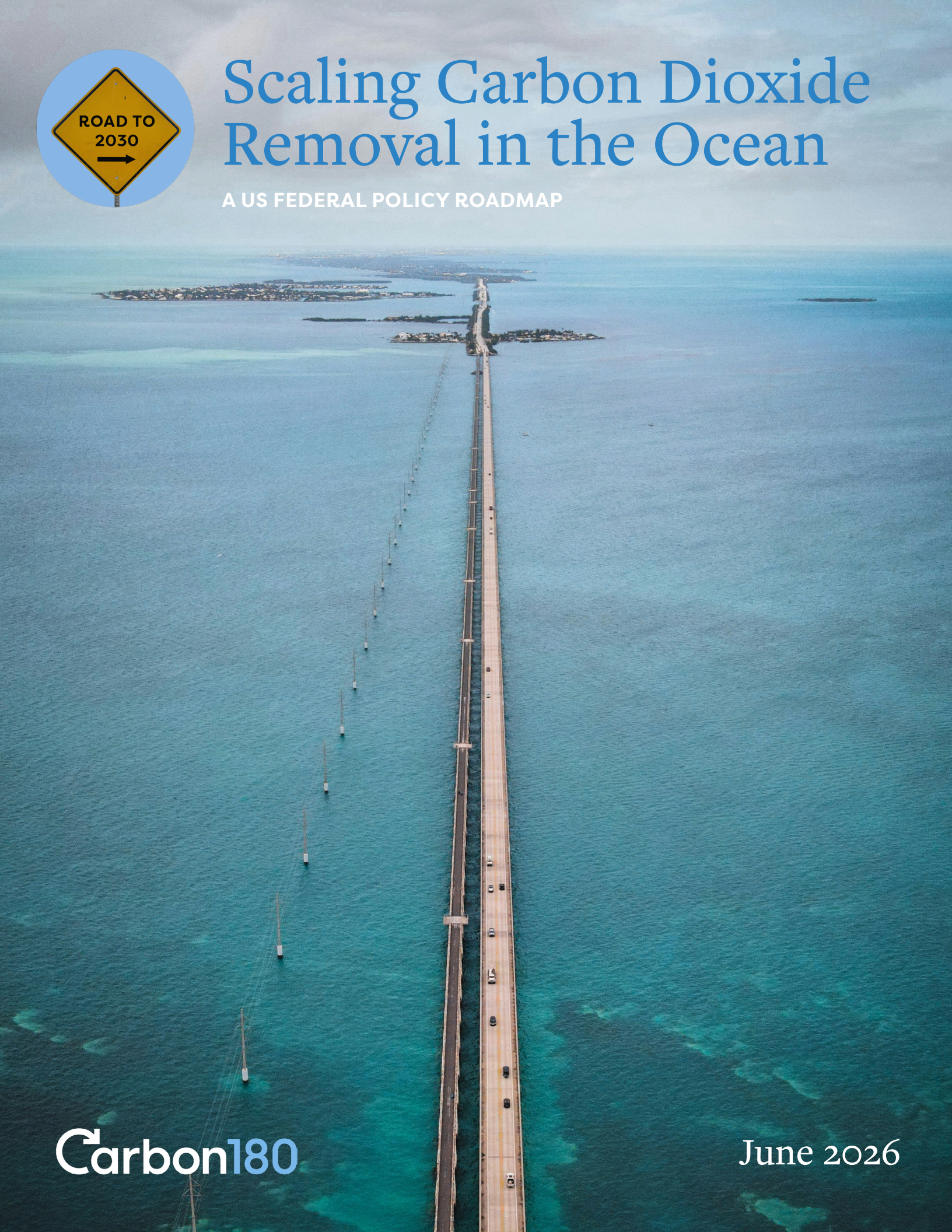

Scaling Carbon Dioxide Removal in the Ocean

A US FEDERAL POLICY ROADMAP

Carbon180

June 2026

ABOUT CARBON180

Carbon180 is a climate NGO with a vision to remove legacy carbon emissions from the atmosphere and create a livable climate in which current and future generations can thrive. Based in Washington, DC, we design and champion equitable, science-based policies that bring carbon removal solutions to gigaton scale.

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To learn more about any of the recommendations in this report, email ocean@carbon180.org.

CITATION

Aguilera-Peterson S., Vieillard A. (2026). *Ocean Policy Roadmap*. Carbon180.

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Introduction & Overview

Introduction

The US has built the world's leading marine carbon dioxide removal (mCDR) field, but we are now at risk of losing that lead. And as a nation, we have championed a safe, responsible, and economically transformative mCDR industry; however, the decisions we make over the next few years will determine whether we remain a global leader or lose that opportunity.

The scientific community recognizes that, alongside rapid emissions reductions, the world will need 5–10 gigatons (GT) of carbon dioxide removal (CDR) annually by 2050 to meet global carbon dioxide targets.[1] The ocean is the planet's largest carbon sink and is one of our greatest and most underutilized tools for addressing climate change. mCDR includes a suite of approaches that use the ocean's natural ability to pull carbon dioxide (CO_2) out of the atmosphere and store it.

Credible estimates put mCDR's share of total CDR potential at roughly one-third.[2] Depending on the approach, mCDR can also deliver environmental and social benefits such as ocean de-acidification, coastal resilience, ecosystem restoration, and new economic opportunities for coastal communities and maritime industries. But realizing this potential will require urgent action. To scale responsibly, the field needs sustained investment in research and development (R&D), stronger scientific understanding of environmental and economic impacts, broader public engagement, and clear governance and regulatory frameworks. These foundational conditions will enable the field to safely advance first to megaton (MT) scale, with our interim goal of all CDR pathways reaching 30 megatons of carbon removal per year by 2030 in the US, working toward the ultimate goal of reaching gigaton scale by 2050.

