# Marine Carbon Dioxide Removal

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WHAT IS MCDR?

# Marine carbon dioxide removal (mCDR) is a promising solution that will boost local economies while removing harmful greenhouse gas emissions.

The private sector is investing hundreds of billions of dollars to decarbonize, and mCDR could be an essential complement to net zero goals that companies continue to pursue. With greater focus and investment on this emerging sector, mCDR has the potential to bring jobs to communities and protect the environment while producing safe, long-term, and cost-effective carbon removal.

## What is Marine Carbon Dioxide Removal?

mCDR, also referred to as ocean-based carbon dioxide removal (oCDR), refers to approaches that aim to harness the ocean's naturally-occurring carbon removal process and safely accelerate it. In theory, this could help us remove billions of tons of excess carbon from the atmosphere and safely store it away — as we simultaneously work to significantly reduce the amount of carbon we emit.

The ocean is the world's largest carbon sink, covering 70 percent of the Earth's surface and naturally absorbing more than a quarter of all carbon emissions per year. It holds 50 times more carbon than the atmosphere.

Even without deliberate mCDR, the ocean will continue to absorb carbon dioxide, but at a much slower rate than carbon dioxide is building up in the atmosphere.

## How Does mCDR Work?

There are multiple types of mCDR solutions, including ocean alkalinity enhancement (OAE), ocean fertilization (OF), and blue carbon management (i.e. preserving and supporting coastal ecosystems such as mangroves).

Each of these methods require different amounts of time, money, and resources. The public sector can help scientists explore these methods so that the private sector can invest and create jobs across the United States.

OAE, one specific mCDR approach, has already proven effective in lab and small-scale trials. More research is needed to understand exactly how OAE could potentially work at-scale in the open ocean.

## Growing Scientific, Public, and Private Sector Support

Major companies such as Microsoft and Stripe are investing in this technology. This year, Microsoft announced that they will be purchasing 500,000 tons of carbon removal credits over the next six years, in addition to the company's previous $200 million investment in CDR. Stripe has similarly invested $15 million into CDR, helping companies purchase carbon removal credits and bring emerging technologies to the market.

The carbon management industry overall is projected to directly support hundreds of thousands of jobs — in addition to the indirect economic benefits of new businesses.



# mCDR Supports an All of the Above Energy Strategy

Marine carbon dioxide removal (mCDR) could be a new source of well-paying jobs around the U.S., and an essential component to an all-of-the-above energy strategy — if it receives more public sector support to advance foundational research. Demand for energy production is expected to grow in the coming decades, and the Trump administration has prioritized boosting domestic energy production. Developing mCDR could offset emissions while diversifying the economy, supporting environmental stewardship for clean air and water, and preserving existing energy infrastructure.

## mCDR Supports Energy Dominance

The Trump administration's push for American energy dominance depends on increasing all types of energy production. While the private sector is on board, major companies will need support to meet those goals alongside existing decarbonization efforts.

As major companies scale up energy production, they will need to invest in carbon offsets to help them diversify and hedge their portfolios. Carbon dioxide removal — and mCDR in particular — is a market-led solution that can fill this gap and support a resilient U.S. energy economy.

## Multiple mCDR Pathways

There are multiple types of mCDR solutions, including ocean fertilization (OF) and blue carbon management (i.e., preserving and supporting coastal ecosystems such as mangroves), in addition to ocean alkalinity enhancement (OAE).

Each of these methods require different amounts of time, money, and resources, and might have varying degrees of success in reducing the acidity of ocean water at scale. It's worth exploring these methods to determine which, if any, could help mitigate climate change without adverse effects.

## OAE is a High Potential mCDR Pathway

For millions of years, minerals from weathered rock have washed into the ocean, boosting its alkalinity and allowing it to safely lock away CO2, thereby balancing the climate.

OAE builds on this natural process, enhancing the ocean's CO2 absorption while also counteracting local ocean acidification. OAE helps the ocean continue its absolutely crucial role in stabilizing the Earth's climate.

The world's leading scientific bodies — like the Intergovernmental Panel on Climate Change (IPCC) and the National Academies of Science, Engineering and Medicine (NASEM) — have specifically identified mCDR as a high-potential climate solution.





# Economic Potential of mCDR

mCDR has huge economic potential. Marine carbon dioxide removal (mCDR) will help preserve coastal livelihoods by creating well-paying jobs in scientific research, construction, and operations. Jobs and opportunities will not be limited to the coasts — with manufacturing and supply chain, technology development, and mineral procurement job growth across the country. Many of these roles will not require four-year college degrees and will be important pathways for students at trade and vocational schools. Developing the industry will make the U.S. a global leader in carbon management, while maintaining a strong market-driven approach.

