertainties are conveyed to stakeholders will vary among projects and should be tailored to the preferred communication style of stakeholders. It is also important to consider the impact of different value systems on groups' views of uncertainty (e.g., whether nature is controllable) and differences in groups' risk tolerances.

I.D.7. Explore possible future outcomes in collaboration with stakeholders.

Efforts should be made to actively and inclusively map the wider range of possible future effects a research activity may have, and the implications of scaling up and deploying mCDR. For example, participatory foresight workshops involving researchers and community members can be used to anticipate a wide range of plausible future threats and opportunities which could be presented by mCDR research. Such inclusive anticipation processes encourage reflexivity on behalf of researchers, can contribute to the creation of trust between researchers and stakeholders, and enable the co-design of research plans with communities that balance precaution with enabling the benefits that arise from the generation of new knowledge.[76]

II. Execution of Research

Research projects typically begin with the completion of agreements between funders and researchers. For larger projects involving researchers from multiple organizations, projects often begin following the completion of a consortium agreement. However, for research projects that are not externally funded, it is useful to consider the first physical implementation (e.g., initiation of procurement, assembling hardware) of the planned research as the point at which the research project has begun. This would also include pilot experimentation that may aid in the development and design of larger trials.

76 Satterfield, T., et al., *Supra* note 66.

The governance and regulation of field trials can be complex. Establishing proper frameworks to oversee and manage these trials is essential to ensure responsible and transparent testing, minimize risks, and avoid uncontrolled experimentation that could harm marine ecosystems. Field trials involving significant environmental alterations may raise ethical concerns. Ethical discussions about the potential impacts on vulnerable communities and ecosystems, and the equitable distribution of any benefits that may arise from these trials should continue throughout the duration of activities.

II.A. ESTABLISH, MAINTAIN, AND (AS NECESSARY) REVISE MONITORING AND EVALUATION PROCESSES

A key outcome of initial inclusive decision processes would be the identification of the range of potential intended or unintended outcomes from a research intervention. Researchers may employ a range of methods for monitoring mCDR research. These methods are typically designed to test specific hypotheses, which may result in unintended consequences not being detected. Because best practices to monitor mCDR are still being developed, the initial approaches for monitoring, reporting, and verification of outcomes may change over time.

II.A.1. Establish or maintain monitoring and evaluation processes for mCDR activities.

In order to ensure collection of transparent and accurate data to monitor the impacts of a given project, its leaders must ensure that their monitoring and evaluation methods include the following elements:

a. Resourcing and time to enable the collection of baseline data such as the form and function of an ecosystem or elemental flows through an environment prior to executing any activity.

b. Means of acquiring physical data related to technical performance of an mCDR approach, such as carbon dynamics and accumulation, and any additional parameters that may have an ecological or human impact.

c. Flexibility in application of resources and monitoring strategies so that they can be adapted to explore unintended outcomes if detected during an experiment, or identified iteratively through the inclusive decision process. This will facilitate the improvement of monitoring and reporting best practices.

d. Adequate resourcing and communication protocols for sharing updated monitoring information in appropriate languages and formats with diverse stakeholders. Communication processes should be determined in conjunction with stakeholders and may vary in format across groups even in a single project. They also should adhere to a model such as the FAIR Principles of Findability, Accessibility, Interoperability, and Reuse of digital assets.[77]

e. Tracking outcomes and how they are distributed over time. Regular assessments should be conducted to determine whether the intended equitable outcomes outlined in the benefit sharing plan are being achieved, and mechanisms adjusted as needed. This should include maintaining comprehensive and transparent records of benefit sharing activities and outcomes, such as production of regular reports that detail the distribution of benefits and their impacts on stakeholders.

77 Wilkinson, M., Dumontier, M., Aalbersberg, I. et al. The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* 3, 160018 (2016). https://doi.org/10.1038/sdata.2016.18

Special attention should be paid to ensuring that any particular benefits, risks or harms identified by local communities, Indigenous nations or other groups who could be directly impacted are adequately monitored. The obligation to generate adequate monitoring data may entail the addition of expertise to existing research teams or wider research programs. For instance, this might include adding people with local knowledge, Traditional Ecological Knowledge, or practical experience, or those from the humanities, ethics, or social sciences.

II.A.2. Establish or amend monitoring systems and procedures for collection of baseline data using identification of intended and potentially unintended outcomes of mCDR research that occurred during scoping.

Project leads should monitor for acute onset harmful or beneficial environmental outcomes in the vicinity of research activities. These could result from mCDR activities themselves or from interactions between mCDR approaches and other existing marine activities or environmental conditions. Examples of potential acute-onset, harmful outcomes could include anoxia, acidification, toxic or pathogenic algal blooms, attainment of ecological tipping points, mortality of species, zooplankton entrainment, or loss of ecosystem services.

