From: Nicolas Sdez
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] [PRONOE][EOP] Marine Carbon Dioxide Removal Research Plan
Date: Wednesday, April 24, 2024 3:57:35 AM
Attachments: PRONOE - Marine Carbon Dioxide Removal Research Plan.pdf

Hi Tricia,

I am an entrepreneur submitting the following letter regarding the RFI for the Marine Carbon Dioxide Removal Research Plan.

Thank you for your consideration,

Have a good day,

Best regards,

Nicolas Sdez
CEO & Co-Founder @ PRONœ

(b) (6) [redacted]

pronoe.earth

NICOLAS SDEZ
18 RUE MICHEL LE COMTE
75003 PARIS, FRANCE
April 22, 2024

To the National Science Foundation.
I am a greenhouse gas removal entrepreneur working on ocean-based carbon removal through my company PRONOE.

I'm writing to express my strong support for the establishment and expansion of startup incubator programs specifically tailored for startups focused on ocean-based carbon removal technologies. As the global community seeks viable solutions to combat climate change, the ocean presents a vast and relatively untapped resource for carbon sequestration.

Ocean-based carbon removal technologies, including methods like algae cultivation, artificial upwelling, and electrochemical conversion, hold significant potential to reduce atmospheric CO2 levels. However, the development of these technologies faces unique challenges, such as high initial research and development costs, regulatory hurdles, and the need for specialized scientific and business expertise.

Incubator programs dedicated to this sector could provide crucial support in the form of mentorship, funding, and strategic partnerships, thus facilitating rapid technological advancements and commercial scalability. For example, my startup participated in the AirMiners Launchpad accelerator, and it was catalytic for our success. Such initiatives would not only foster innovation but also accelerate the deployment of effective carbon removal strategies, contributing significantly to global efforts to mitigate climate change.

The leadership of the NSF in supporting these endeavors is vital. By prioritizing and investing in accelerator programs for ocean-based carbon removal, the NSF can play a pivotal role in nurturing the growth of startups that may hold the keys to our future sustainability.

Thank you for considering this vital initiative. I am eager to see how the NSF's support can transform our capabilities in fighting climate change through innovative and sustainable ocean-based solutions.

Sincerely,
NICOLAS SDEZ
(b) (6) [redacted]
PRONOE

From:	Philip Kithil
To:	Light, Tricia M. EOP/OSTP
Cc:	David Keefer
Subject:	[EXTERNAL] "Marine Carbon Dioxide Removal Research Plan"
Date:	Thursday, February 29, 2024 1:11:48 PM
Attachments:	Marine Carbon Dioxide Removal Research Plan RFI from The Sea Upwelling Co.pdf Marine Carbon Dioxide Removal Research Plan RFI from The Sea Upwelling Co.docx

Hello Tricia - please find attached our RFI response.

Thanks

Phil

--

Phil Kithil

Managing Director

The Sea Upwelling Company LLC

(b) (6) [redacted]

(b) (6) [redacted]

www.ocean-based.com

1274 Vallecita, Santa Fe, NM 87501

Let's connect! View my calendar

THE SEA UPWELLING COMPANY LLC

RESPONSE TO RFI.

(b) (6)

"Marine Carbon Dioxide Removal Research Plan"

1. How would a Marine CDR Plan affect you, your organization, or your community?

Our sole business is marine CDR so this proposed Plan could accelerate our solution or could eliminate it, depending on the Plan implementation.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

It is absolutely critical that regulations do not restrict small scale ocean testing.

"Small scale" can be defined as testing that potentially modifies the carbon uptake capacity of an ocean volume less than xxx cubic kilometers for a time duration up to yy months. We suggest "xxx" is 100, and "yy" is 60.

It is imperative that regulations allow the technology provider the freedom to conduct this ocean testing within the US EEZ with an expedited permit from EPA or other agencies that is obtainable at very low cost, using a simple questionnaire, with EPA/other providing decision within 3 months.

It is critical the regulations allow free-drifting as well as fixed-location ocean CDR technologies. In the case of free-drifting, "xxx" is a moving volume not a fixed (stationary) volume.

"At-scale" testing should be defined according to the "xxx" and "yy" criteria.

Ocean measuring of CDR remains challenging and expensive. The Federal government should provide free or very low cost instrumentation including ship time to assist technology providers in this effort.

The focus should be on narrowing the field of "we don't know what we don't know" rather than on re-proving fundamental science. Example: the biological carbon pump is well known and reproving it is unnecessary. The actual transfer of CO2 between the atmosphere and surface ocean is less well known/characterized... and dynamic!

Decisions on commercial application of mCDR technologies should be made by the commercial stakeholders with input from Federal agencies and the public......these decisions should NOT be made by the Federal government! Case in point: the DAC Hubs promoted by DOE are not economic now, nor any time in the future; far too small scale to address the vast scale of the global CO2 problem; and create subsidies where none are justified (e.g. Occidental Petroleum).

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

The Federal government is NOT qualified to prioritize one technology over another! This RFI is asking what knowledge is needed, then suggests the Fed's have the knowledge to prioritize? Makes no sense.

mCDR approaches that add substances (iron, olivine, etc) are inherently more risky.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

All data from ocean testing should be made public.

While it is mandatory to avoid further harmful outcomes to "disadvantaged communities" (indigenous or any other), these societal outcomes should be divorced from the scientific outcomes.

The Fed's cannot solve societal problems with mCDR! The focus of mCDR should be.....mCDR! Not immigration, lack of housing, low incomes, or the myriad other societal ills we face. Yes, ensure any mCDR is unlikely to cause bigger hurricanes (a far-fetched example) – but does that mCDR technology actually achieve mCDR?

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Clearly, artificial upwelling is poorly recognized, and not well understood by the Federal government (nor most others). We recommend a synthesis of RECENT papers on AU as first step to educate. Here is a starter list:

Recent Science Papers.

1. National Academies of Sciences, Engineering, and Medicine 2021. *A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration.* Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.
2. Devries, Tim. *The Ocean Carbon Cycle.* Annual Review of Environment and Resources 2022 47:1, p317-341.
3. Koweek DA (2022) *Expected Limits on the Potential for Carbon Dioxide Removal From Artificial Upwelling* Front. Mar. Sci. 9:841894. doi: 10.3389/fmars.2022.841894.
4. Kemper J, Riebesell U and Graf K (2022) *Numerical Flow Modeling of Artificial Ocean Upwelling* Front. Mar. Sci. 8:804875. doi: 10.3389/fmars.2021.804875.
5. Jürchott, M., Oschlies, A., & Koeve, W. (2023). *Artificial upwelling—A refined narrative.* Geophysical Research Letters, 50, e2022GL101870. https://doi. org/10.1029/2022GL101870.
6. Wu, J., Keller, D. P., andOschlies, A.: *Carbon dioxide removal via macroalgae open-ocean mariculture and sinking: an Earth system modeling study.* Earth Syst. Dynam., 14, 185–221, https://doi.org/10.5194/esd-14-185-2023, 2023.
7. Bach, L.T., Ho, D.T., Boyd, P.W. andTyka, M.D. (2023), *Toward a consensus framework to evaluate air–sea CO_2 equilibration for marine CO_2 removal.* Limnol. Oceano. Lett. https://doi.org/10.1002/lol2.10330.
8. Wilfried Rickels et.al. Preprint: *Valuing the ocean carbon sink at the country level.* DOI: https://doi.org/10.21203/rs.3.rs-3232579/v1.
9. Chen S, Strong-Wright J and Taylor JR (2024) *Modeling Carbon Dioxide Removal via Sinking of Particulate Organic Carbon from Macroalgae Cultivation.* In review.
10. Chikamoto, M. O., DiNezio, P., & Lovenduski, N. (2023). *Long-term slowdown of ocean carbon uptake by alkalinity dynamics.* Geophysical Research Letters, 50, e2022GL101954. https://doi.org/10.1029/2022GL101954.
11. Goldenburgh et.al. *Diatom-mediated food web functioning under ocean artifcial upwelling* Nature.com Scientifc Reports | (2024) 14:3955 | https://doi.org/10.1038/s41598024-54345-w.

Earlier references and papers, while informative at the time of publication, may not reflect current knowledge.

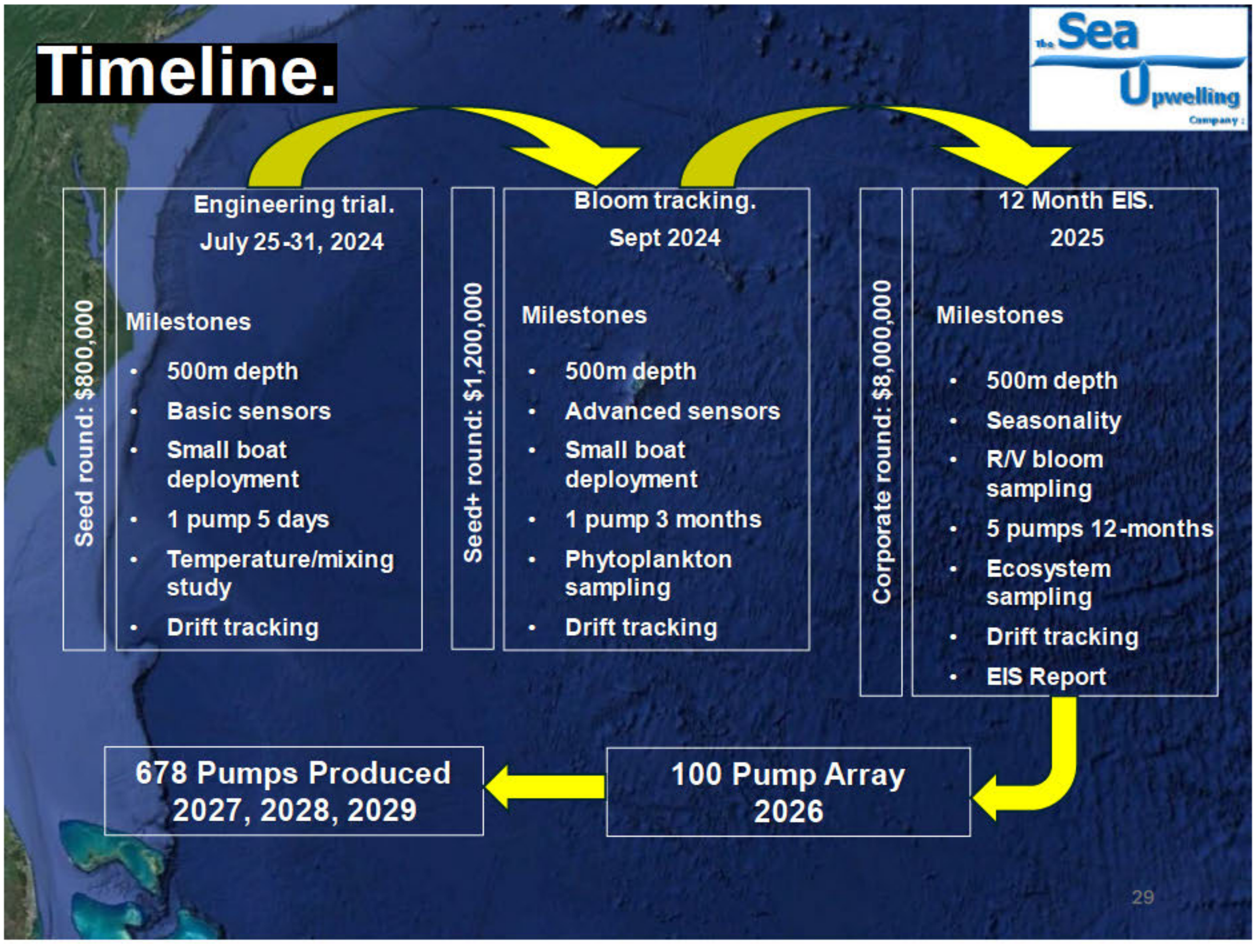
The business model proposed by the mCDR provider should have equal weight as the actual technology.