By 2024 the US held roughly 60% of the global mCDR market, built largely on early US federal support that encouraged private investment, created high-quality jobs, and provided new environmental and economic benefits for coastal communities.[3] By 2032, the industry is projected to be worth nearly $2.4 billion and support more than 40,000 jobs.[3,4] But federal investment in mCDR fell from over $30 million in 2023 to roughly $11 million in FY26.[5] Other countries are not slowing down. The UK, the EU, China, Singapore, Canada, and others are all investing in mCDR. Without immediate federal

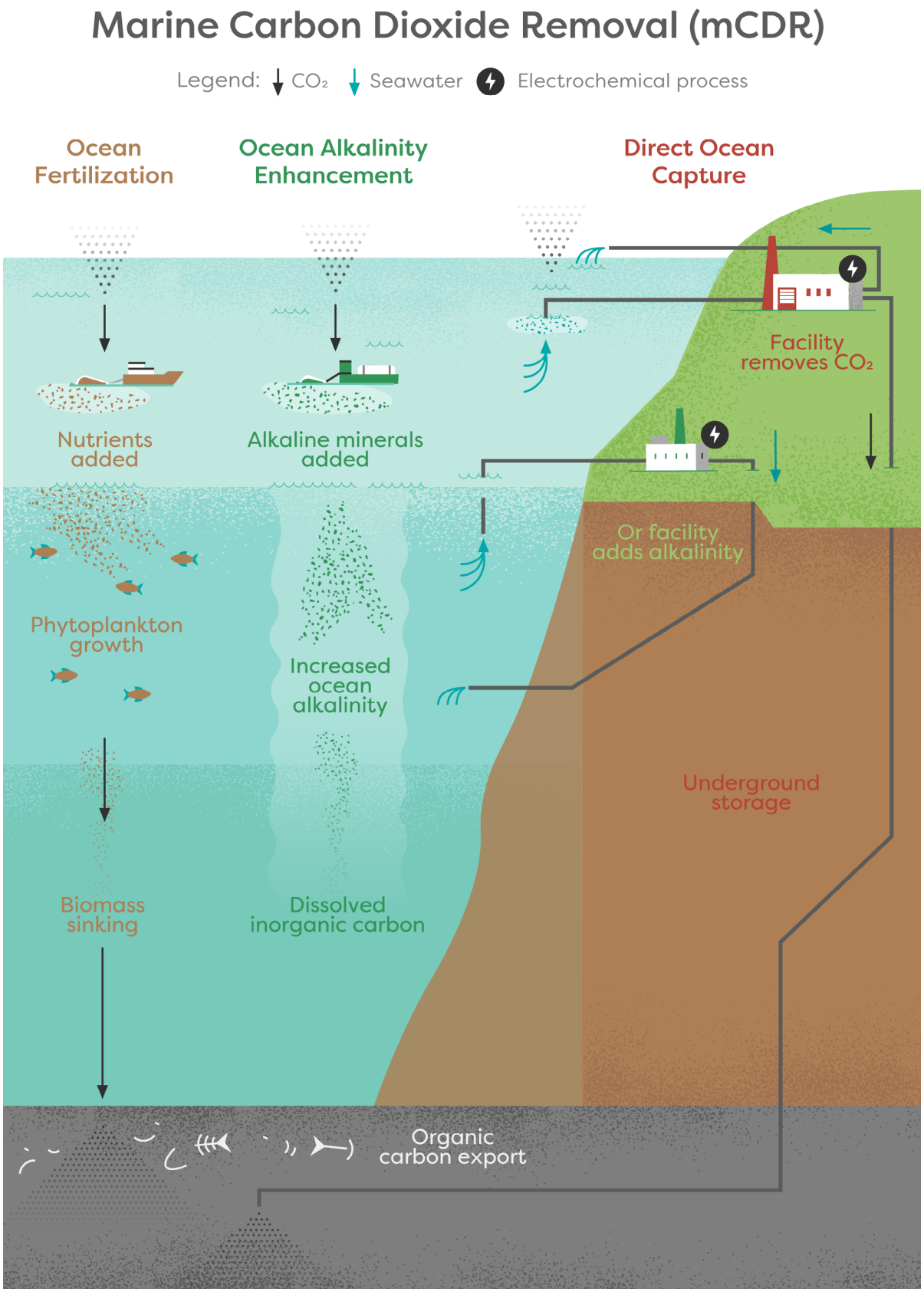
action, the US risks ceding both economic and strategic advantages in a field it helped pioneer.

This roadmap is grounded in a simple principle: mCDR must scale responsibly, or it should not scale at all. Any intervention that could affect ocean ecosystems or coastal communities must be approached carefully, transparently, and with strong accountability.[6] Because the field is still young, there is also a unique opportunity to put community voices at the center from the start. If mCDR is to fulfill its promise as a meaningful climate and economic opportunity, it must first earn trust at the local level while building the scientific and policy foundation needed for long-term success.

FIGURE 1: SELECT MARINE CARBON DIOXIDE REMOVAL PATHWAYS

Direct Ocean Capture	Removing CO_2 directly from seawater via either electrolysis or electrodialysis. The seawater is then returned to the surface ocean where it can absorb more CO_2 from the atmosphere.
Ocean Alkalinity Enhancement	Increasing seawater alkalinity (increasing pH) to allow for more CO_2 absorption by the surface ocean and conversion to long-term storage as dissolved bicarbonate. This can be achieved by mineral additions or electrochemical methods.
Ocean Fertilization	Increasing the concentration of specific micronutrients (usually iron) in the surface ocean to allow for enhanced phytoplankton growth and increased carbon export to the deep ocean.

FIGURE 2: MARINE CARBON DIOXIDE REMOVAL APPROACHES ADVANCED BY THIS ROADMAP



Overview

The Opportunity

Policy action and federal investment in mCDR research, development, coordination, and governance place the US at the forefront of this field.

Without them, both science and the market move offshore. The federal government has a long and deep-seated interest in ocean research, monitoring, technology development, and policy across agencies such as the National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), Department of Energy (DOE), Navy, and more.[7] As a result, strong federal coordination and policy action are critical to advance a new ocean-based industry like mCDR.

Early federal policy drove mCDR's momentum in the United States. In 2020, Congress directed the Department of Energy (42 U.S.C. § 16298e) to assess the potential for mCDR. A few years later, the White House US Ocean Climate Action Plan highlighted the potential for ocean-based climate solutions to benefit the US and global community, and identified mCDR as a top priority for the nation. A Fast Track Action Committee on mCDR then released The National Marine Carbon Dioxide Removal Research Strategy, which laid out a visionary plan for advancing a responsible, science-based mCDR industry across the nation.