Project leads should also monitor for gradual onset environmental changes in the vicinity of research activities. In so doing, it may be helpful to give additional consideration to areas that already have existing monitoring capacity such as offshore wind farms or areas with higher ocean observing operations (see Box 7: Ocean Observation Capabilities). Ecological outcomes from interacting anthropogenic stressors can be additive, synergistic, or antagonistic for individuals, and can act as selective pressures for populations.[78] It is also possible that mCDR activities could act as a nonlethal driver on different species—individuals or entire populations—or ecosystems, which will be more difficult to detect and attribute, including changing species diversity in the vicinity of projects, acceleration of trends caused by other anthropogenic drivers, and degradation of coastal ecosystem services.

78 Intergovernmental Panel on Climate Change, Working Group II, 2022. *Supra* note 21.

BOX 7: Ocean Observation Capabilities

Modern observational oceanography employs a range of techniques to gather data which would form the basis for a measurement system for mCDR:

Ships and Vessels: Research vessels equipped with scientific instruments are used to collect data on water temperature, salinity, currents, and other physical properties. They also allow for the collection of samples for biological and chemical analysis.

Buoys: Moored or drifting buoys equipped with sensors provide continuous measurements of ocean properties, such as temperature, salinity, wave height, and increasingly sophisticated chemical properties. They help monitor long-term changes in the ocean and provide real-time data.

Satellites: Remote sensing satellites orbiting the Earth collect data on sea surface temperature, ocean color, sea level, and other variables. These data provide a global perspective and helps monitor large-scale oceanographic phenomena such as ocean circulation patterns and the extent of sea ice.

Acoustic Techniques: Sonar systems are used to measure water depth, map the seafloor, and detect the presence of marine organisms.

Autonomous Vehicles: Autonomous floats and underwater vehicles are used to collect data in remote and/or hazardous areas. These vehicles are equipped with sensors and can be programmed to follow specific paths to gather data on temperature, salinity, currents, and other parameters, often across a range of depths.

The Global Ocean Observing System (GOOS) is an international program that aims to coordinate and enhance the collection and dissemination of oceanographic data worldwide. It was established by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization in collaboration with various partners. GOOS focuses on systematically observing the global ocean to provide timely and accurate data for understanding and predicting oceanic processes, climate variability, and marine ecosystem health.

II.B. IMPLEMENT THE PLANNED ITERATIVE APPROACH TO RESEARCH

II.B.1. Involve stakeholders in the execution of the research plan they helped to co-develop.

Involving stakeholders in the execution of research plans (consistent with the co-development principles established in subsection I.B.) is critical for accountability, to promote trust, and to ensure the ongoing provision of consent. When warranted by the scale of the research, one way to ensure ongoing involvement by stakeholders is through the establishment of community advisory boards to provide continuing input on the research project's implementation. Community advisory boards can help ensure that the way research is executed aligns with community needs and concerns. It may additionally be possible—given sufficient community interest and capacity—to tap into local expertise and knowledge by involving community members as research assistants or co-researchers who contribute to data collection, interpretation, and dissemination. This can be accompanied by offering training and capacity-building workshops to community members to equip them with research skills, empowering them to actively participate in data collection and analysis.

II.B.2. Involve communities in the ongoing monitoring and evaluation of research projects.

It is essential that researchers provide local communities and other stakeholders with regular updates about the project and share data and findings with them. Researchers should take care to ensure that updates, data, and findings are communicated in a way that is accessible to and understandable by individuals who may lack a scientific background, including efforts to provide clarification and response or pushback to deliberate dissemination of misinformation.

Going beyond regularly informing stakeholders about research progress and results, researchers and funders should create inclusive opportunities for the local stakeholders to provide feedback on research. Convening regular community-led workshops and presentations can be a useful means of facilitating two-way communication between the research team and local stakeholders. In some cases, it may be appropriate to involve stakeholders in monitoring and data collection to aid in the evaluation of the project through activities such as collecting water samples, reporting changes in local ecosystems, and noting changing relationships within communities as a result of the research activity. Researchers can additionally collaborate with stakeholders in analyzing the resulting research data, by organizing joint discussions, workshops, or co-analysis sessions where community members contribute their insights and interpretations and shape the way the project moves forward.

The community's input can help iteratively co-develop more effective strategies for applying initial findings (i.e., of modeling, lab or mesocosm experiments) in real-world contexts. Through ongoing inclusive evaluation, potential unexpected negative impacts of the research activity on the community can also be identified and addressed quickly.[79]

II.B.3. Ensure inclusive decision-making regarding project changes.

Where changes are made to the design, scope, or other aspects of a research project, the project leads should consider whether those changes will result in different groups being impacted (see Fig. 4). Where that is the case, researchers will need to ensure that those groups are effectively engaged, and secure their consent to the changes.