If you cannot sell it at a reasonable price, then nothing else matters.

And, "it" must be massive scale from day one!

Finally, the business model must include CO2 reduction in equal share to CO2 removal. If emissions continue in equal amount as the CDR, that CDR is simply treading water. The business model must incorporate both removal of legacy CO2 and **reduction of future CO2**. Preferably 1:1 ratio, but more reduction even better!

The partnership between BIOS and my company is a great place to start!



6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

As the famous automotive pioneer Lee Iococca once said “Lead, follow, or get out of the way!” The Federal government is not very good at leading – once again citing the DAC-Hub pending disaster.

From:	Isabella Corpora
To:	Light, Tricia M. EOP/OSTP
Cc:	Ben Rubin
Subject:	[EXTERNAL] Carbon Business Council Submission: Marine Carbon Dioxide Removal Research Plan
Date:	Tuesday, April 23, 2024 12:16:48 AM
Attachments:	CO2BC_FTAC RFI Response.pdf

Dear Ms. Light,

Hope you are well. The Carbon Business Council would like to submit this letter in response to the request for information regarding the Marine Carbon Removal Research Plan. We are a member-driven nonprofit coalition of more than 100 companies unified to restore the climate.

We thank you for this opportunity to submit input and please let us know if there are any inquiries.

Best,
Bella

--
Bella Corpora
Associate Director
W: Carbon Business Council
Follow us on Twitter and LinkedIn

The Carbon Dioxide Removal Responsible Deployment Training is out now! Sign up for our newsletter and the Ethical Oath.

Carbon Business Council

April 22, 2024

Tricia Light
White House Office of Science and Technology Policy (OSTP)
RE: Marine Carbon Dioxide Removal Research Plan
Submitted via email to (b) (6) [redacted]

Dear Ms. Light and Colleagues:

The Carbon Business Council (CO2BC) is a nonprofit trade association of more than 100 innovative carbon management companies with over $16.5 billion in combined assets working across six continents. We appreciate this opportunity to submit comments on the Marine CDR Plan in response to the National Science Foundation (NSF) Request for Information (RFI) 89 FR 13755, on behalf of the White House National Science and Technology Council (NSTC) Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC).

In January 2024, the CO2BC published an Issue Brief, developed with a working group of over 20 CO2BC member companies and ecosystem partners, highlighting the critical importance of marine carbon dioxide removal (mCDR) to achieving national and global climate goals. We and our members are thus pleased to see the emphasis and urgency to develop a mCDR Plan represented by the MCDR-FTAC, and strongly support the Committee's vital work.

We would like to provide comments on the following "Questions to Inform Development of the Strategy," as listed in the RFI:

1. How would a Marine CDR Plan affect you, your organization, or your community?

- As highlighted in CO2BC's January 2024 Issue Brief, mCDR has to date not received funding support or regulatory guidance commensurate with its massive climate mitigation potential. The National Academies of Science have estimated that at least $1.5 billion of funding is needed this decade for mCDR across research, development, and deployment (RD&D), and our hope is that the mCDR Plan will galvanize support for increased funding, and offer a roadmap for how that funding can be most beneficially deployed.[1]
- Another key obstacle for mCDR RD&D is the lack of any fit-for-purpose regulatory framework. We are hopeful that the mCDR Plan will address this gap, and provide more detailed thoughts on regulation and permitting in comments on question #2.
- A comprehensive and appropriately funded federal mCDR Plan that provides a framework and roadmap for RD&D of the full range of mCDR approaches will establish the U.S. as a global leader in the responsible advancement of mCDR. This would serve as a model for other nations, as well as attract investment and position the U.S. to reap significant

[1] Research Strategy for Ocean Carbon Dioxide Removal and Sequestration. NASEM, 2022.

economic benefits (including jobs creation) from this promising commercial sector.[2] Strong and science-based Federal Government oversight will additionally help foster the social license needed to responsibly advance mCDR RD&D.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

- We understand that the term "dumping" has legal, regulatory, and legislative precedent both in the U.S. and internationally. However, we urge the MCDR-FTAC to take the opportunity of the mCDR Plan to retire this language, which has a strongly negative connotation, in favor of more neutral terminology. mCDR activities seek to generate net climate benefit via restoring and sustaining ocean health and should not be conflated with waste disposal or other polluting activities. Furthermore, many mCDR approaches may offer meaningful ecosystem co-benefits, such as local mitigation of ocean acidification.[3] Additionally, not all mCDR activities encompass adding material to the ocean – e.g. direct ocean capture, blue carbon, marine permaculture, etc.
- We encourage the Federal Government to avoid the conflation of mCDR with other climate interventions, such as marine solar radiation management (mSRM), that employ distinct methods for a differing purpose.
- We do not see a clear distinction between "research" and "commercial" mCDR activities in practice, and encourage the mCDR Plan to avoid these labels in favor of a focus on project scope, scale, climate benefit, and other impacts. Public-private partnerships offer an opportunity to accelerate the advancement of the mCDR field and create a magnifying effect on public investment. It has been encouraging to see the Federal Government's support for this kind of public-private collaboration by many of the September 2023 NOPP awards and October 2023 ARPA-E mCDR grants, and we are hopeful that the mCDR Plan will continue to foster such engagement.
- While existing statute offers some pathway for permitting mCDR RD&D – and the CO2BC was pleased to see the permit recently awarded member company Vesta for its Duck, NC field trial – we encourage the MCDR-FTAC to identify opportunities to implement more fit-for-purpose regulatory frameworks for mCDR RD&D activities. Additionally, given the number of federal agencies involved, we echo others' call for the creation of a permanent interagency working group to facilitate and expedite mCDR permitting questions.
- Pre-permitted mCDR testing facilities (potentially implemented via National Labs) would offer a significant accelerant to responsible RD&D.

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[2] Carbon Removals: How to Scale a New Gigaton Industry, McKinsey & Company, 2023.
[3] CDR: Mitigating Ocean Acidification and Climate Change. NOAA Ocean Acidification Program.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

- As a tech-neutral trade association, the CO2BC encourages the Federal Government to develop the mCDR Plan in a method-neutral fashion that does not promote or exclude any individual approach. Just as we will need a portfolio of CDR solutions to meet our climate goals, we should seek to advance RD&D for a portfolio of approaches within mCDR.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

- The Federal Government has a critical role to play in public engagement and education with respect to mCDR. While public awareness is currently very low, initial polling suggests that coastal communities are open to the mCDR opportunity, and concerned about the effects of climate change.[4] We encourage the mCDR Plan to include significant funding and operating support for public engagement and education, and capacity building for marine NGOs.
- Providing resources and support to state and local permitting authorities who may be unfamiliar with mCDR can potentially help to advance responsible RD&D. Similarly the Federal Government can beneficially provide materials to support public engagement for mCDR RD&D and templates for effective and equitable community benefit plans.
- Initial mCDR field trials and pilot deployments are starting to scale, and represent an excellent opportunity for the Federal Government to showcase the mCDR opportunity with site visits supported by clear, evidence-based communication and transparent data sharing. Existing deployments from CO2BC members in the U.S. include:
    - Captura: two operational direct ocean capture pilots in Los Angeles
    - Ebb Carbon pilot system at DOE's Pacific Northwest National Laboratory
    - Equatic pilot system in Los Angeles
    - Planetary ocean alkalinity enhancement field trial in Hampton Roads, VA.
    - Vesta coastal carbon capture field trial in Duck, NC
    - Vycarb pilots in New York and Massachusetts

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering

[4] Coastal Americans Overwhelmingly Support Ocean-Based Carbon Dioxide Removal, and Are Alarmed About Climate Change Impacts. Climate Nexus, March 2022.

potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

- CO2BC would be pleased to partner with the Federal Government to advance mCDR RD&D. Additionally, CO2BC ecosystem partners such as Ocean Visions, Carbon to Sea, [C]Worthy, Columbia's Sabin Center for Climate Change Law, the Institute for Responsible Carbon Removal, World Ocean Council, and Yale Center for Natural Carbon Capture offer excellent partnership opportunities with strong mCDR domain expertise.
- Public-private partnership will be a key enabler and accelerant for advancing responsible mCDR RD&D. mCDR expertise, capacity, and capability are distributed across the public and private sectors, as well as the marine research community, National Labs, and NGOs. The field will advance most quickly when ecosystem actors work together, and are not separated into silos such as "research" and "commercial." Deployment-led learning and innovation will be key, and we encourage the mCDR Plan to facilitate this kind of collaboration to enable the participation of private-sector and philanthropic capital, including the sale of CDR credits, to supplement and help scale public sector investment.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

- As outlined in CO2BC's May 2023 Issue Brief, high-quality monitoring, reporting, and verification (MRV) is of critical importance to building the market trust and social license necessary to scaling CDR to meet our climate goals. NOAA's September 2023 $24M funding awards and ARPA-E's October 2023 $36M funding awards included some MRV projects, but further sustained and scaled support is needed.[5]
- In addition to scaling RD&D funding for mCDR, the Federal Government has the opportunity to set verification standards and show what high-quality, science-based MRV looks like via its CDR procurement and other funding programs. E.g. more explicit inclusion of mCDR as areas of interest (AOI) in DOE's CDR Purchase Pilot Prize and Voluntary CDR Purchase Challenge, as well as funding an mCDR AOI for DOE's Carbon Negative Shot Pilot Program would contribute significantly to advancing high-quality MRV for mCDR. The CO2BC encourages the MCDR-FTAC to include these ideas in the mCDR Plan.
- A key accelerant for the mCDR field would be the expansion of the 45q tax credit to include mCDR – or the implementation of a separate method-neutral CDR tax credit that supports mCDR activities. The CO2BC encourages the MCDR-FTAC to highlight this opportunity in the mCDR Plan.

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[5] U.S. Congressional Action Needed to Accelerate Ocean-Based CDR Solutions. Carbon to Sea, March 2024.

We would be pleased to discuss these questions further with the MCDR-FTAC and other relevant Federal Government stakeholders, and connect you with CO2BC members and partner organizations working to advance mCDR. We very much appreciate the important work that you and your colleagues do, and the opportunity to submit this input for your consideration.

Sincerely,

Benjamin Rubin

Ben Rubin
Executive Director, Carbon Business Council

Isabella Corpora

Isabella Corpora
Director, Carbon Business Council

From: Richard Norris
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] CDR comments
Date: Friday, April 19, 2024 8:34:10 PM
Attachments: CDR Comments-Norris.docx

Hi Tricia,

It is a delight to see this informational circular cross my email. I imagine that CDR will be a hot area for a while so it is great to see some thinking given to it now at the federal level.

I attach some comments on some of your questions in blue text (to differentiate them from the questions).

Cheers, Dick

Richard D. Norris
Scripps Institution of Oceanography
University of California San Diego
La Jolla CA 92093-0244
Ph: (b) (6)
email: (b) (6)
"We are off on the Greatest Adventure of our lives!"

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Given the amount of CDR investor money out there, I have concerns that there will be a lot of funding chasing ideas that are either ineffective, wasting opportunity for productive investment, or damaging, particularly to marine environments by supporting technologies that do not consider marine ecosystems to have appreciable value. To head off some of these problems, I would like to see the US (perhaps with international partners) establish a working panel that consolidates information, acts to vet and streamline proposals to use national waters as disposal sites, collects relevant information on the sites to be affected by CDR, and helps streamline permitting and perhaps funding, for proposals that pass review.