In 2023 alone, mCDR secured investments across the federal government including, $36 million at the DOE for its Sensing Exports of Anthropogenic Carbon through Ocean Observation (SEA-CO_2) program at ARPA-E, $24.3 million at the National Oceanographic Partnership Program (NOPP, supported by NOAA, DOE, ONR, NSF, and ClimateWorks Foundation), expanded activities and research within the NOAA Ocean Acidification Program, DOE's Fossil Energy and Carbon Management and Water Power Technologies offices, and NSF. As of April 2026, the Environmental Protection Agency (EPA) has issued two Marine Protection, Research, and Sanctuaries Act (MPRSA) research permits and three National Pollutant Discharge Elimination System (NPDES) permits for mCDR research and pilots, and US Army Corps of Engineers (USACE) has issued several dredge

and fill permits for mCDR activities such as beach nourishment and coastal ocean alkalinity enhancement (OAE) field trials. With these investments, the field has been able to collect data on environmental impacts, with preliminary results showing little to no impact to the ecosystem or natural resources.[8] These permitted activities also have demonstrated examples for continuous community engagement and partnership co-development for mCDR projects.

This progress is now under threat. Federal investment in mCDR is waning. Without immediate action, the window for US leadership in mCDR technological innovation and industry leadership will begin to close. Countries across the globe, from the UK to the EU, China, Singapore, Canada, and more, are exploring and investing in mCDR. The US needs to write the policy, fund the R&D, and support the permitting and governance structures that will allow the field to advance responsibly and in the best interests of Americans.

The Challenge

Even as mCDR represents an exciting opportunity, the field also faces significant barriers. mCDR sits at the intersection of a promising climate solution, an ocean-economy opportunity, and substantial scientific and governance uncertainty.

This uncertainty is rooted in the foundational questions that remain about environmental impacts, efficacy, and durability — especially in the open ocean, where carbon flows are difficult to track and model.

The ocean environment also presents additional measurement, monitoring, reporting, and verification (MMRV) challenges: detecting and attributing carbon removal in a dynamic ocean system requires new and improved sensors, expanded observing infrastructure, and validated models capable of tracking diffuse signals over long timescales.

Non-technical barriers are just as heavy. mCDR does not yet have a broad social license, with calls for stronger environmental assessments, transparency, and community co-development, particularly around shared benefits and community consent. Further deployment is constrained by high costs, limited infrastructure, energy demands, and regulatory gaps.

What is MMRV?

Measurement, monitoring, reporting, and verification (MMRV) is the process used to track, document, and validate the performance and impacts of mCDR interventions. It ensures that key outcomes are measured accurately, reported transparently, and verified through independent review. MMRV includes monitoring and measuring environmental impacts, as well as tracking carbon removal.

Measurement involves quantifying key variables at a given point in time, using methods such as field sampling, laboratory analysis, or remote sensing.

Monitoring involves collecting data over time to track key variables, using tools like ocean variable measurements, sensors, or remote sensing.

Reporting presents that data in a standardized, transparent format, often for regulators, stakeholders, or the public.

Verification is the independent review of the reported data to confirm its accuracy and credibility.

Early-stage technologies depend on in-water tests, which are costly and hard to permit under current frameworks. Overall, governance frameworks for mCDR remain fragmented, and uncertainty persists as US mCDR oversight spans multiple agencies with overlapping jurisdictions.

The voluntary carbon market is immature, and premature crediting could undermine credibility before the field has a chance to earn it. While private sector investment in mCDR has accelerated rapidly, federal funding has not kept pace, with private investment more than double the combined contributions of philanthropic and public funding for mCDR to date.[9] This imbalance shows the need for independent, publicly accessible mCDR R&D to validate claims, reduce uncertainty, and fill critical knowledge gaps that private actors alone are not positioned to resolve.

These challenges are happening alongside competing ocean priorities like conservation, fisheries, national defense, and economic uses. Scaling mCDR responsibly will require coordinated policy, sustained public investment, and robust safeguards to ensure environmental integrity, scientific credibility, and public trust.

Section Two:

Policy Recommendations

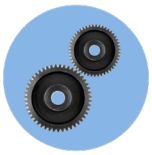
Policy Recommendations

This roadmap outlines approaches to advance three mCDR pathways: ocean alkalinity enhancement (OAE), direct ocean capture (DOC), and ocean fertilization (OF). The following recommendations address the five conditions that mCDR needs to scale responsibly:

Understanding Environmental Impact

Confirming Efficacy & Durability

Building Social License



Establishing Scaling & Deployment

Enabling Responsible Commercialization

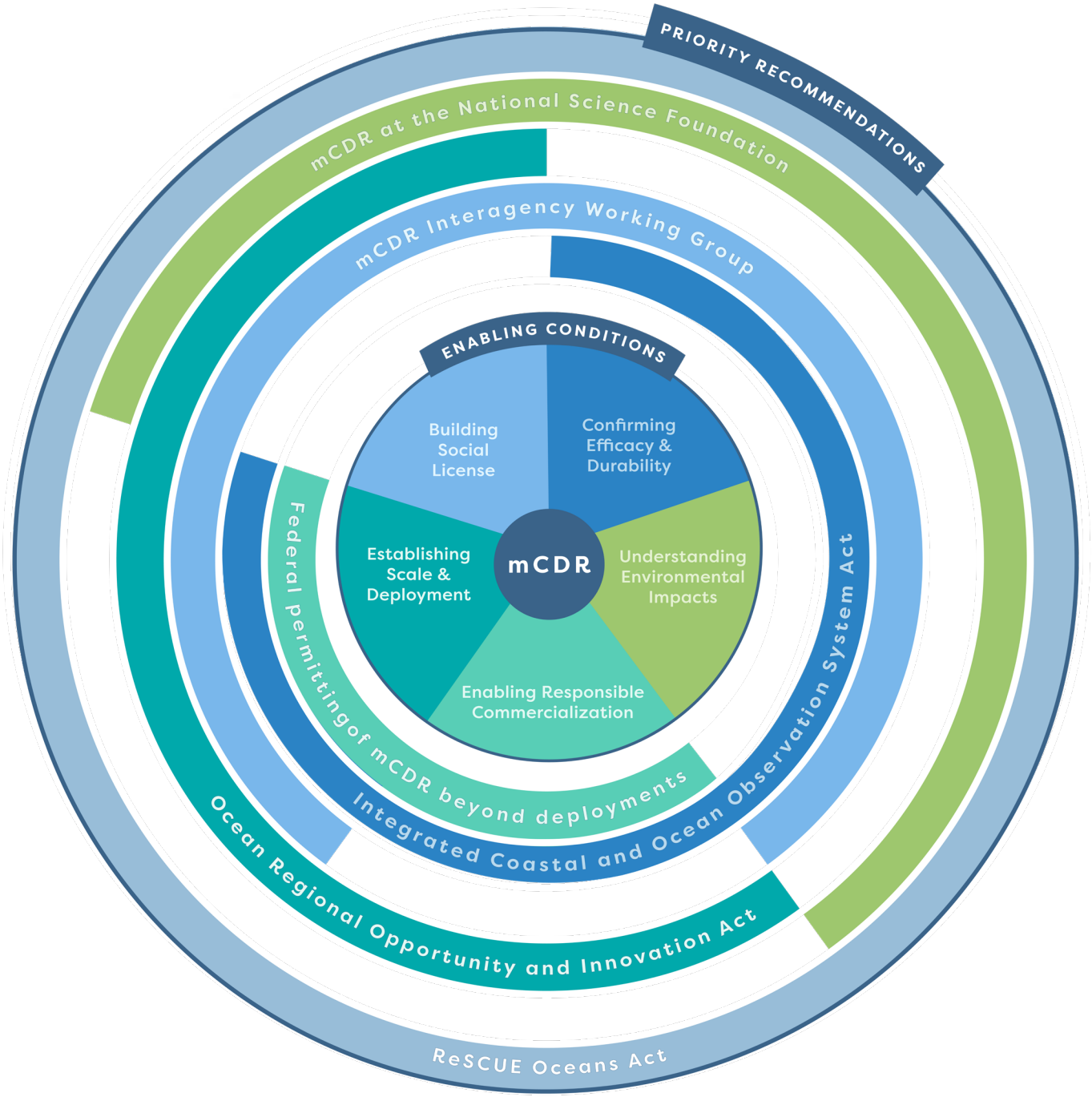
High-Level Recommendations

Priority recommendations to fill mCDR's most pressing policy needs

ENABLING CONDITION	RECOMMENDATION
Crosscutting	Pass the ReSCUE Oceans Act
Understanding Environmental Impact	Fund mCDR at the National Science Foundation via Appropriations
Confirming Efficacy & Durability	Reauthorize the Integrated Coastal and Ocean Observation System Act
Building Social License	Support the mCDR Interagency Working Group
Establishing Scaling and Deployment	Reintroduce the Ocean Regional Opportunity and Innovation Act
Enabling Responsible Commercialization	Conduct a GAO review of potential mCDR permitting pathways, jurisdictions, and statutory authorities

Each section highlights a priority recommendation with the greatest potential impact, alongside additional actions to strengthen the mCDR field in the US. Each of the supporting recommendations can be implemented with or without its preceding priority recommendation. Our policy wheel shows, at a glance, how our recommendations work across more than one enabling condition.

FIGURE 3: MCDR POLICY WHEEL



Cross-cutting Recommendations

Given how fast the field is moving in the private sector and abroad, federal policy that can address or lay the foundation for multiple enabling conditions at once will be most impactful — so policy is not playing catch-up to industry, and the US isn't playing catch-up to the global market.

The five enabling conditions to advance responsible mCDR can be tackled individually — targeting environmental impact, as well as efficacy and durability, before addressing scaling and deployment, and eventually commercialization. Or they can be addressed in tandem through these crosscutting recommendations.

Priority Recommendation: Pass the ReSCUE Oceans Act.

The Removing and Sequestering Carbon Unleashed in the Environment and Oceans Act (ReSCUE Oceans Act) is the **first-ever bill dedicated exclusively to mCDR**.

This bipartisan, bicameral bill lays the groundwork for advancing the research, development, and federal coordination needed to responsibly scale mCDR. The ReSCUE Oceans Act is a comprehensive bill that addresses all of the mCDR enabling conditions described in this roadmap. Among its many actions, the Act creates a focused mCDR program at NOAA, which will evaluate the **environmental impact** of mCDR as well as work to better understand **efficacy and durability** and advance MMRV.

The Act helps build **social license** by implementing a code of conduct, funding engagement and consultation, and developing publicly available data management systems. It lays the **foundation for scaling and deployment**, through research for demonstration, investing in mCDR monitoring instrumentation and infrastructure, designating research areas, and developing a mCDR workforce. It sets up the mCDR field for eventual successful responsible **commercialization** by standardizing materials, measurements, data, and models to accelerate innovation in and validate mCDR performance.

Passing the ReSCUE Oceans Act is the **single most impactful step** Congress can take for mCDR right now.

Supporting Recommendation 1: Fund mCDR at NOAA.

NOAA brings research programs, vessels, satellites, science centers, laboratories, and a vast pool of distinguished scientists and experts to mCDR. The agency is well-positioned to responsibly advance safe and effective mCDR at speed and scale. Congress should annually provide to NOAA through appropriations not less than $25 million to support mCDR research, development, and demonstration, including field trials. In doing so, Congress should encourage the Administration to collaborate with relevant agencies when carrying out this work. NOAA should direct most of the funding to the NOAA Ocean Acidification Program, which leads the agency's mCDR efforts. Other NOAA programs important to mCDR, which can benefit from mCDR appropriations, include funding ocean observing infrastructure for mCDR MMRV through the Global Ocean Monitoring and Observing (GOMO) Program and the US Integrated Ocean Observing System (US IOOS), funding mCDR in-water testing at the Pacific Marine Environmental Laboratory (PMEL), and funding mCDR modeling at the Geophysical Fluid Dynamics Laboratory (GFDL).