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79 Mintz, K. K. et al., "Multiple forms of engagement and motivation in ecological citizen science," *Environmental Education Research*, 2021. Available at: https://www.tandfonline.com/doi/full/10.1080/13504622.2022.2120186; Ardoin, N. M., et al., "Environmental education outcomes for conservation: a systematic review," *Biological Conservation,* 2020 available at https://www.sciencedirect.com/science/article/pii/S0006320719307116; and, Davis, L. F., et al., "Participatory Research for Environmental Justice: A Critical Interpretive Synthesis," *Environmental Health Perspectives*, 2021. Available at: https://ehp.niehs.nih.gov/doi/10.1289/EHP6274

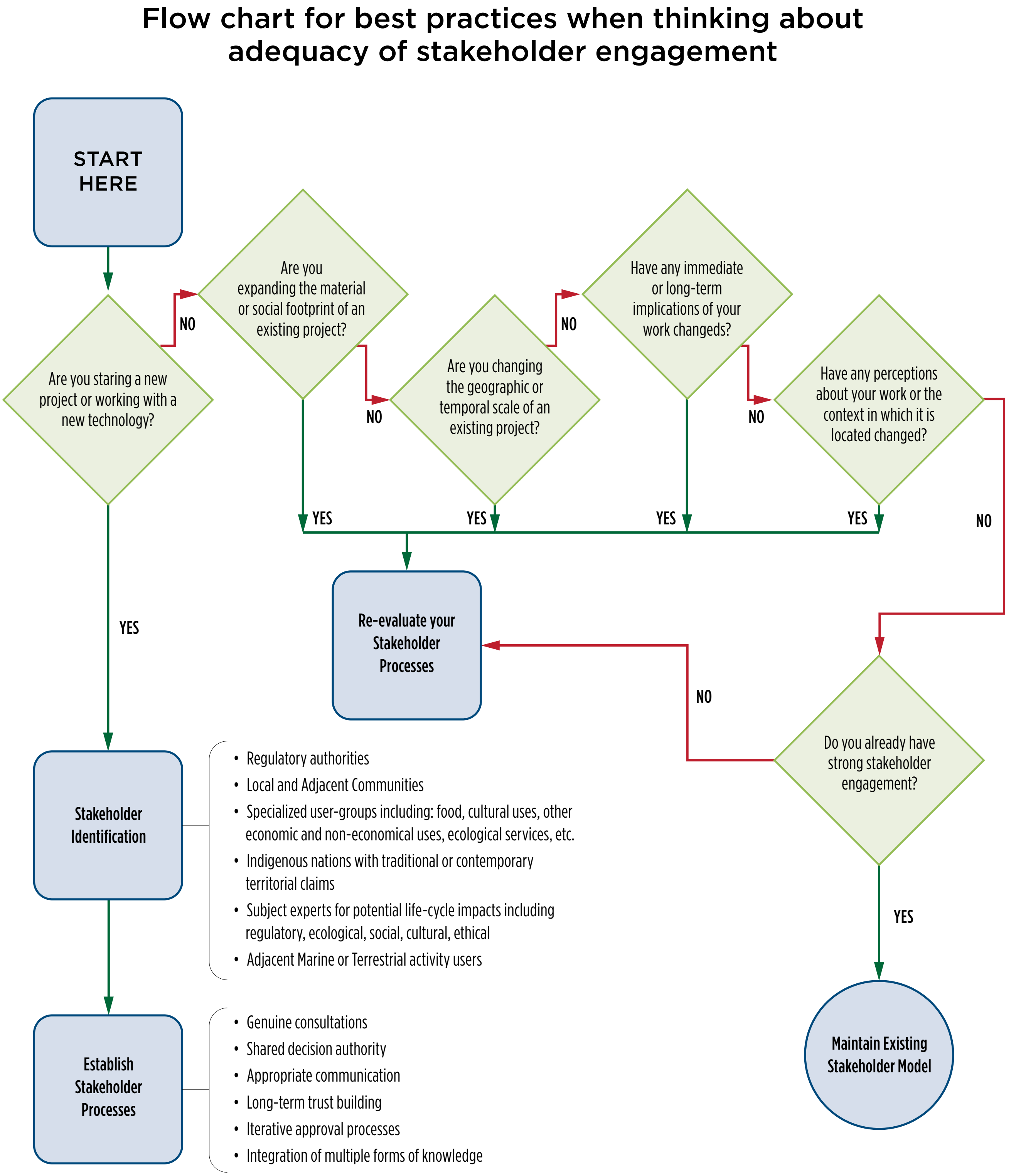

Figure 4. Example flowchart for adequate stakeholder engagement.