My experience in this area is with International Scientific Ocean Drilling where there was a "Science support office" coordinating proposals and the review process, a set of scientific panels (The" Scientific Evaluation Panel" or SEP) that set the format for proposals and reviewed submitted projects, and a "Databank" that retained proposals ad supporting data. The program also had an "Environmental Safety and Pollution Panel" that consisted of people involved in industry evaluating the potential hazards of the active proposals. The whole system evaluated both projects proposed by the academic community and proposals from industry that used the same panel system and ship platforms. If we developed a similar panel structure for CDR that involved carbon disposal on the sea floor, the community could be encouraged to submit projects to the panel system by having a coordinating body that would also fund experimentation and implementation of CDR approaches, perhaps with industry partners.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Priority should be given to proposals that bury carbon for longer than the ocean overturning period of about 1500 years. Otherwise, disposal in one part of the ocean will become a problem in other upwelling parts of the ocean, on relatively short societal timelines. Ideally, burial would be effectively "forever"—namely geologic time of tens of thousands to millions of years. Hence, methods that merely transfer carbon from the surface ocean to mid water depths, where upwelling might re-expose "buried" carbon to the atmosphere in decades to centuries, should be given less priority than methods of longer-term burial. For example, I am surprised that methods to bury kelp in the ocean have gotten as far as they have. Major kelp production is likely to be *significantly remineralized in the water column, exaggerating oxygen minimum zones, and also provide a rich food supply to benthic organisms that will change their composition and abundance. Further, the carbon is likely to be largely released back into the ocean at midwater depths and the ocean floor, where it is unlikely to remain for more than a few centuries—creating a problem for future generations. Iron fertilization methods to stimulate phytoplankton production are likely to have similar broad-reaching effects on marine ecosystems.*

Various methods of CRD are associated with significant impacts on benthic life. For example, liquid CO2 disposal is likely to create dead zones on the seafloor. Methods with a high degree of disturbance to marine communities should be given less priority for development and access to funding or regulatory relief than less destructive methods of CDR. For instance, some methods with relatively low impact on benthic life include disposal of carbon below the seabed (as in shallow injection wells, or place non-reactive carbon on the sea floor such as biochar. The CDR industry will need some value to be attached to minimizing disturbance to the sea floor community—probably through a regulatory price to be paid for disposal methods with different assessed impacts, or through a priced- in value for minimizing seafloor disturbance. Another mechanism toward improving CDR industry compliance to avoid damage to marine ecosystems would be to have a professional certification process that assesses what a given company or industry could charge as a carbon price as a function of the relative lack of damage from specific disposal processes. An equivalent in the Fishing industry is the "Marine Stewardship Council" sustainability certifications of different fisheries.

As to methods of CDR, I am personally interested in the production of biochar using agricultural or city waste streams and burial of this biochar at sea. Biochar production generates syngas which can be used as a fuel, and yields a form of carbon that is biologically inactive and looks broadly like sand or small pebbles. Disposal could be down submarine canyon systems which already transport large quantities of coarse-grained sediment into the deep ocean. The burial of biochar in submarine canyon deposits is likely to have similar impacts to increasing the sand supply to deep sea ecosystems. Therefore, biochar should have relatively modest impacts on deep ocean communities that are already used to living in a sandy seafloor system with regular disturbance by bottom currents. Since biochar is biologically non-reactive, it should remain on the seafloor for the foreseeable future and qualify as a "forever" disposal method. Burial near land in submarine canyon systems also has the advantage of minimizing the transportation distance of biochar made in coastal carbon markets. Transportation is a factor in the total carbon value of any method.

Ideally, ideas like mine would be vetted the research community and, if found promising, would be granted seed funding to test and develop the method. A related issue would be to streamline permitting for experimental work to study the impacts of biochar disposal on the marine environment. For example, one question would be what the net impact of biochar sand would have on submarine canyon ecosystems. Other issues would include the engineering methods of introduction of biochar into submarine canyon systems, and the economics of developing a carbon market in biochar given available feed stocks.

From:	Jasmine Yu
To:	Light, Tricia M. EOP/OSTP
Cc:	Hillary O'Brien; Savita Bowman
Subject:	[EXTERNAL] ClearPath Response to the Marine Carbon Dioxide Removal Research Plan RFI
Date:	Wednesday, April 17, 2024 2:13:21 PM
Attachments:	Final_ClearPath_FTAC_MCDR_RFI.pdf

Dr. Light,

ClearPath appreciates the opportunity to provide a response to the Marine Carbon Dioxide Removal Research Plan RFI (Document Citation: 89 FR 13755, Page: 13755-13757, Document Number: 2024-03758).

Please find attached a PDF version of our 5-page response, with copies of referenced materials after the response.

Thank you for the opportunity to provide a response, and please do not hesitate to reach out to me if you need any additional information or have any questions.

Many thanks,
Jasmine

--
Jasmine Yu, Ph.D
Policy Advisor
ClearPath
518 C St NE
Suite 300
Washington, DC 20002
(b) (6)

CLEARPATH

ClearPath
518 C St NE, Suite 300
Washington, DC 20002

April 23, 2023

National Science Foundation
2415 Eisenhower Ave.,
Alexandria, VA 22314

Subject: ClearPath Response to the National Science Foundation's Request for Information on the Marine Carbon Dioxide Removal Research Plan

Dear NSF and MCDR FTAC:

ClearPath appreciates the opportunity to provide a response to the NSF RFI: Document Citation: 89 FR 13755, Page: 13755-13757, Document Number: 2024-03758.

ClearPath's mission is to develop and advance policies that accelerate innovations to reduce and remove global energy emissions. To advance that mission, we develop cutting-edge policy solutions on clean energy and industrial innovation. An entrepreneurial, strategic nonprofit, ClearPath (501(c)(3)) collaborates with public and private sector stakeholders on innovations in nuclear energy, carbon capture, hydropower, natural gas, geothermal, energy storage, and heavy industry to enable private-sector deployment of critical technologies.

Coordination for marine carbon dioxide removal (mCDR) is vital for the deployment of effective carbon dioxide removal (CDR) in the near future to meet net-zero targets. We have attached recommendations to facilitate the successful execution of this plan, with question numbers correlating to RFI question numbers. Additional details are found in ClearPath's published Policy Sequencing in mCDR Development[1] report and Ocean CDR Permitting and Regulations 101[2] with copies included after this 5-page response.

Thank you for the opportunity to provide a response. Please do not hesitate to reach out to me if you need additional information or have any questions.

Sincerely,
Jasmine Yu
Policy Advisor, Carbon Management

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[1] https://clearpath.org/wp-content/uploads/sites/44/2024/03/ocean-cdr-report-4-24.pdf
[2] https://clearpath.org/tech-101/ocean-cdr-permitting-and-regulations-101/

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?

The existing legal framework for the regulation of U.S. oceans was designed in the 1970s for ocean activities that did not consider innovative climate solutions like mCDR. These regulations include the Outer Continental Shelf Lands Act; the Marine Protection Research, and Sanctuaries Act (MPRSA) and more, as detailed in the attached reports. Under current laws, mCDR projects are likely subject to duplicative permitting processes and other unintended legal requirements. As written, these outdated laws present significant barriers to the (1) initiation of mCDR field tests to validate solutions in a real ocean environment, (2) acceleration of research to determine whether and how these approaches are worth scaling and (3) deployment of mCDR.[3] **The Federal Government should provide updated guidance for a clear and streamlined U.S. mCDR regulatory process** to effectively and safely test and develop mCDR solutions.[4]

Imposing irrelevant regulatory frameworks on mCDR projects may also result in inaccurate perceptions of mCDR technologies. For instance, the mCDR technologies that utilize ocean alkalinity enhancement (OAE) or macroalgae cultivation and sinking may require approvals from both the MPRSA and the Clean Water Act's National Pollutant Discharge Elimination System. These regulations oversee the permitting of materials discharged into ocean waters, primarily the "dumping" of hazardous materials, which could cause harm to the marine environment. However, dumping is broadly defined as the disposition of material.[5] The intent of OAE and macroalgae-based mCDR is to remove CO_2 in addition to tracking and monitoring this removal, not for disposal of hazardous materials. Implying that mCDR climate solutions are hazardous could damage the social license of these important technologies.

In January 2024, the Environmental Protection Agency (EPA) published a resource summarizing laws that may impact mCDR, which they plan to continuously update as they gain additional information. **Similarly, the Federal Government should publish progress reports, every 3 years on the state of mCDR**, including all mCDR research projects performed with Federal funding and/or engaged in the Federal regulatory process. The report should be a coordinated effort between the Department of Energy (DOE), EPA, National Oceanic and Atmospheric Administration (NOAA), Bureau of Ocean Energy Management (BOEM), United States Department of Agriculture (USDA) and other relevant agencies. The report should also include the stage of research and relevant findings, such as carbon removal and storage potential. This report is to encourage transparency of (1) mCDR research and (2) permitting and regulatory processes.

[3] https://clearpath.org/tech-101/ocean-cdr-permitting-and-regulations-101/
[4] https://www.oceancdrscience.org/
[5] https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?

The Federal Government should prioritize the rigorous and transparent measurement, reporting and verification (MRV) of mCDR pathways. MRV is necessary to quantify and evaluate the efficacy and durability of carbon removal and storage and supports the understanding of co-benefits and risks, especially in open systems like the ocean. By prioritizing MRV research, the Federal Government can maintain a technology-neutral approach during the early stages of research and development of this emerging technology area, to avoid selecting one mCDR pathway over another. The development of new MRV tools or the improvement of existing MRV methods would also optimize the accuracy, transparency and consistency of ocean data collection overall. In addition to assessing the carbon removal efficacy of mCDR pathways, MRV tools would monitor ocean properties like partial pressure of CO_2, nutrients, pH, dissolved inorganic carbon and total alkalinity.[6] This is important to ensure the impact of emission removals is correctly valued and creates a foundation for continued support and accelerated adoption of mCDR pathways. DOE has a history of supporting important work in this space, For example, ARPA-E's SEA-CO2 program, released in February 2023, has funded 11 projects to advance mCDR MRV technologies and is a promising step towards more mCDR MRV research.[7]

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to stakeholders?

Information about mCDR most helpful for the research community, is discussed in question 2. Information about mCDR that could be most helpful for the public includes the economic development potential of mCDR for existing industries. Information such as potential co-benefits, which include local economic development, job production specifically the types of jobs, education, and relevant trades, co-location and utilization of existing facilities and environmental benefits would be beneficial to the public and local stakeholders. Coastal Americans overwhelmingly support mCDR, with 82% of coastal residents supporting the enhancement of the ocean's natural ability to remove CO_2. Roughly two-thirds believe mCDR will increase good-paying jobs, improve ocean-based recreation and have a positive impact on tourism.[8] The economic development potential of existing industries will vary depending on the mCDR technology pathway. For example, macroalgae cultivation could be used for the production of marketable products like biofuels and food supplements, which would displace or reduce emissions from existing sectors. OAE pathways could mitigate ocean acidification and have positive impacts on shellfish aquaculture and fisheries. Electrochemical processes may also mitigate ocean acidification and produce

[6] https://sciencecouncil.noaa.gov/wp-content/uploads/2023/06/mCDR-glossy-final.pdf
[7] https://arpa-e.energy.gov/technologies/programs/sea-co2
[8] https://climatenexus.org/poll/coastal-americans-overwhelmingly-support-ocean-based-carbon-dioxide-removal-are-alarmed-about-climate-change-impacts/

marketable byproducts like hydrogen, chlorine and silica.[9]

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What examples of partnerships are most relevant to potential marine CDR partnerships?