Funding at NOAA can improve environmental and ecosystem responses to mCDR and can help us better understand mCDR efficacy, durability, measurability, magnitude, and additionality. NOAA plays an important role in understanding social and economic impacts and co-benefits of mCDR, and in producing transparent sharing of data from federally funded research efforts. Appropriations to NOAA should also be used to develop recommendations for which mCDR approaches may be safe and effective for larger-scale deployment, and should be used to develop MMRV best practices. NOAA leadership in mCDR is imperative for all stages of scaling mCDR, from laboratory and mesocosm studies to modeling, to working with communities for in-water testing, and for data sharing and ocean planning when mCDR reaches commercialization.

Supporting Recommendation 2: Support Regional Ocean Partnerships in fostering regional mCDR collaboration among ROPs and among ROP stakeholders.

Regional Ocean Partnerships (ROPs) are voluntary, governor-led organizations to foster collaboration between states, federal agencies, Tribes, and ocean users. ROPs include the

Northeast Regional Ocean Council, the Mid-Atlantic Regional Council on the Ocean, the West Coast Ocean Alliance, and the Gulf of America Alliance. In regions where a formal ROP does not exist, such as Alaska, the Southeastern US, and the US territories, the IOOS Regional Associations serve the role of a ROP. Congress should fund through appropriations the ROPs with an additional $4 million, and provide the IOOS Regional Associations acting in the ROP capacity with an additional $3 million through appropriations for mCDR collaboration. NOAA should support the ROPs with in-kind resources to foster mCDR coordination and leverage existing relationships and networks to build mCDR with a community-led and public-trust approach. ROPs that are well resourced for mCDR play important roles in sharing the data and findings of basic research on mCDR environmental impact and efficacy and durability, for using their networks for building social license, and for co-developing deployments at scale and commercialization projects with coastal communities.

Understanding Environmental Impact

The environmental impacts of mCDR remain one of the most significant and least resolved areas of uncertainty in the field.

While some approaches may offer co-benefits such as mitigating local ocean acidification or enhancing coastal ecosystems and fisheries, others could pose risks to marine food webs, nutrient cycles, and biodiversity, including commercially and culturally important and endangered species. While progress has been made, these impacts are not sufficiently understood to support large-scale deployment.

Our policy recommendations prioritize foundational, independent research to assess ecosystem responses across different geographies and timescales, including impacts to higher trophic level species as well as cumulative and long-term effects. Building this evidence base is essential to determine which, if any, mCDR approaches are environmentally safe, effective, and appropriate to pursue.

Priority Recommendation: Fund mCDR at NSF.

NSF supports basic science for mCDR through the Directorate for Geosciences (GEO), which works to advance and revolutionize research, expand educational opportunities, oversee vital infrastructure, and build partnerships across the geosciences and beyond. Congress should **annually provide through appropriations not less than $49.5 million to NSF** to support meritorious research into mCDR technologies and approaches. Congress should also reinstate full operational funding for the Ocean Observatories Initiative (OOI) and support the US Academic Research Fleet (ARF) in the NSF Scientific Facilities and Instrumentation line item.

Funding the NSF Directorate of Geosciences supports the basic science that the rest of the field depends on. It builds the foundational ocean research and MMRV methodologies to ensure that the field advances in a way that is grounded in the best available science and with the most cutting-edge, American-led technology.

Supporting Recommendation 1: Create a NOPP mCDR 2.0 Call.

The National Oceanographic Partnership Program (NOPP) facilitates partnerships among federal agencies, academia, and industry to advance ocean science research and education. Through this collaboration, agencies can leverage resources to invest in priorities like mCDR that fall between agency missions or that are too large for any single agency to support. In 2023, NOPP catalyzed mCDR R&D through a $24.3 million partnership, which supported 17 mCDR projects with partners from 47 institutions. Given the resource-limited environment many of the agencies are currently facing, now is the prime time to pool resources and assemble public-private partnerships to meet mutual goals. FY26 appropriated $10.5 million to NOAA for mCDR, $500,000 of which was specifically directed to be used by NOAA within NOPP.[5] Other agencies, such as DOE, NSF, the Navy, and NASA, have engaged in NOPP for decades, and should now partner with NOAA and other non-governmental organizations to pull the FY26 appropriated resources towards the greatest needs for mCDR R&D. Through a co-developed Broad Agency Announcement (BAA), a NOPP mCDR 2.0 can ensure the appropriated dollars are spent and further advance the most critical mCDR research priorities.

Supporting Recommendation 2: Reauthorize the National Oceanographic Partnership Program through the National Defense Authorization Act.

Authorized in 1997 in the National Defense Authorization Act (NDAA) (10 U.S.C. § 8931) and reauthorized in the 2021 NDAA (10 U.S.C. § 8932), the continuation of NOPP is an excellent opportunity for ocean and mCDR innovation through public-private partnerships. Congress can provide specific direction for interagency coordination and public-private partnership development by directing NOPP to include mCDR R&D as a specific focus of its annual activities. Given the nature of mCDR research being costly, dependent on sensor and technological development, and meeting multiple agency missions, such a codified direction will accelerate the field and ensure that mCDR public-private partnerships are prioritized. This language also incentivizes US industry and non-governmental organizations to invest in mCDR R&D, furthering the impact of publicly invested dollars.

Confirming Efficacy & Durability

In parallel with environmental questions, uncertainties remain around whether mCDR approaches can reliably remove atmospheric CO_2 and store it on climate-relevant timescales.

Questions of efficacy, additionality, and durability are especially complex in ocean systems, where carbon flows are diffuse and difficult to measure. Robust investment in research, development, and demonstration is needed to validate which approaches can deliver real, measurable, and long-lasting carbon removal, and under what conditions. Without this evidence, it will be difficult to establish credible MMRV systems or to support responsible inclusion of mCDR in climate policy and carbon markets.

Priority Recommendation: Reauthorize the Integrated Coastal and Ocean Observation System Act.

The Integrated Coastal and Ocean Observation System Act of 2009 (33 U.S.C. §§ 3601–3610) establishes a National Integrated Coastal and Ocean Observation System. Now, the US Integrated Ocean Observing System (IOOS), it is a network that provides critical data and tools for many ocean uses, including climate monitoring and mCDR measurement and monitoring. From sensor development to autonomous systems to modeling testbeds, the ICOOS Act provides the fundamental ocean observation system that the full mCDR industry relies on. **Reauthorization could include specifications of programmatic foci onto mCDR explicitly**, such as calling out for mCDR MMRV among other priority areas, developing federally recognized protocols for monitoring mCDR, maintaining interoperable mCDR public datasets, creating a mCDR national observing MMRV program to easily find and use essential mCDR variables such as total alkalinity, dissolved inorganic carbon, pH, dissolved oxygen, nutrient fluxes, etc.