II.C. SHARE DATA ACCESS, KNOWLEDGE OWNERSHIP, AND INFORMATION

Knowledge created through research has diverse forms of value. Issues about data ownership, access, and sharing should be addressed in the planning stage, anticipating that they will continue to generate obligations after the active research phase is complete. Promotion and facilitation of knowledge-sharing and technology transfer can strengthen research capabilities of low- and middle-income countries or underserved communities and help enhance the long-term prospects for a more equitable global ecosystem of research. Data ownership should have been negotiated with stakeholders in advance, pursuant to the principles outlined in the “Planning and Scoping” section of the code.

Many public funders of research request that data be archived and made publicly available following their collection. Researchers typically embargo the release of data such that they have sufficient time to analyze and publish the results. Embargo periods on the order of 24 to 36 months are typical, but should not be used to prevent the early dissemination of results.

II.C.1. Facilitate collaborative partnerships between mCDR project leaders from developed countries or regions to less-developed countries or regions during project operations.

Building partnerships between mCDR researchers and practitioners from regions with differing economic strength (i.e., the global north and south) can promote equitable knowledge-sharing and technology transfer. This can be facilitated through research collaborations, joint projects, and visiting researcher programs that focus on the exchange of ideas, expertise, and resources. Such partnerships can enable developing countries to access cutting-edge research, technologies, and expertise, while also fostering mutual learning and capacity building on the issue of mCDR. Access to scientific literature, data, technology, and other resources is crucial for researchers in less developed countries to keep up with the latest academic knowledge and research results. Project leads should improve access to these resources through open access publications and open source data platforms (see also subsections I.B. and II.B).

II.C.2. Prioritize and promote local and Indigenous knowledge.

Recognizing and valuing local and Indigenous knowledge can contribute to a more equitable global ecosystem of mCDR research. Such activities include providing resources for communities to contribute to the execution of research alongside science teams from developed countries and reflecting those contributions when results are communicated in academic formats, such as conference talks and peer-reviewed publications. Effort should also be made to ensure generated knowledge is communicated back in locally-preferred avenues. This can empower researchers, practitioners and communities in various situated contexts to contribute more equally to global knowledge production on mCDR.[80]

III. Conclusion of Research

The responsibilities of project leads and participants do not end at the conclusion of a research project. While many projects may conclude at a pre-planned time or when certain objectives have been achieved or the next level of experiments is needed, others will end for different reasons that can include early termination due to evidence of harm or ineffectiveness. Public pressure or political decisions can also play a role. Regardless of why a project ends, project leads have certain obligations at the conclusion of research. In fulfilling these obligations, project leads should adopt an inclusive approach that gives other stakeholders, especially local communities, a meaningful say and role in the process. This will help to ensure that ongoing benefits from research are maximized and any harms are avoided or minimized.

80 The European Commission’s “Open Science policy,” available at: https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en#documents; and UNESCO, “Capacity building in basic sciences,” May 2023. Available at: https://www.unesco.org/en/basic-sciences-engineering/capacity

The information obtained and lessons learned from field research projects can advance our understanding of mCDR for a particular region at a given time period, which should lead to model improvements. Combining field projects and modeling studies not only can better quantify the efficacy and durability of mCDR, but also can address near-term as well as the “downstream” environmental and ecological effects. The syntheses of multiple field projects and different scales of modeling allow researchers and stakeholders to evaluate long-term (10 to 100 years) and global impacts. Refined models can be used to design the next level of mCDR projects with goals of optimizing the efficacy and minimizing the environmental and ecosystem risks (see also: Appendix B for more information on how these principles apply to modeling activities).

III.A. ADDRESS THE MATERIAL FOOTPRINT OF RESEARCH

III.A.1. Remove infrastructure, equipment, and other project materials.

mCDR research projects will often have a material footprint. This is particularly true of field trials which may require the installation of physical infrastructure or equipment in coastal areas, or the ocean. In some instances, these project materials might be viewed as a positive and left in place, for instance, where the local community agrees they can use infrastructure or equipment in other applications after the research is complete (see also Guideline III.C.1). More commonly, however, infrastructure and equipment will need to be removed at the conclusion of research. This may be due to legal requirements. For example, research permits might be issued subject to conditions requiring the removal of equipment at the conclusion of research. Even where not legally required, any harmful or burdensome remnants of research–such as unwanted or unsafe infrastructure, harmful materials, and obsolete equipment–should be fully removed at the conclusion of the project. While the project leads are ultimately responsible for doing the work of removal, and must build into its research plan the time and financial resources required to do that work, local communities and other stakeholders should be involved in the process. This could be achieved through co-design of decommissioning plans, following an approach similar to that set out in the project scoping and design section above.