Collaboration across the Federal Government, academic institutions and other stakeholder groups is needed for the successful development and deployment of mCDR technologies.[10] Currently, there are concerns that mCDR research is siloed in program offices at DOE. This structure could hinder the development of adequately coordinated projects that are designed with BOEM, EPA or Army Corps jurisdictions and relevant federal environmental regulations in mind. Additionally, policies and jurisdiction can vary depending on the distance from the coast, resulting in different agencies being responsible for regulations covering separate parts of the ocean. To streamline Federal efforts and accelerate technology development, Congress has suggested various coordination policies that could be implemented by the Federal agencies to prioritize early stakeholder engagement, Federal agency coordination and research community collaboration.[11] Several policies include:

- **Bolstering Federal Agency Coordination —** The bipartisan **Removing Emissions to Mend Our Vulnerable Earth (REMOVE) Act of 2022** would establish a Committee on Large-Scale Carbon Management within the DOE to plan and oversee efforts to remove CO_2 from the air or ocean and store such carbon.[12] The REMOVE Act would also form a Carbon Accounting Coordination Working Group to ensure that government-wide actions on CDR are accounted for and measured. Even without the authorization of these activities, DOE could carry out these initiatives as a best practice.
- **Integration of mCDR into Existing Marine Industries —** Coordinating the deployment of mCDR technologies with existing marine-related industry needs in areas like shipping, off-shore wind development, wastewater treatment, beach nourishment and fisheries, could present opportunities for accelerating wide-scale deployment and clarifying mCDR regulatory processes. Additionally, the co-location of mCDR technologies and marine infrastructure, like off-shore wind turbines, could provide energy resources for carbon removal technologies.
- **Leveraging Stakeholder Engagement —** By partnering with the more than four million fishing vessels worldwide, DOE can help improve global ocean and mCDR data collection efforts, particularly in previously uncharacterized ocean environments.[13] The Fishing Vessel Ocean Observing Network (FVON) advances fishing vessel-based ocean observation on a global scale by maximizing data value, establishing best practices for data collection and management and facilitating

[9] https://www.nationalacademies.org/our-work/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration
[10] https://www.aspeninstitute.org/wp-content/uploads/2023/11/110223_Code-of-Conduct_FINAL2.pdf
[11] https://clearpath.org/wp-content/uploads/sites/44/2024/03/ocean-cdr-report-4-24.pdf
[12] https://www.congress.gov/bill/117th-congress/house-bill/8013?s=1&r=4
[13] https://www.us-ocb.org/fishing-vessel-ocean-observing-network/

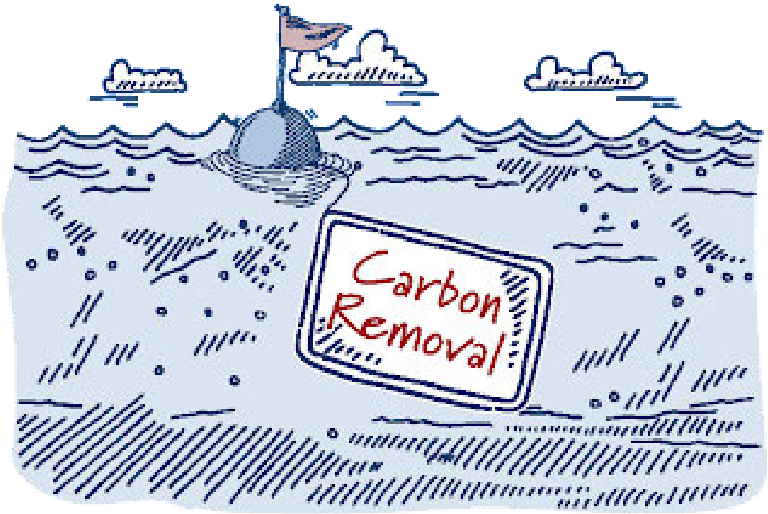
observation uptake.[14] The FVON would outfit sensors onto vessels and fishing gear for fishers to actively participate in closing ocean data gaps without changing standard fishing activities.

- **Enhancing International Research Collaboration —** Collaboration across the international marine research community supports information sharing and data collection across different environments. The **Surface Ocean Carbon Atlas (SOCAT)** is a synthesis of quality-controlled, surface ocean CO_2 observations by the international marine carbon research community.[15] NOAA's Pacific Marine Environmental Laboratory is one of the contributors. It is key for the quantification of the ocean carbon sink and the evaluation of ocean biogeochemical models. SOCAT data is publicly available, discoverable and citable. It has also been used for the evaluation of climate models and sensor data.[16]
- **Driving Technological Advancements through Global Competition—** International engagement could also drive positive technological competition in the mCDR sector, resulting in the most effective and affordable mCDR solutions. For instance, the nonprofit initiative **Carbon to Sea**, launched in 2023, systematically evaluates promising ocean-climate solutions around the world. In year one, they awarded more than 22 million to researchers in the U.S, Canada, Germany, Australia and the United Kingdom to advance science and technology and began launching a global network of field research sites.[17] Japan has pledged to lead efforts to achieve decarbonization, economic growth and energy security in Asia and stated a need for $28 trillion to facilitate carbon removal in the region.[18] The Global South has also begun engaging in mCDR discussions, particularly the role developing countries that depend on oceans can play in shaping CDR strategies and technologies.[19]

5. What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government?

As public and private interest in mCDR grows, it will be necessary to seek alignment to develop a competitive and robust mCDR innovation environment. As partnerships are formed, the Federal Government should take into account the need for data transparency and create frameworks that enable intellectual property sharing and accessibility.[20] The Federal Government should also identify data gaps and utilize proven mechanisms for public-private partnerships to source and disseminate data, initiate public calls for funding, ensure a technology-inclusive representation of mCDR technologies, prioritize domestic talent acquisition and retention and leverage state-of-the-art private resources where possible.

[14] https://www.frontiersin.org/articles/10.3389/fmars.2023.1176814/full
[15] https://socat.info/
[16] https://www.ncei.noaa.gov/news/quantifying-ocean-carbon-sink
[17] https://carbontosea.org/grantees/
[18] https://apnews.com/article/japan-asia-climate-summit-a2c8ea9ba29b0bbf98eea7b4e6b78f53
[19] https://fpanalytics.foreignpolicy.com/2023/02/28/mobilizing-action-to-scale-carbon-removal-solutions-through-the-global-carbon-removal-partnership/
[20] https://www.whitehouse.gov/wp-content/uploads/2023/08/NSTC-JCEIPH-SCST-Sustainable-Chemistry-Federal-Landscape-Report-to-Congress.pdf



Charting a Course for Marine Carbon Dioxide Removal (mCDR): Policy Sequencing in mCDR Development

Jasmine Yu and Savita Bowman

CLEARPATH

March 2024

Executive Summary

Carbon dioxide removal (CDR) is an emerging set of technologies, practices and approaches to remove carbon dioxide directly out of the atmosphere and store it. Marine CDR (mCDR), a subset of CDR solutions, can potentially complement the ocean's natural carbon cycle and carbon storage capacity. CDR pathways are recognized by the U.S. federal government, the International Energy Agency, the Intergovernmental Panel on Climate Change and the private sector, including companies like Microsoft, as a necessary tool for achieving net-zero commitments.[1,2,3,4,5,6] Examples of mCDR technologies include electrochemical processes, direct ocean capture, ocean alkalinity enhancement, as well as macro- and microalgae cultivation paired with carbon storage or production of marketable products. Currently, the U.S. is leading research and development (R&D) in the nascent mCDR sector, and enhanced regulatory clarity will keep mCDR innovators in the U.S.

This report (1) identifies policies to support each innovation stage of mCDR technologies: early-stage R&D, wide-scale deployment and commercialization, (2) highlights the growing U.S. federal engagement and resources for mCDR and (3) describes policies that could create the conditions for successful wide-scale mCDR deployment, dependent on the findings from R&D field trials. Major takeaways from this report include:

1. **The U.S. is one of the leaders in the emerging field of mCDR, and federal policies can help the U.S. secure leadership and a competitive edge.**

   The federal government is supporting at least 36 mCDR research projects across 17 states and has published multiple strategic and exploratory reports that envision the role of federal agencies in the growing mCDR industry. These projects are highlighted in Table 2 and detailed in Appendix Table A1. The U.S. has also taken initial steps to ensure coordinated mCDR development by creating interagency working groups, such as the Fast-Track Action Committee on Marine Carbon Dioxide Removal.

2. **Parallel development of a U.S. regulatory framework and research through field trials will be necessary for innovation and maintaining global competitiveness.**

   The existing legal framework for U.S. oceans was designed to encompass many ocean activities, but not mCDR. This results in mCDR projects being shoehorned into several environmental regulations and laws designed for other purposes and could have unintended consequences, such as delaying or halting the R&D of projects in the U.S.. Additionally, field trials are necessary to better understand the potential effectiveness and safety of various mCDR technologies and approaches.

3. **Other federal policy tools, such as financial incentives, can alleviate uncertainties in mCDR pilot projects.**

   Policy mechanisms like federal procurement of CDR, technology transition activities, at-scale demonstrations, loan financing programs and tax incentives could be utilized to advance mCDR innovations.

1. Marine Carbon Dioxide Removal (mCDR)

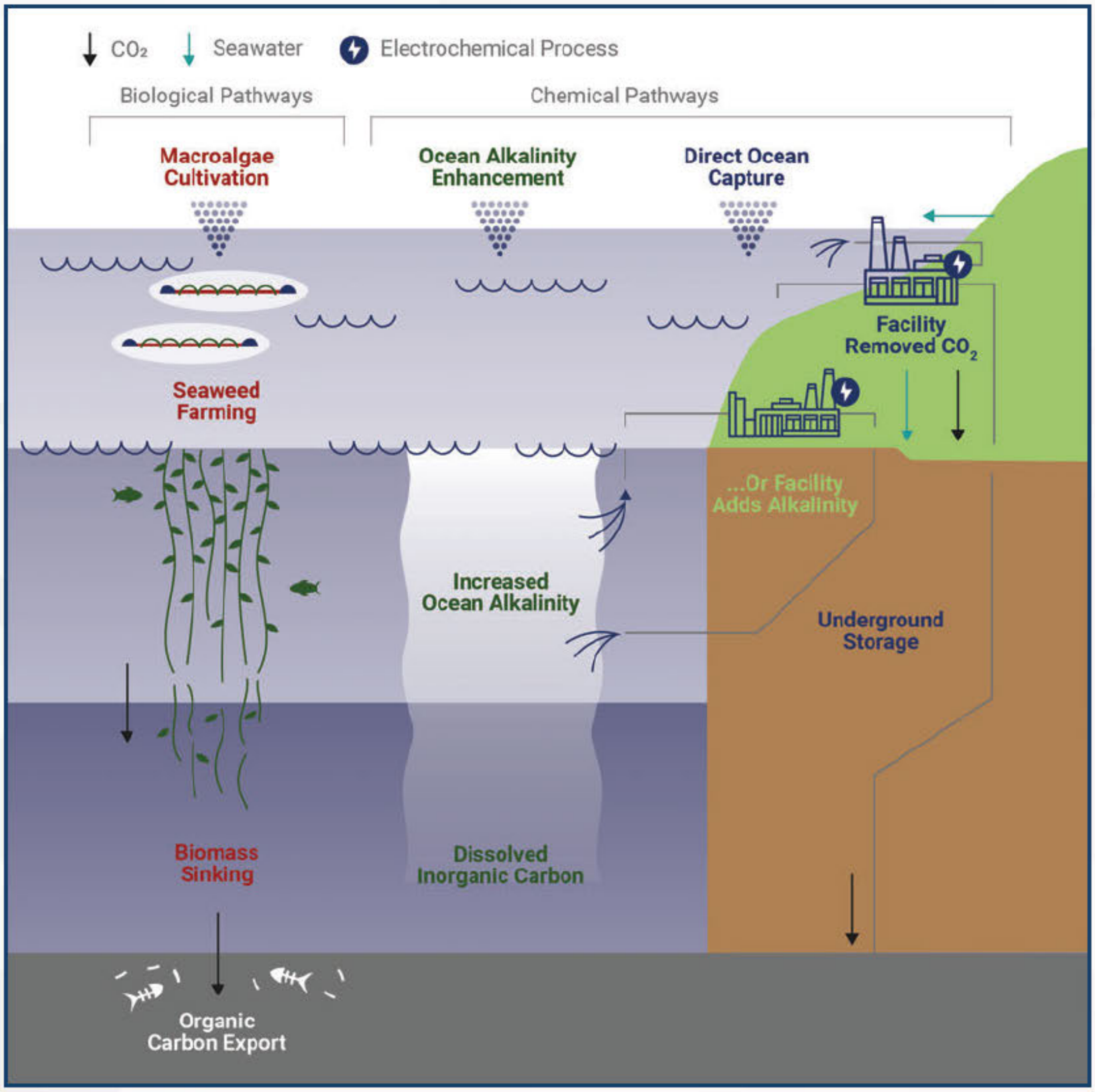
CDR is necessary for the United States to reach 2050 net-zero emission targets by removing an estimated 0.8-2.9 billion metric tons of carbon dioxide (CO_2,), equivalent to emissions from 1.47 billion vehicles.[7,8] The number of corporations with net-zero commitments has more than doubled from 769 in December 2020 to 1,475 in 2023.[9,10] CDR refers to technologies, processes and approaches that remove CO_2 from the atmosphere and store it for long periods of time. There are three categories of CDR: 1) engineered solutions, such as direct air capture (DAC), 2) natural solutions, like afforestation and 3) hybrid solutions that take an engineered approach to natural or biological processes.