## Economic Potential of CDR

Carbon dioxide removal (CDR) is a burgeoning industry full of untapped economic potential. Credible estimates report that the CDR market could eventually be worth anywhere from hundreds of billions of dollars (Rhodium Group) to over a trillion dollars (McKinsey) by 2050.

The U.S. has the opportunity to lead the global charge and harness the economic reward that this technology could provide. The National Oceanic and Atmospheric Administration (NOAA) predicts a total of 300,000 new CDR jobs in the U.S. alone by 2050.

## Under-Explored Potential of mCDR

There are many potential CDR methods, and much of the public discussion and funding to date has focused on direct air capture. Comparatively, mCDR has been underexplored and underinvested — though there's arguably more potential in the industry.

If mCDR proves to be a viable option, it could be the most effective tool we have to remove carbon from the atmosphere while developing new industries for coastal communities.

## The Road Ahead

mCDR has the potential to significantly reduce the amount of carbon in the atmosphere and boost local economies in the process.

Stakeholders are already investing in technology and scientific studies to help us better understand the economic potential of various mCDR pathways.

If mCDR is going to be part of the global carbon removal effort, the private and public sectors will need to work together.



# Bipartisan Policy Momentum for mCDR

Both Republicans and Democrats support increasing the federal government's focus on marine carbon dioxide removal (mCDR). In 2024, it was the focus of one of the most bipartisan Congressional hearings of the year, hosted by Rep. Max Miller (R-OH) — Chair of the House Science, Space, and Technology Subcommittee on Energy. There are a number of specific actions the federal government can take to advance mCDR, including permitting reform and cost-effective investments in basic research.

## A Roadmap for Continued American Leadership on mCDR

The U.S. government has recently made smart, targeted investments in mCDR totaling $61.5 million, including:

+ $24.3 million in grants from the interagency National Oceanographic Partnership Program
+ $35.8 million in grants awarded by DOE's ARPA-E program for research and development of marine carbon dioxide removal techniques
+ Initial investment of $35 million for the world's first government CDR offset procurement project
+ Nearly $2 million in small grants from DOE's Office of Fossil Energy and Carbon Management

Between 2022 and 2024, the federal government released three major reports that lay out a path forward for maintaining American leadership on mCDR:

+ In 2022, the National Academies of Science published a Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration
+ In 2023, the federal government released an Ocean Climate Action Plan to amplify the need for further exploration of mCDR approaches like ocean alkalinity enhancement (OAE)
+ At the end of 2024, the federal government put forward a National Marine Carbon Dioxide Removal Research Strategy to chart a specific path forward for continued support for mCDR

## Targeted Investments with Outsized Returns

Federal investment in mCDR is minimal, especially compared to the billions of dollars being spent to advance CDR more broadly.

The incoming administration has an opportunity to right size investments in mCDR, which are low cost and high potential, and as a result, unlock philanthropic and private sector spending.

According to the 2022 National Academies report, funding for mCDR R&D needs to rise to around $301.5 million annually, for a ten-year investment of $2.41 billion, to activate mCDR technologies to deliver safe and effective carbon removal at scale.

Congress could advance mCDR funding in three common sense ways:

1. Increase funding for DOE's cross-cutting carbon dioxide removal initiative to $353 million, of which not less than $100 million should be dedicated to advancing mCDR.
2. Provide not less than $30 million to NOAA for external mCDR research, development, and demonstration grants.
3. Maintain funding for DOE's ARPA-E program, which should allocate funds commensurate with the need for ongoing improvements in modeling and technology development for monitoring and verifying the effects and efficacy of mCDR.

## Efficient Permitting is Essential

Current policy and permitting infrastructure was not created with the regulation of mCDR in mind.

For mCDR to contribute to net-negative emissions on the timeline and at the scale relevant to address the climate crisis, federal regulatory agencies need to prioritize efficient permitting for field research, demonstrations, and monitoring, in order to evaluate the efficacy, additionality, durability, and environmental safety of various mCDR approaches.

Permitting reform can ensure that these research efforts are as safe, responsible, and efficient as possible. Projects with sound research design and positive net impact should advance, while projects with likely negative impacts and/or projects unlikely to meet federal standards should be provided feedback early in the review process.

Given the number of laws and federal agencies involved, there is a need to create a standing interagency working group on mCDR to:

+ Issue integrated guidance to assist project developers in project design and permit application
+ Provide a one-stop initial point of contact for field project developers
+ Improve communication and ensure coordination, both among the agencies and between the agencies and project developers
+ Minimize duplication and delays in permitting





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