III.B. DOCUMENT AND ADDRESS ANY ENVIRONMENTAL AND OTHER HARMS FROM THE PROJECT

As explained above, during project planning, mCDR researchers should identify and disclose any harms and risks associated with their proposed project. Researchers should be mindful that, given the limited scientific understanding of mCDR techniques, there are likely to be many unforeseeable consequences when it comes to harms and risks. As such, and consistent with the principle of reflexivity, researchers should regularly re-evaluate harms and risks, both during the conduct of the research project and at its conclusion. The potential for risks, harms and unforeseeable consequences can be significantly reduced by scaling research projects such that information gained in small scale experimentation can inform and de-risk research at the next appropriate level of scale. This way important knowledge is gained that allows safer conduct of research and growth of scale rather than conducting research far beyond the scale warranted by the knowledge and the validated, predictive models at hand.

III.B.1. Identify and document all environmental and other harms arising from mCDR research projects.

To ensure accountability and instill and enhance trust, researchers should consider appointing a review board or other independent body to identify and assess project-related harms. In some cases, the researchers themselves may be best placed to identify and assess harms, in which case appointment of an independent body may still be important to oversee and "check" the researchers' work. When identifying and assessing risks, researchers should be mindful of power imbalances, which could result in some groups experiencing harms that are not readily apparent or appear insignificant to outside groups. Given this, and consistent with the principles of inclusiveness, responsiveness and trust, researchers should engage with affected communities and other stakeholders to ensure comprehensive identification and assessment of harms.

III.B.2. Consider whether outcomes identified at the conclusion of a project were foreseen during the planning stage and, if not, how they were missed.

It is essential that researchers think critically about their review processes and identify potential gaps and/or limitations that may have resulted in foreseeable outcomes being missed. Researchers should similarly evaluate whether and why any foreseen outcomes were over or underestimated or otherwise manifested in different ways, for example by affecting a different or broader group of stakeholders.

III.B.3. Determine where there is the potential for ongoing adverse impacts after the conclusion of an mCDR research project and take steps to mitigate and manage those impacts.

Some harms associated with mCDR research may cease when the research project ends for example, damage to the seabed may stop when infrastructure installed on it is removed. Others, however, many continue to be felt for long periods after the research project concludes. In the latter case, researchers must comply with any applicable legal requirements, including with respect to reporting, monitoring, mitigating, and/or managing ongoing harms. This is an important component of accountability, but may not be sufficient by itself.

Under international law, each country has a "responsibility 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," including the high seas.[81] Countries have specific obligations to "protect and preserve the marine environment"[82] and "prevent, reduce, and control pollution" thereof.[83] Where there is imminent or actual damage, countries must notify those likely to be affected, and cooperate to prevent or minimize the damage.[84]

Project leads should work with appropriate legal authorities and others to ensure that the requirements imposed by international law are met. They should also consider what, if any, obligations they may have under applicable domestic law. And, as explained above, in order to uphold the principles of this code, project leads may need to go beyond minimum legal requirements, for example by addressing and compensating for harms even when not legally required to do so (see Guideline I.A.3).

III.B.4. Identify all those who have already been, or could in the future be, impacted by ongoing harms.

Those identified should, where practicable, be included in the planning and implementation of any remedial measures taken to address the harm and consent to the taking of those measures. The principle of reciprocity may also require those impacted to be compensated for harms suffered.

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81 Declaration of the United Nations Conference on Environment and Development, Principle 2, UN Doc A/CONF.151/26/Rev.1 (1992).
82 UNCLOS, Art. 192.
83 United Nations Convention on the Law of the Sea (UNCLOS), Art. 194.
84 UNCLOS, Art. 198–199

Various mechanisms for doing this have been proposed, for example via the establishment of compensation funds, insurance programs, or a more formal grievance management system[85] but they may require further investigation and development before being implemented. Existing, widely accepted principles of international law, such as the polluter pays principle, could help to inform the development of future compensation mechanisms.

III.C. IDENTIFY AND PROMOTE THE FAIR SHARING OF ONGOING BENEFITS FROM RESEARCH

III.C.1. Ensure ongoing equitable sharing of benefits, and accessibility of data after the conclusion of research.

Consistent with the principle of reciprocity, stakeholders and communities who felt the burdens of research should have ongoing access to benefits from it. Prior to the conclusion of a research project, those involved should consider how any community benefits could be sustained beyond its lifespan. The positive outcomes, either tangible/material, such as financial gains or infrastructure which a community could use after the research is complete, or intangible, such as knowledge and expertise, should continue to be distributed fairly after the conclusion of the project. For example, if material elements of research are ones that stakeholders identify as providing concrete benefits to them, arranging to have these transferred permanently to communities could contribute to good relationships. One way of respecting reciprocity and generating benefits for local communities or Indigenous communities who bore risks or burdens through the research process could be to vest some intellectual property rights with these communities.