The ocean is a natural and vast carbon sink that covers approximately 70% of Earth's surface and has absorbed over 30% of CO_2 already in the atmosphere.[11,12] The ocean removes CO_2 from the atmosphere through a natural balancing act: as CO_2 in the atmosphere increases, the ocean absorbs more CO_2 to re-establish balance.[13]

Marine carbon dioxide removal (mCDR) is a nascent category of CDR technologies that enhance the ocean's biological and chemical carbon processes.[14] Co-benefits of mCDR deployment include local economic development, job production, the co-location and utilization of existing facilities and addressing ocean acidification.[15]

Approaches to mCDR include macroalgae cultivation, ocean alkalinity enhancement (OAE) and Direct Ocean Capture (DOC) (or the DAC of the ocean). These approaches and others are summarized in Figure 1 and Table 1, as well as ClearPath's Carbon Dioxide Removal 101 and Ocean CDR Permitting and Regulations 101.

Figure 1. mCDR Pathways.



Source: Carbon 180

Table 1. Comparison of mCDR Removal Pathways.

Ocean CDR Pathway	Technological Readiness	Cost Range ($/ton CO2 removal)	Scale (Gt CO2 Removal/yr)	Storage Duration (years)	Research Groups and Start-Ups
Macroalgae Cultivation (Seaweed/Kelp)	Moderate	\$25 - \$125	Low (0.1 - 0.6)	Low - Moderate (10 - 100 Years)	Macro Oceans, Phykos, RunningTide
Alkalinity Enhancement	Low-Moderate	\$25 - \$160	Moderate - High (1 - 15+)*	High (>20,000 years)**	Planetary, Vesta
Electrochemical Ocean CDR/ Direction Ocean Capture	Low-Moderate	\$400 - \$600	Moderate (1 - 10)	High, using geological storage (>1,000 years)	Captura, Ebb Carbon, Equatic, Heimdal, Massachusets Institute of Technology
Artificial Upwelling/ Downwelling	Low	\$100 - \$150	Low (0.1 - 0.4)	Low - Moderate (10 - 100 years)	Ocean-Based Climate Solutions, Inc., The Climate Foundation

Source: NOAA

* The State of Carbon Removal of 2023 report estimates alkalinity enhancement upper-bound to be 100 Gt CO2 removed per year.

** The mean seawater residence time of alkaline dissolved carbon is about 100,000 years, based on the annual input of alkaline carbon from rivers (0.3 GtC/yr), the alkaline pool of dissolved alkaline carbon resident in the ocean (about 34,000 GtC) and assuming steady state.

2. mCDR Research is Gaining Momentum

CDR approaches have proliferated significantly over the last three years. While most large-scale federal policy support has focused on DAC technologies, there has been a growing interest in mCDR pathways. This has been largely driven by initial support from the private and philanthropic sectors. The U.S. federal government has supported mCDR research to increase fundamental knowledge and to enable the potential deployment and commercialization of solutions to effectively and efficiently remove CO_2 from the atmosphere. Table 2 describes the various mCDR-related programs that have received federal resources.

Research is necessary to prove the efficacy and safety of mCDR approaches. Additionally, future research could identify mCDR technologies that may be lower cost, more efficient and provide greater co-benefits than land-based CDR technologies. Therefore, the allocation of federal resources for mCDR may provide significant returns on investment. mCDR project titles, locations and funding amounts are detailed in Appendix Table A1.

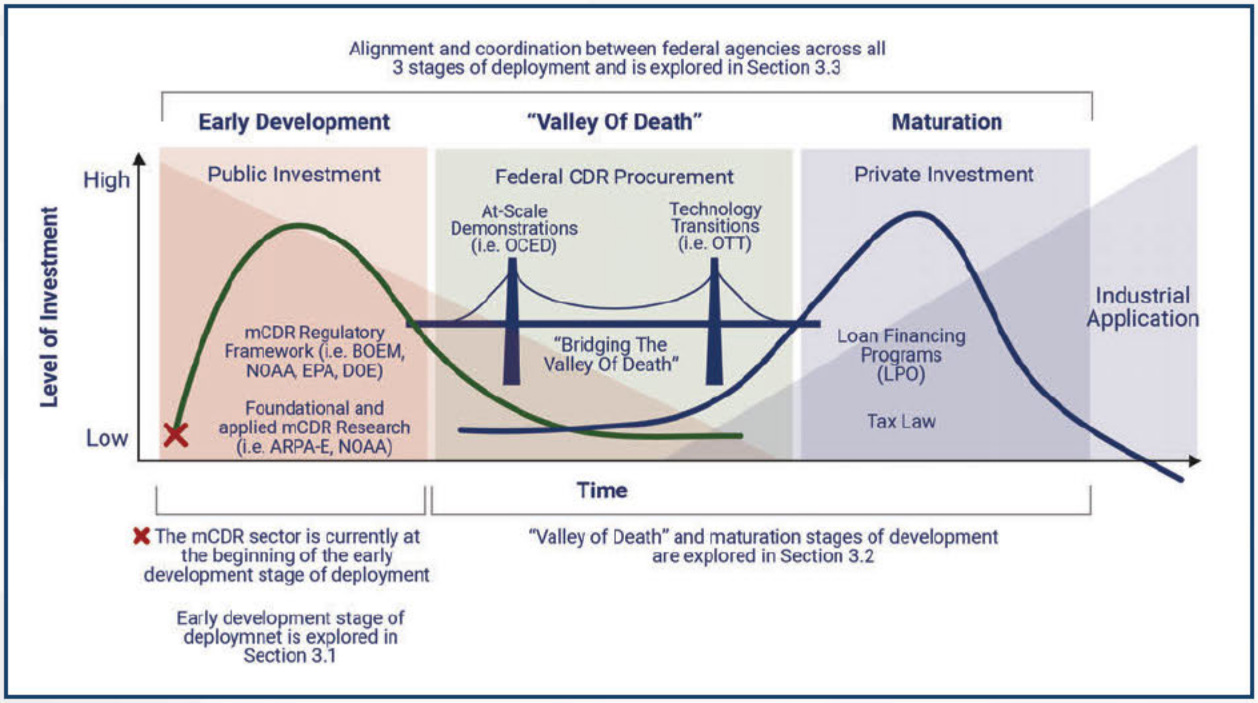
Table 2. Federal Engagement and Resources Supporting mCDR.

Agency	Program	Description	mCDR Projects
Department of Energy (DOE)			
Fossil Energy and Carbon Management (FECM)	Carbon Negative Shot	Supports the potential development and commercialization of a suite of CDR technologies to remove CO_2 from the atmosphere and store it for less than $100 per net metric ton of CO_2eq within the decade.[16]	Up to 5 small mCDR pilot projects in lab, closed-system, and representative field pilot environments to demonstrate the feasibility, cost, and scalability of ocean-based approaches.[17]
	Investments for Carbon Management R&D Projects	19 R&D projects were selected to support cost-effective processes for ocean-based carbon removal technologies and direct air capture technologies to establish the foundation for a successful carbon capture and carbon conversion industry.[18]	8 R&D projects represent ocean-based carbon removal technologies and received around $1.6 million in DOE funding.[19] Project details are listed in Appendix Table A1.
	Carbon Dioxide Removal Purchase Pilot Prize	Will be the first U.S. government initiative to purchase CDR credits from domestic technology providers. Will provide up to $35 million in awards to private entities and academic institutions for CDR.	mCDR projects could qualify for this the purchase prize under "planned or managed carbon sinks, including natural and artificial mechanism within terrestrial and upper hydrosphere".[20]
Advanced Research Projects Agency-Energy (ARPA-E)	Sensing Exports of Anthropogenic Carbon through Ocean Observation (SEA-CO2)	To research ways to develop new approaches to measure and track mCDR transparently and ensure that the quality and quantity of emission removals are correctly valued in carbon markets to support the accelerated adoption of mCDR.[15]	11 projects will support novel efforts to measure, report and validate mCDR and identify cost-effective and energy-efficient carbon removal solutions, using $36 million in funding.[22] Project details are listed in Appendix Table A1.
	Macroalgae Research Inspiring Novel Energy Resources	To develop tools for U.S. leadership in the production of marine biomass for use as feedstock for fuels, chemicals, and animal feed.[23]	22 projects funded since 2017 to develop technologies capable of providing economically viable, renewable biomass for energy applications without the need for land, freshwater, and synthetic fertilizers.
National Renewable Energy Laboratory (NREL)	Mission Analysis for Marine Renewable Energy to Provide Power for Marine Carbon Dioxide Removal	The goal of this study was to understand the CO2 removal potential of mCDR, marine carbon capture, and marine carbon storage, and to understand the compatibility of mCDR, mCC, and mCS with marine and offshore wind energy.	No specific project funding. Published the report investigating mCDR technologies that require power at sea, such as artificial upwelling, deep-ocean storage, electrochemical mCDR and marine carbon capture, offshore microalgae cultivation, seaweed farming and sinking, and monitoring requirements.
National Oceanic and Atmospheric Administration (NOAA)			
National Oceanographic Partnership Program (NOPP)	Investments to Advance mCDR Research	Funding supports collaborative research across academia, federal scientists, and industry to expand understanding of mCDR approaches, risks and co-benefits, and science needed to build regulatory frameworks for testing and scaling of mCDR.[24]	17 projects with partners from 47 institutions utilizing $23.4 million in investments.[25] Project details are listed in Appendix Table A1.
Office of Oceanic and Atmospheric Research National Marine Fisheries Service Office of the Undersecretary for Oceans and Atmosphere	Strategy for NOAA Carbon Dioxide Removal Research Report	This White Paper outlines existing knowledge of mCDR technologies, requirements for increasing foundational knowledge to drive future decisions, and NOAA's role in CDR research.[26]	No specific research projects. Provides next steps for a synthesized research strategy and coordinating research efforts at NOAA.

3. Policies to Develop Conditions for Wide-Scale mCDR Deployment

Wide-scale mCDR deployment can be achieved through a coordinated federal effort, which is important during the early development stage of new technologies and is beneficial for moving pilots and demonstrations into real-world environments. We also highlight federal policy mechanisms, such as demand pulls through federal CDR procurement, that help emerging technologies bridge the "Valley of Death" and provide continued support once technologies reach the mature stage of development. These federal policy mechanisms are highlighted in Figure 2. in reference to the stages of developing technology, time and levels of investment.