Supporting Recommendation 1: Fund mCDR at NASA.

NASA supports cutting-edge research to advance Earth science, including climate, the

Sun, the solar system, and the larger universe. Congress should annually provide through appropriations not less than $4.9 million to NASA to support research and remote sensing development to understand the efficacy and impacts of mCDR, particularly through Earth Science missions. Congress should direct NASA to enhance its monitoring and modeling programs to incorporate relevant data for mCDR. Funding at NASA would leverage the agency's exceptional observational capacity to accelerate learning in understanding mCDR efficacy and impacts to retain US leadership, competitive advantage, and to empower American coastal economies.

Supporting Recommendation 2: Reauthorize the Federal Ocean Acidification Research and Monitoring (FOARAM) Act.

The Federal Ocean Acidification Research and Monitoring (FOARAM) Act of 2009 (33 U.S.C. §§ 3701–3708) was previously reauthorized in the Coastal and Ocean Acidification Research and Innovation Act of 2021 (33 U.S.C. § 3701 note). FOARAM authorizes critical ocean acidification research at NOAA and through the interagency. In a reauthorization, it could mandate the mCDR efforts that currently exist within the NOAA Ocean Acidification Program (OAP), and further expand that program to focus on mCDR MMRV.

Supporting Recommendation 3: Leverage existing capabilities to improve mCDR MMRV.

mCDR MMRV R&D includes a wide variety of technically demanding needs, including sensor technology and in-situ measurement, biogeochemical and Earth system modelling, establishing baselines and quantifying additionality, ocean observational infrastructure, and transparent and open data management systems. Agencies have existing datasets, capabilities, and networks, which can be leveraged to improve mCDR MMRV. Congress, DOE, NOAA, NSF, and NASA should invest in new mCDR MMRV capabilities, leverage or modify existing capabilities to serve mCDR MMRV needs, and strengthen existing MMRV systems. There is also potential for other agencies to expand programs to support mCDR MMRV. For example, USACE should expand the Army Engineer Research and Development Center (ERDC) R&D portfolio to include mCDR MMRV methodologies. Federal actions focused on MMRV will set mCDR on a path toward transparent and trusted procedures.

Building Social License

mCDR is still unfamiliar to most of the public and does not yet have a strong social license to operate.[10]

Responsible development requires proactive public education, transparency, and community participation, particularly with those most directly affected by ocean interventions. This includes real consultation, respect, and attribution for Indigenous knowledge systems, and co-development processes that center community priorities. Building social license produces better research and deployment outcomes by incorporating broad perspectives early. Without this foundation, efforts to scale mCDR risk facing opposition, delays, or unintended harms.[6]

Priority Recommendation: Support and strengthen the mCDR Interagency Working Group (IWG).

Like many ocean topics, mCDR touches the authorities and jurisdictions of many federal agencies. Advancing independent research, scaling mCDR responsibly, promoting transparency, and building public trust all require crosscutting federal policy. Policy vehicles that engage multiple agencies or address multiple barriers to mCDR implementation will be the most effective and impactful at building the field.

Congress should establish in law the mCDR Interagency Working Group under the Ocean Policy Committee (10 U.S.C. § 8932) Subcommittee on Ocean Science and Technology (OST). The IWG should be led by NOAA and DOE, and include representatives from at least USACE, NIST, BOEM, BSEE, USFWS, USGS, BIA, State, EPA, NSF, Smithsonian, ONR, the Navy, USCG, USDA, CEQ, and OSTP.

The IWG should coordinate mCDR research, develop and implement a mCDR code of conduct, provide recommendations for scaling responsible, safe, and effective mCDR operations, and ensure public accessibility and usability of federally funded mCDR data.

What do we mean by *community*?

Community can be an expansive term that incorporates groups of individuals who share a common identity, which can include geographic location, government representation, labor occupation, cultural and ethnic backgrounds, values, and/or common interests. Communities often have their own definitions of themselves, and are composed of many distinct groups with historical dynamics and power differentials.

Supporting Recommendation 1: Develop and implement a mCDR code of conduct.

NOAA and DOE should work with other agencies and non-governmental organizations to develop and implement a 'mCDR code of conduct.' This code of conduct will help build and maintain public trust and will hold developers accountable to a clearly articulated high standard for mCDR activities. The code of conduct should apply to all stages of mCDR development, from laboratory research to in-water testing to at-scale deployment. The code of conduct should address social, ethical, public safety, and environmental considerations, and be shaped by extensive public input. The agencies can pull from existing materials and scientific literature, which have circulated notions regarding mCDR codes of conduct.[11,12] NOAA and DOE should revisit the code of conduct no less than every two years.

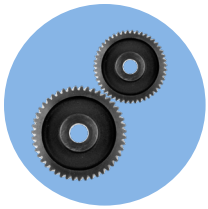
Supporting Recommendation 2: Develop accountability channels for federally funded mCDR efforts.

Agencies funding mCDR efforts should include opportunities for grantees to develop agreements (e.g., community agreements, good neighbor agreements, etc.) outlining how projects will deliver local benefits. Federal funding for mCDR should always include a mechanism for advancing responsible mCDR, through mechanisms like data-sharing standards, adherence to a mCDR code of conduct, community-led monitoring efforts, and engaging with communities prior to engaging with corporations or multilateral stakeholders.[13]

Supporting Recommendation 3: Direct ocean education programs to include mCDR.

Ocean education is included in numerous agency portfolios as it drives technological

innovation and discovery, strengthens public understanding and engagement in how to best protect and best use ocean resources, and provides a foundation for the nation's growing ocean-based workforce. Agency ocean and environmental education programs should feature the fundamentals of mCDR, including the wide diversity of approaches, what constitutes responsible mCDR, and the potential impacts and benefits of mCDR. Programs such as the NOAA Office of Education, the Smithsonian Science Education Center, the Smithsonian National Museum of Natural History's Sant Ocean Hall and the Ocean Portal Educators' Corner, and the NASA Office of STEM Engagement (OSTEM) should be funded and should include mCDR content. The NSF Directorate for STEM Education should include opportunities for expanding K-12 Resources For Ocean Education, for supporting ocean workforce development programs, and for supplemental funding requests to support K-12 ocean education projects. The NSF Research Experience for Undergraduates (REU) should include institutions and laboratories exploring mCDR. The EPA Environmental Education (EE) Grants Program should include new opportunities for mCDR.