Likewise, digital footprints of a project may also have value. This could include any data that were generated about a community or ecosystem that may benefit local planning processes unrelated to the research, such as in-depth ecological assessments or improved understanding of local ocean dynamics. To advance reciprocity, data should be shared with or transferred to local communities at the conclusion of a research project, and remain accessible for future use.

III.C.2. Evaluate outcomes against any benefit sharing plan that was developed for the project.

At the conclusion of a research project, those involved should transparently reflect and report on whether or how the objectives of any benefit sharing plan developed in the project scoping co-design phase were achieved. Additionally, accessible records of ongoing benefit-sharing activities and outcomes should be maintained, even after the research project concludes.

85 For a discussion of possible approaches for compensating those harmed by CDR projects, *see e.g.*, Clare Heyward, Benefiting from Climate Geoengineering and Corresponding Remedial Duties: The Case of Unforeseeable Harm, Journal of Applied Philosophy, Vol. 31, No. 4, 2014.

CONCLUSION

The principles outlined in this code of conduct are intended to direct mCDR research and the activities that support it in a manner that brings the most benefit to local communities and society as a whole. Unabated, climate change could have a devastating impact on global ecosystems and human populations. mCDR approaches have been proposed to limit these risks, and the impacts of mCDR should be contemplated in this context. However, the ecosystems and human populations that might benefit from a reduction in the risks of climate change will not be exclusively the same as those that are impacted by mCDR.

To reiterate, this work focuses solely on activities related to mCDR research. Should these early stage experiments prove safe, equitable, and effective at the test stage, additional principles may be required in advance of any effort to accelerate and grow these practices to the gigaton scale that is likely to be needed to achieve the target threshold of keeping planetary warming at or below 1.5ºC above pre-industrial levels.

As this work points out, it will be no easy task to implement just, inclusive, and equitable solutions with the urgency required to address the existential crisis of climate change. Yet the reality that a perfect solution is functionally impossible to achieve must not prevent us from striving to get as close as possible.

As such, what the authors hope to achieve in the creation of this code is a shared starting point for conversations that can inform action, facilitate inclusive dialogue, and make the pursuit of this set of potential climate solutions as effective as possible with the least amount of harm and greatest potential benefit to ecosystems and cultural practices and values. It is our belief that the investment of time and resources required to implement and adhere to these principles will pay dividends in the form of greater buy-in and support for projects that meet the criteria laid out herein, a more efficient pathway to functional testing and potential implementation of proposed mCDR practices, and minimization of the kinds of short-term and long-term negative unintended consequences that have too often been the result of even the most well-intended attempts to harness nature for the good of humanity.

As asserted at the beginning of this work, the principles laid out here represent a snapshot in time given today's understanding of the ecological and social landscape, the state of our changing climate, and the lack of adequate regulatory and governance structures that can provide mandatory checkpoints for pursuit of mCDR practices on sub-national, national, or international scales. Appendix A outlines the intention to continue to develop this code of conduct on a regular, ongoing basis, under the guidance of a diverse and inclusive set of reviewers so that it can serve as a living document to continue providing guidance that reflects the rapidly evolving state of scientific knowledge, social perspectives, and governance structures. This code is far from the last word on the topic.

APPENDIX A

What Comes Next?

One of the underlying reasons for producing this code of conduct is to create a framework for how mCDR practitioners can serve as responsible good actors in the absence of adequate governance structures or regulations. While each individual or entity's motivation for pursuing these activities will differ, it is highly likely that in the case of emerging practices in this field, the private sector will be eager to move quickly to respond to the demand for CDR. There is ample motivation both to take advantage of a ready flow of investment funding and demand for carbon sequestration credits and to address the looming existential threat of climate change. Inevitably, their ability to pursue solutions will outpace the ability of regulators to impose requirements suited to the activities in question. Furthermore, because scientific understanding of the implications, outcomes, and effectiveness of mCDR practices is developing rapidly, the guidance included in this code of conduct may become quickly outdated—though the fundamental principles on which the code is based are evergreen.

To ensure that the code of conduct's guidance remains relevant to all stakeholders even in the face of emerging understanding and actions, the Aspen Institute has designed this work to include a process for regular, ideally annual, review and updates to its content, though funding has not yet been made available to support this effort. The intent would be to allow for regular review of the code, with an open call for input from all stakeholders. Comments received would then be shared with an expert review board comprised of an inclusive group of individuals representing a diverse set of community leaders, Indigenous groups, mCDR practitioners, academic researchers, policy and governance experts, financial professionals, funders, and other stakeholders as appropriate. The initial group of reviewers would be selected by the Aspen Institute Energy & Environment Program's leadership in close consultation with the authors of this code of conduct, any other co-leading organizations, and other leaders in the relevant fields.