Figure 2. Federal Policy Mechanisms that Support Innovation from Early Development to Maturation



3.1 Ensuring a Competitive Research and Innovation Environment

The more nascent technologies and solutions, the more foundational and applied research will be needed, followed by testing, demonstration and deployment. Today, mCDR pathways are in the nascent stages of R&D, mostly performed in a laboratory setting or small controlled conditions simulating ocean environments. At this stage, innovation policies that support R&D through cost sharing and grants for pre-Front-End Engineering and Design (pre-FEED), FEED and pilot lab-scale projects are valuable.

The successful deployment and eventual commercialization of mCDR pathways in the U.S. to address global carbon removal commitments in a timely manner relies on the parallel (1) updating of regulatory frameworks to improve the timeliness and transparency of mCDR projects and (2) establishment of a coordinated, transparent, robust and well-resourced research environment. The

White House Office of Science and Technology Policy (OSTP) has begun coordinating efforts through the establishment of the Fast-Track Action Committee (FTAC) to evaluate the different types of mCDR and shape relevant policy and research on mCDR and carbon sequestration. Additional information on FTAC and other federal coordination efforts is presented in section 3.3 of this report.

3.1.1 A Streamlined and Consolidated U.S. mCDR Regulatory Framework is Needed to Encourage Innovation

The continuation of fundamental and exploratory research is important, but to answer important scientific questions about mCDR approaches, field tests are necessary to understand and validate the effectiveness of technologies in a real ocean environment.[27] However, current regulatory processes and laws in the U.S. for real-world mCDR experiments are highly fragmented.[28] Without changes and clarifications, the current U.S. regulatory processes and laws pose significant challenges, not only for full-scale deployment of mCDR, but for accelerating research to determine whether and how these approaches are worth scaling. This could result in U.S. innovators developing and deploying in other countries with more favorable regulatory systems.

The U.S. has an opportunity to maintain intellectual and economic leadership for mCDR deployment if it can determine an appropriate regulatory regime and policy ecosystem to support leading companies in their efforts to commercialize. Already we've seen U.S. companies begin to deploy pilots internationally.[29] RunningTide, a Maine-based ocean CDR start-up, is building its first global research and development base in Iceland through an Icelandic research permit.[30] Captura, a California-based mCDR company founded at the California Institute of Technology, has two operational pilot plants in California and is building its third pilot plant in Norway to test, mature and industrially scale its DOC technology. Captura is also working to build DOC plants in Canada.[31] Similarly, Equatic, a California-based mCDR company using technology created at the University of California, Los Angeles (UCLA), has partnered with a Montreal-based carbon removal project developer and will install their technology at a pilot facility in Quebec in 2024.[32] Establishing a clear and predictable U.S. regulatory process to indicate U.S. government support for mCDR pathways is needed to ensure that America can lead the world in mCDR research, development and deployment.

The existing legal framework for U.S. oceans was designed decades ago for numerous ocean activities that are not specific to mCDR RD&D considerations. Therefore, mCDR projects would be shoehorned into several general environmental regulations and laws that have not considered innovative mCDR technologies. Under these laws, mCDR projects would be subject to duplicative permitting processes and other legal requirements. A dedicated mCDR framework could reduce the time, cost and complexity associated with the variety of requirements by creating clarity, coordination and a sequential agency review process needed by mCDR technologies to effectively and safely test and develop their solutions.[33]

Additionally, assigning ocean regulations that are not applicable to mCDR projects may result in inaccurate perceptions of mCDR technologies. For instance, the mCDR technologies that utilize OAE or macroalgae cultivation and sinking may require approvals from both the Marine, Protection, Research and Sanctuaries Act (MPRSA) and the Clean Water Act's National Pollutant Discharge Elimination System. These regulations oversee the permitting of materials discharged into ocean waters, primarily the "dumping" of hazardous materials, which could cause harm to the marine environment. However, dumping is defined broadly to encompass the disposition of material.[34] OAE and macroalgae-based mCDR are for purposes other than disposal, as the intent is to remove CO_2 in addition to tracking and monitoring this removal. In January 2024, the EPA published a resource summarizing laws that may impact mCDR, which they plan to continuously update as they gain additional information.[35] A thorough regulatory guidance or framework could further clarify requirements for the mCDR field research trials and potential deployment. Regulatory mismatches not only stymie innovation but can create a negative general perception of mCDR pathways.

A variety of mCDR pathways aim to effectively maximize the ocean's carbon removal ability in the early stages of R&D. Updating regulations can achieve timely and transparent processes that address potential risks without forestalling innovations by addressing overlapping permitting processes and other requirements.[36]

3.1.2 Research Policy is Essential for Driving marine CDR Innovation

While a regulatory framework is being established, it is also essential to create and sustain a transparent and coordinated mCDR research and innovation environment. The current state of research has been primarily laboratory-scale experiments, conceptual theory and modeling on mCDR technologies and pathways.[37] Recently, field trials have begun. For instance, Ebb Carbon is operating its first 100-ton mCDR system at DOE's Pacific Northwest National Lab (PNNL)-Sequim.[38] The parallel acceleration of both a regulatory framework and expanded research that supports field trials of increasing scale would result in identifying optimal mCDR approaches to support global net-zero commitments. Federal engagement in mCDR research has begun at the DOE and NOAA, as highlighted in Table 2. With DOE and NOAA's leadership in carbon management and early support for mCDR research, further engagement and more directed mCDR efforts within the carbon management portfolio could further develop the various mCDR pathways.

In the 118th, 117th and 116th Congresses, legislation has supported the expansion of mCDR solutions by bolstering R&D programs toward mCDR technologies and marine carbon storage.

- The bipartisan **Carbon Removal and Emissions Storage Technologies (CREST) Act of 2023** would expand the DOE's carbon removal R&D programs to include mCDR and marine carbon storage, among other developing carbon removal pathways. It also creates a carbon removal footprint program to provide grant funding to entities seeking financial assistance to complete a techno-economic assessment or life-cycle assessment. This bill is sponsored by Sens. Collins (R-ME), Cantwell (D-WA), Cassidy (R-LA), King (I-ME), and Coons (D-DE).[39]
- The **Carbon Dioxide Removal Research and Development Act of 2023** would authorize funding to support R&D on a range of carbon removal pathways across nine government agencies, such as NOAA, to advance research on mCDR pathways. This bill is sponsored in the Senate by Sens. Schatz (D-HI), Bennet (D-CO), Coons (D-DE), Heinrich (D-NM), Hickenlooper (D-CO), Lujan (D-NM), Smith (D-MN), Whitehouse (D-RI), Welch (D-VT) and Reps. Tonko (D-NY), Clark (D-MA), Peters (D-CA), Kuster (D-NH) and McGovern (D-MA).[40,41]
- The bipartisan and bicameral **Blue Carbon for Our Planet Act**, introduced in 2021, highlights the need for a coordinated research effort between NOAA and the National Academy of Sciences to assess the technologies for CO_2 storage in the deep sea floor environment, solutions for removal of CO_2 from the ocean and feasibility of coastal macroalgae cultivation for carbon sequestration. This bill was originally sponsored in the Senate by Sens. Murkowski (R-AK) and Whitehouse (D-RI), and in the House by Reps. Bonamici (D-OR), Posey (R-FL), Beyer (D-VA) and Mast (R-FL).[42,43]

- The bipartisan and bicameral **Securing Energy for our Armed Forces Using Engineering Leadership (SEA FUEL) Act**, included in the National Defense Authorization Act (NDAA) for Fiscal Year 2020, directs the Departments of Defense and Homeland Security to pioneer new technologies that will capture CO_2 from air and seawater and convert it to clean fuels or other useful products.[44,45] The U.S. Navy has already patented a technology that would remove excess CO_2 from ocean water and turn it into fuel.[46] This bill was originally sponsored in the Senate by Sens. Whitehouse (D-RI), Reed (D-RI) and Sullivan (R-AK), and in the House by Reps. Beyer (D-VA), Schweikert (R-AZ) and Brown (D-MD).

The nascent field of mCDR technologies would benefit from both foundational research and applied R&D through support across federal agencies. Areas for continued research include but are not limited to the following:

The measurement, reporting and verification (MRV) of mCDR pathways locally and globally. Rigorous and transparent MRV is necessary to quantify and evaluate the efficacy and durability of carbon removal and storage of mCDR pathways and supports the understanding of co-benefits and risks, particularly in open systems like the ocean. The development of new MRV tools or the improvement of existing MRV methods would optimize the accuracy, transparency and consistency of ocean data collection. In addition to assessing the carbon removal efficacy of mCDR pathways, MRV tools would monitor ocean properties like partial pressure of CO_2, salinity, nutrients, pH, dissolved inorganic carbon, total alkalinity and dissolved oxygen.[47] This is important to ensure the impact of emission removals is correctly valued and creates a solid foundation for continued support and accelerated adoption of mCDR pathways. ARPA-E's SEA-CO_2 program, released in February 2023, has funded 11 projects to advance mCDR MRV technologies and is a promising step towards more mCDR MRV research.[48]

Further work by a lead federal agency such as the DOE in coordination with national labs and other agencies like NOAA, National Science Foundation (NSF), Department of Defense (DOD) and the Environmental Protection Agency (EPA) is needed to ensure the effective development of MRV guidelines and rubrics, especially for novel approaches like mCDR, which do not have significant historical data to inform MRV. These agencies have already supported mCDR research as outlined in **Appendix Table 1**. For instance, the Department of Defense- Office of Naval Research could also be a likely partner for permitting and regulations over marine spaces. Additionally, the DOE's Earth System Model Development Analysis program supports innovative and computationally advanced earth system modeling capabilities to provide information on Earth systems for energy and related sectoral infrastructure planning.[49] This program coordinates its activities with the climate modeling programs at other federal agencies, primarily NSF, NOAA and NASA. This program released a $16 million funding opportunity announcement in 2023, soliciting applications that, in part, would further the development of marine biogeochemical simulations.[50]

Understanding the economic development potential of existing industries by developing the mCDR sector. Potential co-benefits include local economic development, job production, co-location and utilization of existing facilities and environmental benefits. Coastal Americans overwhelmingly support mCDR, with 82% of coastal residents supporting the enhancement of the ocean's natural ability to remove carbon dioxide. Roughly two-thirds believe mCDR will increase good-paying jobs, improve ocean-based recreation and have a positive impact on tourism.[51]

The economic development potential of existing industries will vary depending on the mCDR pathway and how it will be implemented. Macroalgae cultivation could be used for the production of marketable products like biofuels and food supplements, which would displace or reduce emissions from existing sectors. OAE pathways could mitigate ocean acidification and have potential positive impacts on shellfish aquaculture and fisheries. Electrochemical processes may also mitigate ocean acidification and produce marketable byproducts like hydrogen, chlorine and silica.[52]

A coordinated federal effort to establish an mCDR-specific regulatory framework in tandem with continued mCDR research will be necessary to ensure the timely development of promising mCDR solutions.

3.2 Federal Mechanisms for Deployment and Commercialization

Concurrent policies and existing federal programs can accelerate deployment and support the commercialization of effective and safe mCDR pathways while also reducing emissions.[53] Promising early-stage technologies often receive limited investment because of technical or financial uncertainties, resulting in the "Valley of Death" or the large gap between early-stage scientific research and industry commercialization. The "Valley of Death" can be avoided by incorporating supportive policies during the crucial stage of translational research.[54] The lack of federal deployment incentives to bridge the "Valley of Death" could prevent research, particularly for at-scale field trials, needed to mature the mCDR industry. This section explores federal support mechanisms that could set the course for the maturation of mCDR technologies for successful commercialization. The support mechanisms are also highlighted in **Figure 2** in coordination with the different stages of innovation.