Establishing Scaling and Deployment

For mCDR to deliver on its climate potential, the most promising approaches must move beyond small-scale research into responsible deployment. However, scaling cannot outpace science.

Our policy recommendations help develop clear, adaptive pathways for testing and potential scale-up, grounded in empirical data and strong safeguards. This means enabling well-designed field trials, investing in ocean observing infrastructure, and establishing environmental and operational guardrails informed by ongoing research. A stepwise approach, moving from lab to pilot to larger-scale deployment only when supported by evidence, keeps scaling both effective and environmentally responsible.

Priority Recommendation: Reintroduce the Ocean Regional Opportunity and Innovation Act.

The Ocean Regional Opportunity and Innovation Act (OROIA) of 2025 would authorize and fund Ocean Innovation Clusters as areas in predesignated parts of the US coast for research and development, job training, and cross-sector partnerships.

Ocean Innovation Clusters would be prime opportunities for mCDR **in-water testing**, would provide the **monitoring, governance, and community engagement infrastructure** needed for scaled mCDR research and development, and would foster co-development with other ocean uses such as marine energy, autonomous underwater vehicles, or aquaculture.

A reintroduced OROIA could specify supporting the **regional ocean economy** through pre-permitted testbeds and specify that one of the many uses of the testbeds will be for mCDR R&D. This Act would be an excellent complement to the ReSCUE Oceans Act and not only support mCDR R&D, but would also support US coastal communities and the American ocean economy.

Supporting Recommendation 1: Fund mCDR at DOE.

Congress should annually provide through appropriations $42 million for mCDR among the three following DOE offices:

- **$12 million** at the Office of Fossil Energy
- **$10 million** at the Office of Science
- **$20 million** at the Office of Energy Efficiency and Renewable Energy's Water Power Technologies Office

Specifically, Congress should provide $12 million to Fossil Energy for DOE-NOAA mCDR Memorandum of Agreement Implementation, to leverage each agency's strengths and reduce duplication. Congress should provide $10 million to the DOE Office of Science for basic research. As the largest federal sponsor of basic research in the physical sciences, the Office of Science would advance the basic understanding of the efficacy and impacts of mCDR, which is critical for understanding which approaches to target in scaling to responsibly grow this emerging industry. Congress should provide $20 million to the Office of Energy Efficiency and Renewable Energy's Water Power Technologies Office (WPTO) for in-water testing and development at the national labs. As the Office with historical precedence for mCDR research and with current staff capacity and expertise in mCDR, funding at WPTO would support mCDR technology development, increase understanding of mCDR efficacy and durability, and leverage public-private partnerships to measure, report, and validate mCDR and identify cost-effective and energy-efficient mCDR solutions.

Supporting Recommendation 2: Encourage mCDR co-location and reutilization + industrial integration.

As the ocean increasingly demonstrates benefits from numerous uses, co-location is becoming a more popular way to reduce duplicate infrastructure and limit ocean disturbance. mCDR research can include co-development of other ocean economy technology development, and mCDR can be integrated into multiple technologies such as desalination, hydrogen extraction, marine energy, critical mineral extraction, and water treatment. Establishing a market for mCDR within existing industrial systems and with

community buy-in, and in the same places as other ocean uses, reduces risk for the mCDR market. Congress and agencies should encourage, through funding opportunities and tax incentives, the co-location and reutilization of coastal infrastructure and industrial systems for mCDR. DOE should create a Technology Development Prize for integrating mCDR with existing technologies. These opportunities would spur innovation to maximize industry investment in the ocean economy, save money on raw materials, infrastructure, and coastal development, and likely minimize environmental disturbance.

Supporting Recommendation 3: Catalyze mCDR innovation through a NSF Tech Accelerator + DOE Technology Development Prize.

The NSF Technology, Innovation and Partnerships (TIP) Directorate accelerates breakthrough technologies and transitions these technologies to the market. TIP's prioritization of building more jobs in emerging technology fields, bolstering small businesses and startups to build technologies, and investing in research for future investment or impact meets the mCDR field exactly where it is today. By uniting cross-sector partnerships to leverage expertise and resources, NSF Tech Accelerators remove commercialization barriers, address ecosystem gaps, and foster collaboration — ensuring breakthrough technologies move swiftly to the marketplace and reach Americans faster. Similarly, DOE funds technology development prize competitions to encourage innovation and accelerate the development of novel technologies. Leveraging these existing models, either independently or collaboratively, to catalyze mCDR innovation, will address the most pressing needs of the mCDR industry. The NSF TIP and DOE Technology Development Prize programs should target new technology applications to mCDR and innovations to strengthen mCDR MMRV.

Enabling Responsible Commercialization

As private sector interest accelerates, science needs to lead commercialization, not the other way around.

Early market activity that is not grounded in strong evidence puts both environmental integrity and public trust at risk. Policymakers should focus on creating conditions for responsible innovation: sustained public investment in independent research, clear standards for crediting and verification, and safeguards against premature or misleading claims. Laying the groundwork for credible, mission-aligned companies can help ensure that any future mCDR industry develops in a way that prioritizes safety, minimizes harm, and delivers real climate and societal benefits.

Commercialization strategies also need to ensure that coastal and frontline communities share in the economic benefits — through local, high-quality job creation, workforce development, and co-developed project design — so that the growth of the mCDR sector contributes not only to climate goals, but also to equitable and durable economic opportunity.

Priority Recommendation: Conduct a federal review of potential mCDR permitting pathways, jurisdictions, and statutory authorities beyond research scale deployments.

The US Government Accountability Office (GAO) should conduct a review of **federal regulatory and permitting frameworks applicable to mCDR activities**, including research, field trials, and commercial-scale deployment.