This group would put forth an open call for comments and updates that would remain open through Q1 2024. It would establish a timeline for consideration, deliberation, and development of a response to the comments received which would include the group's reactions to the comments, a set of updates to the code's recommendations, and rationale to justify the implementation or rejection of commenter concerns. A revised code of conduct, including an assessment of the review process itself would then be published in late fall of 2024.

APPENDIX B

How the Code of Conduct's Principles Could Apply to Modeling Activities

Modeling may initially appear to be outside the obvious realm of a code of conduct because it may not carry immediate or direct social and environmental risks. However, modeling provides the intellectual foundation for many aspects of mCDR which means that it can have long-term implications for both social and environmental outcomes. Decisions embedded throughout the modeling process shape what risks, harms, and benefits are visible for discussion by stakeholders. For instance, deciding what conceptual frameworks to use, how to parameterize variables, and which variables to include or exclude in the first place all radically shape both which types of positive or negative outcomes are considered and how the distribution of these is understood. Over time, model assumptions can 'lock in' particular ways of thinking about any given form of mCDR and could be used to systematically exclude alternate ways of thinking, along with potential risks, harms and benefits. Of central concern would be any intangible risks, harms or benefits, or any culturally specific considerations that elude straightforward model representations.

The following guidelines suggest some ways that modelers, funders, and model users could use the principles in this code of conduct to design and interrogate model-based mCDR research. However, as modeling research funding has not traditionally included such activities, for this to happen in the future, funders must ensure that adequate resources are available.

1. **Awareness of Power Imbalances:** It is essential to recognize that modeling decisions and outcomes can have significant implications for various stakeholders, including marginalized communities and nations (i.e., enabling or legitimizing certain types of mCDR activities in certain regions). Modelers, both in natural and social sciences, should actively seek to understand the historical and contemporary power imbalances that might influence modeling input assumptions and thus results. This awareness should guide efforts to mitigate potential biases and to ensure that the modeling process does not reinforce existing inequalities.

2. **Inclusiveness:** Bringing modelers and stakeholders into conversation, and engaging them in reflexive or situated modeling practices can increase the inclusivity of modeling activities. This can be done at different stages of the modeling process. Upstream input might involve using public engagement outcomes to inform future modeling efforts, for example by identifying societally relevant questions about mCDR that might be modeled in the future. Downstream input might involve bringing stakeholders and modelers together to discuss whether the model outputs have answered societally and scientifically relevant questions (i.e., to aid decision-making on mCDR activities). Inclusive processes ensure that diverse perspectives and knowledge types are considered during the development, implementation, and evaluation of models. Such inclusive and iterative engagement can contribute to more holistic and equitable modeling outcomes.

3. **Consent:** In the realm of modeling, seeking consent involves transparently communicating the objectives, methodologies, potential risks, and benefits of the modeling activities to all relevant stakeholders. This ensures that those who will be affected by the modeling results have a chance to provide input on the modeling assumptions and parameters. Modelers need to consider feedback from different stakeholder groups and provide model results under the different scenarios, and make modeling activities iterative.

4. **Reciprocity:** Modeling activities should acknowledge the relationships among stakeholders and foster a sense of obligation to consider their concerns and needs. The reciprocity principle suggests that if modeling activities (or the activities that may result from modeling activities) pose risks or burdens on certain groups, the benefits of the modeling outcomes (and resulting activities) should be commensurate and shared equitably. This consideration is particularly important when modeling has the potential to lead to activities which impact marginalized communities disproportionately. Modeling activities should be considered at the very beginning of any field experiments and modelers need to know who the stakeholders are and what their values, needs and concerns may be.
5. **Reflexivity:** Modelers should critically reflect on their own assumptions, biases, and value systems that shape the design and interpretation of models. Reflexivity also extends to recognizing the historical and contemporary power dynamics that shape the modeling process and underlying assumptions of different models. Transparently sharing underlying assumptions and engaging in open dialogues with stakeholders can enhance reflexivity in modeling activities.
6. **Responsiveness and Trust:** Trust is built through repeated demonstrations of respect for and responsiveness to the values, concerns and feedback of stakeholders as modeling activities progress. Modelers should actively consider and address the concerns raised by diverse stakeholders, adapting the models and their assumptions as needed.
7. **Accountability:** Modelers, researchers, and funders all have obligations beyond themselves, including to communities, the public, future generations, and non-humans. Accountability mechanisms should be established to ensure that modeling activities are conducted with transparency and integrity. This may involve formal agreements, stakeholder advisory councils, and ongoing efforts to share information on modeling inputs and outputs with a wide range of stakeholders. All models and model results need to be well documented and shared with the public.
8. **Anticipation and Precaution:** Anticipation is inherent to modeling, which involves envisioning potential future scenarios and their implications. However, modelers should also attempt to anticipate the potential (intended and unintended) consequences of their modeling outcomes themselves. Precautionary measures should be taken when there are uncertainties about the potential impacts of modeling outcomes (i.e., when environmentally or socially damaging mCDR activities may be enabled through modeling results). This principle encourages researchers to consider worst-case scenarios and to take steps to prevent or mitigate environmental or societal harm that may arise from their modeling results.