Federal Procurement of CDR — Procurement of innovative technologies helps bridge the "Valley of Death" by addressing uncertainty through guaranteed demand. The DOE Office of Fossil Energy and Carbon Management (FECM) launched the CDR Purchase Pilot Prize, which will provide $35 million in awards to private entities and academic institutions to compete for the opportunity to sell CDR credits directly to the federal government. This program will help build metrics (such as MRV) for successful CDR programs and create a market to encourage technology innovation and the growth of the industry. It also signals to buyers and investors the legitimacy of the carbon removal space through government interest, which can, in tandem, help to bolster the voluntary market. The following recently introduced legislation also supports the creation of a federal procurement program for CDR and could support mCDR.

- The bipartisan **Carbon Removal and Emissions Storage Technologies (CREST) Act of 2023** would establish a five-year pilot carbon removal purchasing program to accelerate the deployment and market commercialization of proven carbon removal technologies within the U.S.[55]
- The **Federal Carbon Dioxide Removal Leadership Act (CDRLA) of 2022** would require the DOE to remove and permanently store CO_2 on a specified schedule, culminating in 10 million metric tons of CO_2 removed for fiscal year 2025 and each fiscal year after.[56]

At-Scale Demonstrations — The DOE Office of Clean Energy Demonstrations (OCED), authorized in the bipartisan Infrastructure Investment and Jobs Act (IIJA), accelerates market adoption and deployment of pre-commercial technologies to achieve net zero emissions by 2050 through at-scale clean energy demonstration projects in partnership with the private sector.[57] The technologies selected for OCED's portfolio face significant barriers to scale, making OCED's role to address those barriers and help de-risk them. At-scale demonstrations are a critical tool utilized by OCED because they validate the performance of technologies in complex real-world environments, allow learning by doing and build confidence in key stakeholder groups such as industry, the financial sector and communities where facilities will be located.[58] OCED supports a carbon management portfolio that includes the Regional Direct Air Capture Hubs and may consider supporting a broader portfolio of CDR pathways as their scalability and viability become established. Therefore, mCDR at-scale demonstrations, or field trials, could be selected for development by OCED as various mCDR solutions achieve a higher technology readiness level and complementary demonstration-level regulatory process.[59]

Technology Transitions for Commercialization — The DOE Office of Technology Transitions (OTT) was formed to expand the commercial impact of the DOE's portfolio of research, development, demonstration and deployment (RDD&D) activities to bolster the U.S's innovation ecosystem and increase the return on investment in federally-funded science and energy research. OTT guides the coordination and optimization of technology transition activities between national labs and the private sector. OTT also oversees the Energy Technology Commercialization Fund (TCF). The TCF is used to provide matching funds with private partners to promote energy technologies for commercial purposes based on future planned activities.[60] OTT using funding from the TFC, in partnership with FECM and OCED, is supporting four national lab carbon management projects, three of which are focusing on MRV of diverse carbon removal pathways.[61] The eventual commercialization of mCDR technologies and MRV frameworks could benefit from efforts at OTT, such as through the TCF.

Loan Financing Programs — The DOE Loan Programs Office (LPO) finances large-scale, all-of-the-above energy infrastructure in the United States. The Energy Act of 2020 expanded project eligibility within the Title XVII Clean Energy Financing Program to include carbon management technologies, such as synthetic technologies to remove carbon from the air and the ocean.[62] With this expansion, LPO can finance early commercial deployments of carbon management technology by 1) demonstrating bankability and readiness for widespread adoption to a range of investors, 2) accelerating commercial deployments and 3) reducing cost uncertainty.[63] The Title XVII Clean Energy Financing Program– Innovative Energy and Innovative Supply Chain Projects (Section 1703) finances clean energy projects that use innovative technologies or processes not yet widely deployed in the U.S. that reduce greenhouse gas emissions or air pollutants. Once ready for early commercial deployments, mCDR technologies may be eligible for LPO financing.

Tax Law — Tax incentives are monetary credits offered by the federal government to private entities or individuals for certain products or activities that reduce the amount of tax due. The 45Q tax credit was introduced in 2008 as a carbon capture sequestration (CCS) specific incentive that provides stable and predictable cash flow for carbon oxide that is geologically stored permanently, stored through enhanced oil recovery, or through other utilization. In 2022, 45Q was expanded to include DAC projects and raised the monetary credit for those types of projects. Expanding existing tax credits or the creation of a new technology-inclusive CDR tax credit to include mCDR solutions would facilitate wide-scale commercialization of mCDR.[64] Eligibility of mCDR technologies under tax law would be done through robust MRV and life cycle assessment methods for assessing and monitoring the net CO_2 removed and stored, which currently do not yet exist and may require investments in R&D. Pragmatic MRV would strengthen confidence in the capability of mCDR solutions to remove CO_2 already in the atmosphere and oceans and safely store or sequester it.

To conclude, each mCDR pathway is unique and in different stages of development. The respective rate of R&D and decision-making on deployment and commercialization will vary. Therefore, a combination of different federal support mechanisms for mCDR technologies will be needed to evaluate different technologies and ensure that the proven solutions can achieve commercialization and contribute to net-zero emission commitments.

3.3 Supporting Alignment and Coordination

Collaboration across the federal government, research entities and various stakeholder groups is also needed to ensure the successful development and commercialization of mCDR technologies.[65] For instance, mCDR research has the tendency to be highly siloed, so technologically focused projects may be designed without consideration of legal issues, environmental considerations, or other research that has already been performed. Additionally, policies and jurisdiction can vary depending on the distance from the coast, resulting in different agencies being responsible for regulations covering separate parts of the ocean. To address redundancies and accelerate technology development, policies may be developed to prioritize early stakeholder engagement, federal agency coordination and research community collaboration.

Coordination for mCDR can leverage the progress made by the Ocean Policy Committee (OPC), which was created to coordinate federal action on ocean-related matters.[66] The OPC does this by engaging and collaborating with the ocean community, facilitating coordination and integration of federal activities in ocean and coastal waters to inform ocean policy, identifying priority ocean science and technology needs and leveraging resources and expertise to maximize the effectiveness of federal investments in ocean research. In March 2023, the OPC released an Ocean Climate Action Plan (OCAP), which highlights advancing mCDR and storage technologies to provide powerful levers for reducing net greenhouse gas emissions.[67] To fulfill one of the recommendations from the OCAP, the White House Office of Science and Technology Policy (OSTP) created the Fast-Track Action Committee (FTAC) to evaluate the different types of mCDR and shape relevant policy and research on mCDR and carbon sequestration. FTAC includes experts from over a dozen federal departments and agencies to develop an implementation plan to advance mCDR. The committee will also 1) draft recommendations for policy, permitting and regulatory standards for mCDR research and implementation, 2) develop a plan for a comprehensive federal research and scaled testing program for mCDR approaches and 3) explore approaches for coordinating public-private funded mCDR research activities.[68] Examples of additional coordination efforts are listed below.

Bolstering Federal Agency Coordination — The bipartisan **Removing Emissions to Mend Our Vulnerable Earth (REMOVE) Act of 2022** would establish the Committee on Large-Scale Carbon Management within the DOE to plan and oversee efforts to remove CO_2 from the air or ocean and store such carbon.[69] The REMOVE Act would also form the Carbon Accounting Coordination Working Group to ensure that government-wide actions on CDR are accounted for and measured.

Integration of mCDR into Existing Marine Industries — Coordinating the nascent mCDR industry with existing marine-related sectors, such as shipping, off-shore wind development, wastewater treatment, beach nourishment and fisheries, could present promising opportunities for easing wide-scale deployment. For instance, leveraging existing permitting regulations of well-established marine-related sectors could clarify and streamline mCDR regulatory processes. The co-location of mCDR pathways with marine infrastructure, like off-shore wind turbines, could provide energy resources for emissions reduction.

Improving Methods for Stakeholder Engagement — Improving global data collection of the oceans can be achieved by partnering with the more than four million fishing vessels worldwide, which cover significant portions of ocean environments with limited data.[70] The Fishing Vessel Ocean Observing Network (FVON) aims to advance fishing vessel-based ocean observation on a global scale by maximizing data value, establishing best practices around data collection and management and facilitating observation uptake.[71] The FVON would outfit sensors onto vessels and fishing gear for fishers to actively participate in closing ocean data gaps without changing their standard fishing activities.

Enhancing Research Community Collaboration — Collaboration across the international marine research community supports information sharing and data collection across different environments. The Surface Ocean Carbon Atlas (SOCAT) is a synthesis of quality-controlled, surface ocean CO_2 observations by the international marine carbon research community.[72] It is key for the quantification of the ocean carbon sink and the evaluation of ocean biogeochemical models. SOCAT data is publicly available, discoverable and citable. It has also been used for the evaluation of climate models and sensor data.[73]

Driving Technological Advancements through Global Competition— International engagement could drive positive technological competition in the mCDR sector, resulting in the most effective and affordable mCDR solutions. For instance, the nonprofit initiative Carbon to Sea was launched in 2023 to systematically evaluate promising ocean-climate solutions around the world. In year one, they awarded more than 22 million to researchers in the U.S, Canada, Germany, Australia and the United Kingdom to advance science and technology and began launching a global network of field research sites.[75] Japan has pledged to lead efforts to achieve decarbonization, economic growth and energy security in Asia and stated a need for $28 trillion to facilitate carbon removal in the region. The Global South has also begun engaging in mCDR discussions, particularly the role developing countries that depend on oceans can play in shaping CDR strategies and technologies.[76]

As interest in the promise of mCDR grows and more stakeholders become involved, it will be necessary to seek alignment to create a competitive and robust mCDR environment.

4. Conclusion

The Earth's oceans provide an incredible opportunity to reduce and remove global carbon dioxide emissions. U.S. federal lawmakers can support marine carbon dioxide removal technologies in several ways. While novel solutions, such as direct air capture, provide another path to removing carbon dioxide already in our atmosphere, ensuring support for a diverse set of solutions will avoid technology lock-in, optimize limited resources for innovation by leveraging the ocean's higher carbon concentration and carbon uptake capacity, as well as retain mCDR innovators ensuring American leadership of this nascent space.

The successful deployment and eventual commercialization of mCDR pathways in the U.S. to address global carbon removal commitments on time relies on the parallel establishment of a regulatory framework specific to mCDR innovations and a coordinated, transparent and robust research environment. Once a regulatory framework is established and comprehensive research has been conducted, policies that support the testing and demonstrating early-stage innovative technologies can be designed to provide targeted support for mCDR technologies. These policies would allow mCDR technologies to avoid the innovation "Valley of Death." Demand-side support mechanisms such as procurement, federal loans and tax policies can support the wide-scale commercialization of mCDR solutions. Finally, policies prioritizing early stakeholder engagement and education, federal agency coordination and research community collaboration provide a cohesive and structured approach to mCDR development that optimizes and coordinates federal and private resources.