Given climate change impacts are already imposing substantial costs on US taxpayers and, without mitigation, represent an uncapped fiscal risk, mCDR offers an opportunity for GAO to explore the field as a potential cost-saving measure for the US. The GAO report should provide a clearer understanding of agency roles, permitting pathways for different types of mCDR, and oversight mechanisms, in addition to recommendations

for potential improvement.

Specifically, the GAO report should: identify Federal agencies with jurisdiction over mCDR activities; review applicable statutory authorities and their applicability to varied mCDR approaches; assess the efficiency and effectiveness of existing permitting processes, including timelines, coordination mechanisms, and duplication or gaps in regulatory oversight; evaluate engagement and consultation opportunities within the applicable regulatory and permitting frameworks, including with affected coastal communities and Indian Tribes, Tribal organizations, and Native Hawaiian organizations, noting community capacities to engage and recognizing participation incentives; evaluate the capacity of relevant agencies to oversee and permit mCDR activities, including both research and commercial deployment; and identify regulatory uncertainties, jurisdictional overlaps, statutory gaps, or barriers that may impede responsible research, testing, or deployment of mCDR.

The report would assist Congress in determining whether existing authorities are sufficient or whether legislative clarification or regulatory updates are warranted. In conducting this review, GAO should consult with relevant federal agencies, state regulators, Indian Tribes, Tribal organizations, Native Hawaiian organizations, industry participants, academic experts, and other stakeholders. Congressional action based on a GAO report would signal to the industry and investors that the US is serious about building a regulatory system that works for mCDR.

Supporting Recommendation 1: Create a mCDR Small Business Innovation Research program.

The Small Business Administration should create a mCDR Small Business Innovation Research (SBIR) program to strengthen a durable mCDR market by de-risking mCDR technologies through proof of concept research, pilot studies, and lab-to-market efforts. A mCDR SBIR program can fund tools, sensors, and software systems to track and verify carbon removal. SBIR can also help technologies and mCDR data systems become interoperable and directly inform developer assessments and permitting reviews. A mCDR SBIR program would help make sure the transition of mCDR R&D to market is

done in a responsible way that is guided by the best available science and is supported by ground-truthed American innovation.

Supporting Recommendation 2: Reintroduce the Carbon Removal and Emissions Storage Technologies (CREST) Act.

The Carbon Removal and Emissions Storage Technologies (CREST) Act invests in carbon removal R&D across pathways and authorizes a CDR procurement program. By amending the Energy Policy Act of 2005 (42 U.S.C. 16298d) to include a range of mCDR approaches, CREST harnesses the capabilities of DOE to accelerate mCDR R&D at speed and scale. CREST authorizes mCDR assessments, such as analyzing the potential for removing carbon dioxide directly from the ocean, and better understanding the potential for offshore carbon storage. CREST also amends the DOE Carbon Capture and Sequestration Research, Development, and Demonstration Act of 2007 (42 U.S.C. § 16293) to establish a mCDR program to monitor, research, and model potential mCDR ecological impacts. Reintroducing CREST sets up the innovation system to accelerate mCDR technological development for responsible scaling.

Supporting Recommendation 3: Fund mCDR at NIST.

NIST promotes US innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. Without standardization, the market cannot scale. Congress should annually provide through appropriations $11.5 million to NIST to develop and standardize benchmark materials, measurements, data, and models to accelerate innovation in and validate performance of materials and technologies for mCDR. Funding at NIST would establish high standards for broad adoption by the American mCDR industry to create a credible market, retain market leadership, and develop at the speed and scale needed to remain competitive.

Section Three:

Next Steps & Call to Action

Next Steps & Call to Action

Removing 30 megatons (MT) of carbon dioxide by 2030 in the US will take sound research by the scientific community, sustained coastal community engagement, technological development, durable markets, and clear governance. None of that happens without robust public policy that holds together over the next several years.

The immediate work ahead has a natural order. Federal policy should first fund the research that lowers environmental risk, enhances MMRV, advances technological development, and supports in-water testing. Second, it should resolve the governance and permitting questions, and strengthen interagency cooperation. Third, federal policy should strengthen mCDR financial markets, procurement, and infrastructure that scaled deployment will need.

Each step must be taken with public support and social license in mind, as they are the conditions under which the first three steps work. Through the recommendations in this roadmap, Congress and the federal agencies can position the US to retain global leadership and competitive advantage in mCDR while growing the ocean economy and empowering American coastal economies.

To learn more about any of the recommendations in this report, email ocean@carbon180.org.

Appendix

Acronyms

CDR: Carbon Dioxide Removal

CEQ: The White House Council on Environmental Quality

CO_2: Carbon Dioxide

CREST: Carbon Removal and Emissions Storage Technologies (CREST) Act

BIA: Bureau of Indian Affairs, Department of Interior

BOEM: Bureau of Energy Management, Department of Interior

BSEE: Bureau of Safety and Environmental Enforcement, Department of Interior

DHS: Department of Homeland Security

DOC: Direct Ocean Capture

DOE: Department of Energy

DOI: Department of Interior

DOT: Department of Transportation

DNI: Director of National Intelligence

EPA: Environmental Protection Agency

GAO: US Government Accountability Office

ICOOS: Integrated Coastal and Ocean Observation System Act

IOOS: US Integrated Ocean Observing System

IWG: Interagency Working Group

mCDR: Marine Carbon Dioxide Removal

MMRV: Measurement, Monitoring, Reporting, and Verification

NASA: National Aeronautics and Space Administration

NIST: National Institute of Standards and Technology

NOAA: National Oceanic and Atmospheric Administration

NOPP: National Oceanographic Partnership Program

NSF: National Science Foundation

OAE: Ocean Alkalinity Enhancement

Acronyms

ONR: Office of Naval Research

OSTP: The White House Office of Science and Technology Policy

OROIA: Ocean Regional Opportunity and Innovation Act

R&D: Research and Development

ReSCUE: Removing and Sequestering Carbon Unleashed in the Environment and Oceans Act

ROP: Regional Ocean Partnership

SBIR: Small Business Innovation Research

USACE: US Army Corps of Engineers

USCG: US Coast Guard

USDA: US Department of Agriculture

USFWS: US Fish and Wildlife Service, Department of Interior

USGS: US Geological Survey, Department of Interior

WPTO: Water Power Technologies Office, Department of Energy

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