APPENDIX C

Definitions of Categories of Actors

The following table defines terms used in this code of conduct to refer to various groups of individuals or organizations and their roles in mCDR projects.

Funders or Research Funders	Organizations or individuals that support the research either financially or through in-kind resources. These may include governments or other public funders, philanthropists, foundations or charities, or academic institutions.
Indigenous communities	Indigenous communities would include those who self-identify as such, typically based on having a continuous historical continuity with pre-colonial and/or pre-settler societies, a strong link to territories, and distinct social, economic and/or political systems.[86]
Local Communities	Communities that might be directly impacted by the research activity, who may be represented by local community organizations, or local governments.
Project Leads	Individuals or organizations who have or continue to contribute to decision-making obligations in any given mCDR effort, including researchers, practitioners, regulators, funders, and others.
Research Ecosystem or Research Communities	Inclusive of all Research and Researcher categories on this list, and particularly organizations that may not be actively involved in the research, but which might facilitate or prevent research activities, for example, NGOs or regulators.
Research Organizations	Organizations that employ researchers or with which researchers are affiliated. Examples could include academic institutions (universities or research laboratories), private companies, or public sector organizations.
Research Projects or Research Activities	mCDR research activities, planned, executed, or competed by a research organization or other entity.
Researchers	Individuals conducting research. They could be working within an academic research organization, but may also be employed in private or public sector organizations.
Stakeholders	Persons or organizations with interest in the outcomes of a research project.

86 See also: United Nations Permanent Forum on Indigenous Issues, "Indigenous Peoples, Indigenous Voices Factsheet," available at: https://www.un.org/esa/socdev/unpfii/documents/5session_factsheet1.pdf

AUTHOR BIOS

DR. MIRANDA BOETTCHER is a Research Associate at the German Institute for International and Security Affairs (SWP) in Berlin, Germany and an Adjunct Assistant Professor in the Environmental Governance Section at the Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands. She additionally coordinates the Carbon Removal Working Group of the Earth System Governance Climate Taskforce, and is a member of the UN GESAMP Working Group 41 on Ocean Interventions for Climate Mitigation.

DR. FEI CHAI is a Chair Professor at Xiamen University in China, and a Professor Emeritus at University of Maine in the United States. He studies physical and biological processes contributing to global carbon cycle, ocean-based CDR, open ocean and coastal hypoxia, and climate variability affecting marine ecosystems and fisheries. He is a member of the Organizing Committee for Exploring Ocean Iron Solutions.

MICHAEL CONATHAN is a Senior Policy Fellow, Ocean & Climate with the Aspen Institute Energy & Environment Program.

DR. SARAH COOLEY is the Director of Climate Science at Ocean Conservancy. She was a Coordinating Lead Author on Working Group II of the IPCC's 6th Assessment Report, and chapter author on the 5th National Climate Assessment.

DR. DAVID KELLER is a senior scientist in the Marine Biogeochemical Modelling Department at the GEOMAR Helmholtz Centre for Ocean Research in Kiel, Germany. His research expertise and interests include the assessment of carbon dioxide removal approaches for climate change mitigation, understanding feedback between biogeochemical cycles and the climate, and investigating interactions between marine ecosystems and biogeochemical cycles.

DR. SONJA KLINSKY is an Associate Professor at the School of Sustainability, Arizona State University. Her research focuses on the justice dilemmas embedded in climate change and climate change policy.

DR. JAVIER LEZAUN is Director of the Institute for Science, Innovation and Society (InSIS) and Professor in the School of Anthropology at the University of Oxford. He studies the governance of emerging technologies, including new approaches to carbon sequestration.

DR. PHIL RENFORTH is a Professor of Carbon Dioxide Removal at Heriot-Watt University, and has led research projects exploring the feasibility of ocean alkalinity enhancement.

DR. MICHELLE SCOBIE is a Professor at the Institute of International Relations at The University of the West Indies in St. Augustine, Trinidad and Tobago. Her research interests include small island developing states' perspectives on global environmental governance issues, international law, environmental justice, ocean, and climate governance.

ROMANY M. WEBB is the Deputy Director of the Sabin Center for Climate Change Law, a Research Scholar at Columbia Law School, and an Adjunct Assistant Professor of Climate at Columbia Climate School.

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