Appendix

Table A1. Federal Support for mCDR Projects

Funding Source Abbreviations

- DOE- FECM: Department of Energy- Fossil Energy and Carbon Management
- DOE- ARPA-E: Department of Energy- Advanced Research Projects Agency- Energy
- NOAA: National Oceanic and Atmospheric Administration
- OAP: Ocean Acidification Program
- GOMO: Global Ocean Monitoring and Observing
- WPTO: Water Power Technologies Office
- NSF: National Science Foundation
- ONR: Office of Naval Research

Funding Source	Program	mCDR Project	Lead Institution	Location	Total Value
DOE-FECM	Investments for Carbon Management R&D Projects	Ocean-Based Carbon Capture, Storage, and Alkalinity Improvement by a Seawater-Regenerated Metal-Polymer Hybrid Sorbent	Advanced Cooling Technologies, Inc	Lancaster, PA	$249,999
DOE-FECM	Investments for Carbon Management R&D Projects	Atmospheric CO2 Removal via Direct Ocean Capture on an Offshore Platform	Captura Corporation	Pasadena, CA	$249,919
DOE-FECM	Investments for Carbon Management R&D Projects	Optimizing the integration of aquaculture and ocean alkalinity enhancement for low-cost carbon removal and maximum ecosystem benefit	Ebb Carbon, Inc.	San Carlos, CA	$250,000
DOE-FECM	Investments for Carbon Management R&D Projects	Ocean Energy Carbon Removal	Ocean Energy USA LLC	Sacramento, CA	$250,000
DOE-FECM	Investments for Carbon Management R&D Projects	Development of Modular Electrochemical Tubes to Remove Dissolved Inorganic Carbon from Ocean	University of Houston	Houston, TX	$250,043
DOE-FECM	Investments for Carbon Management R&D Projects	Depolarized Electrochemical Reactor for Ocean Alkalinity Enhancement and Facile Recovery of High Purity Carbon	University of Kentucky Research Foundation	Lexington, KY	$249,998
DOE-FECM	Investments for Carbon Management R&D Projects	Hydrolytic Softening for Ocean Carbon Dioxide Removal	University of North Dakota Energy & Environmental Research Center (EERC)	Grand Forks, ND	$235,935
DOE-FECM	Investments for Carbon Management R&D Projects	TRACER: Electrochemical Removal of Carbon Dioxide from Oceanwater: Field Validation	University of Texas at Arlington	Arlington, TX	$250,000
DOE-ARPA-E	Sensing Exports of Anthropogenic Carbon through Ocean Observation (SEA-CO2)	Scalable, Multiparameter Chip-Size Carbon Sensors	Woods Hole Oceanographic Institution	Woods Hole, MA	$3,738,960

DOE-ARPA-E	SEA-CO2	Acoustic Methods for mCDR based on Blue Carbon Burial in Seagrass Meadows	University of Texas at Austin	Austin, TX	$2,034,903
DOE-ARPA-E	SEA-CO2	Monitoring, Reporting and Verification of Zooplankton-Mediated Export Pathways for Carbon Sequestration	Bigelow Laboratory for Ocean Sciences	East Boothbay, ME	$2,279,867
DOE-ARPA-E	SEA-CO2	SLEUTH: Spectroscopy of Oceanic Liquid Environments Using Towed Optical Sensor Heads	University of Colorado, Boulder	Boulder, CO	$5,904,233
DOE-ARPA-E	SEA-CO2	A Scalable, Integrated, Real-Time, GPU-Based Modeling System to Enable MRV for mCDR	atdepth MRV	Cambridge, MA	$2,524,964
DOE-ARPA-E	SEA-CO2	SEAfloor Self-sustaining CO2 Assessment Probe Edge (SEASCAPE)	University of Utah	Salt Lake City, UT	$2,004,554
DOE-ARPA-E	SEA-CO2	Spatially Resolved Multi-Parameter Sensing Of Ocean Carbon Dynamics Utilizing Fiber Optic Time-Of-Flight Sensors	General Electric (GE) Research	Niskayuna, NY	$4,274,658
DOE-ARPA-E	SEA-CO2	Hybrid Distributed pH, CO2, Temperature, and Acoustic Sensing for Monitoring and Verification of Marine Carbon Dioxide Removal Applications	University of Pittsburgh	Pittsburgh, PA	$2,274,859
DOE-ARPA-E	SEA-CO2	Quantification of Atmospheric Carbon Dioxide Removal Using an Autonomous Ocean Sensor that Measures Sinking Particulate Carbon Flux	Woods Hole Oceanographic Institution	Woods Hole, MA	$4,802,245
DOE-ARPA-E	SEA-CO2	Integrated Experimental and Modeling Assessment of Ocean Alkalinity Enhancement for Scalable Marine Carbon Dioxide Removal	Pacific Northwest National Laboratory	Seattle, WA	$2,080,715
NOAA OAP and NOPP	Investments to Advance mCDR Research	Carbon capture and ocean acidification mitigation potential by seaweed farms in tropical and subtropical coastal environments	Scripps Institution of Oceanography	San Diego, CA	$1,451,575
NOAA	Investments to Advance mCDR Research	Assessing chemical and biological implications of alkalinity enhancement using carbonate salts obtained from captured CO2 to mitigate negative effects of ocean acidification and enable mCDR	Scripps Institution of Oceanography	San Diego, CA	$995,891
DOE-FECM and WPTO	Investments to Advance mCDR Research	Electrolysis-driven weathering of basic minerals for long-term ocean buffering and CO2 reduction	Oregon State University	Corvallis, OR	$2,000,000
NOAA-GOMO, NOAA-OAP, NSF	Investments to Advance mCDR Research	Multiscale observing system simulation experiments for iron fertilization in the Southern Ocean, Equatorial Pacific, and Northeast Pacific	Woods Hole Oceanographic Institute	Woods Hole, MA	$1,983,731
NOAA	Investments to Advance mCDR Research	An opportunity to study Ocean Alkalinity Enhancement, CDR, and ecosystem impacts through coastal liming	University of Rhode Island	Kingston, RI	$1,538,452
NOAA	Investments to Advance mCDR Research	Tidal wetlands as a low pH environment for accelerated and scalable olivine dissolution	United States Geological Survey	Reston, VA	$1,895,531
NOAA	Investments to Advance mCDR Research	Assessing the laboratory and field responses of diatoms and coccolithophores to ocean alkalinity enhancement	Woods Hole Oceanographic Institution	Woods Hole, MA	$1,026,045

NOAA	Investments to Advance mCDR Research	Determining the Influence of Ocean Alkalinity Enhancement on Foraminifera Calcification, Distribution, and CaCO3 Production	Vassar College	Poughkeepsie, NY	$510,359
DOE-FECM	Investments to Advance mCDR Research	Assessing the effects and risks of ocean alkalinity enhancement on the physiology, functionality, calcification, and mineralogy of corals and crustose coralline algae in the Pacific	University of Hawai'i, Manoa	Honolulu, HI	$1,999,835
NOAA	Investments to Advance mCDR Research	Assessing Carbon Dioxide Removal and Ecosystem Response for an Ocean Alkalinity Enhancement Field Trial	Woods Hole Oceanographic Institution	Woods Hole, MA	$1,877,644
NOAA, ClimateWorks Foundation	Investments to Advance mCDR Research	Assessing efficacy of electrochemical ocean alkalinity enhancement at an existing outfall using tracer release experiments and oceanographic models	University of Hawaii	Honolulu, HI	$1,915,600
NOAA	Investments to Advance mCDR Research	Quantifying the Efficacy of Wastewater Alkalinity Enhancement on mCDR and Acidification Mitigation in a Large Estuary	University of Maryland Center for Environmental Science	College Park, MD	$1,864,561
NOAA	Investments to Advance mCDR Research	Biotic calcification impacts on marine carbon dioxide removal additionality	University of Washington (CICOES)	Seattle, WA	$1,250,482
NOAA	Investments to Advance mCDR Research	Developing a coupled benthic-pelagic biogeochemical model to evaluate the effectiveness of mCDR interventions	Northeastern University	Boston, MA	$1,258,967
ONR, ClimateWorks Foundation	Investments to Advance mCDR Research	Engaging U.S. Commercial Fishing Community to Develop Recommendations for Fishery-Sensitive mCDR Governance, Collaborative Research and Monitoring, and Outreach to Fishing Communities	Responsible Offshore Development Alliance	Washington, DC	$1,258,967
ONR	Investments to Advance mCDR Research	Coupling Desalination with Novel mCDR Membranes	University of Pittsburgh	Pittsburgh, PA	$1,403,802
NSF, NOAA OAP	Investments to Advance mCDR Research	Data requirements for quantifying natural variability and the background ocean carbon sink in mCDR models	Columbia University	New York, NY	$589,464

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Ocean CDR Permitting and Regulations 101

The ocean is a promising tool for carbon dioxide removal (CDR). It covers over 70% of the surface area of the planet, holds about 50 times more carbon than the atmosphere, and can store carbon for millennia at its deepest depths. The ocean removes carbon dioxide from the atmosphere through two main ways: 1) a natural chemical adjustment system: where the seawater absorbs carbon dioxide from the atmosphere, and 2) by photosynthesis of organisms, like seaweed, to remove carbon. Together, this shows that ocean CDR has a substantial ability to scale.

Ocean CDR innovations are in the early stages of research and development, with most innovations occurring in a laboratory setting and some companies conducting early field trials. These efforts are important, but in order to move from the lab to deployment, widespread field tests are necessary to understand and validate the effectiveness in a real ocean environment. Today, real-world ocean CDR tests are nearly impossible to conduct in the U.S. due to unclear regulatory processes and laws. Additionally, situations with existing regulatory frameworks, that may include CDR activities, require an arduous and opaque permitting process. For instance, early field trials in the U.S. are being performed by start-ups like Planetary through wastewater permits, and Vesta through beach restoration. Without changes and clarifications, the current U.S. regulatory processes and laws pose significant challenges for full-scale deployment of ocean CDR and could send U.S. innovators to develop and deploy in countries with more favorable regulatory systems.

We are beginning to see this happen. RunningTide, a Maine-based ocean CDR start-up, is building its first global research and development base in Iceland, in part due to different in-ocean regulations. Similarly, Planetary, whose technology was originally conceived at the Lawrence Livermore National Labs in California, has focused work in the United Kingdom and Canada, for similar reasons. A clear and predictable U.S. regulatory process for ocean CDR pathways is needed to ensure that America can lead the world in ocean CDR research, development, and deployment (RD&D).

The ocean's natural chemical adjustment system removes CO2 from the atmosphere to balance the amount of CO2 in the atmosphere and the ocean. Therefore, with increasing atmospheric CO2, the ocean absorbs more CO2, which leads to ocean acidification, which has impacted ocean health, and has reduced the ability of the ocean to act as a carbon sink. Ocean CDR pathways are a potential method to deacidify the ocean to maintain its crucial role in global carbon sequestration.

Table 1. Comparison of Ocean Carbon Dioxide Removal Pathways

Ocean CDR Pathway	Technological Readiness	Cost Range ($/ton CO2 removal)	Scale (Gt CO2 Removal/yr)	Storage Duration (years)	Research Groups and Start-Ups
Macroalgae Cultivation (Seaweed/Kelp)	Moderate	$25 - $125	Low (0.1 - 0.6)	Low - Moderate (10 - 100 Years)	Macro Oceans, Phykos, RunningTide
Alkalinity Enhancement	Low-Moderate	$25 - $160	Moderate - High (1 - 15+)*	High (>20,000 years)**	Planetary, Vesta
Electrochemical Ocean CDR/ Direction Ocean Capture	Low-Moderate	$400 - $600	Moderate (1 - 10)	High, using geological storage (>1,000 years)	Captura, Ebb Carbon, Equatic, Heimdal, Massachusets Institute of Technology
Artificial Upwelling/ Downwelling	Low	$100 - $150	Low (0.1 - 0.4)	Low - Moderate (10 - 100 years)	Ocean-Based Climate Solutions, Inc., The Climate Foundation

Source: NOAA
* The State of Carbon Removal of 2023 report estimates alkalinity enhancement upper-bound to be 100 Gt CO2 removed per year.
** The mean seawater residence time of alkaline dissolved carbon is about 100,000 years, based on the annual input of alkaline carbon from rivers (0.3 GtC/yr), the alkaline pool of dissolved alkaline carbon resident in the ocean (about 34,000 GtC), and assuming steady state.

The Need for an Ocean CDR Regulatory Framework

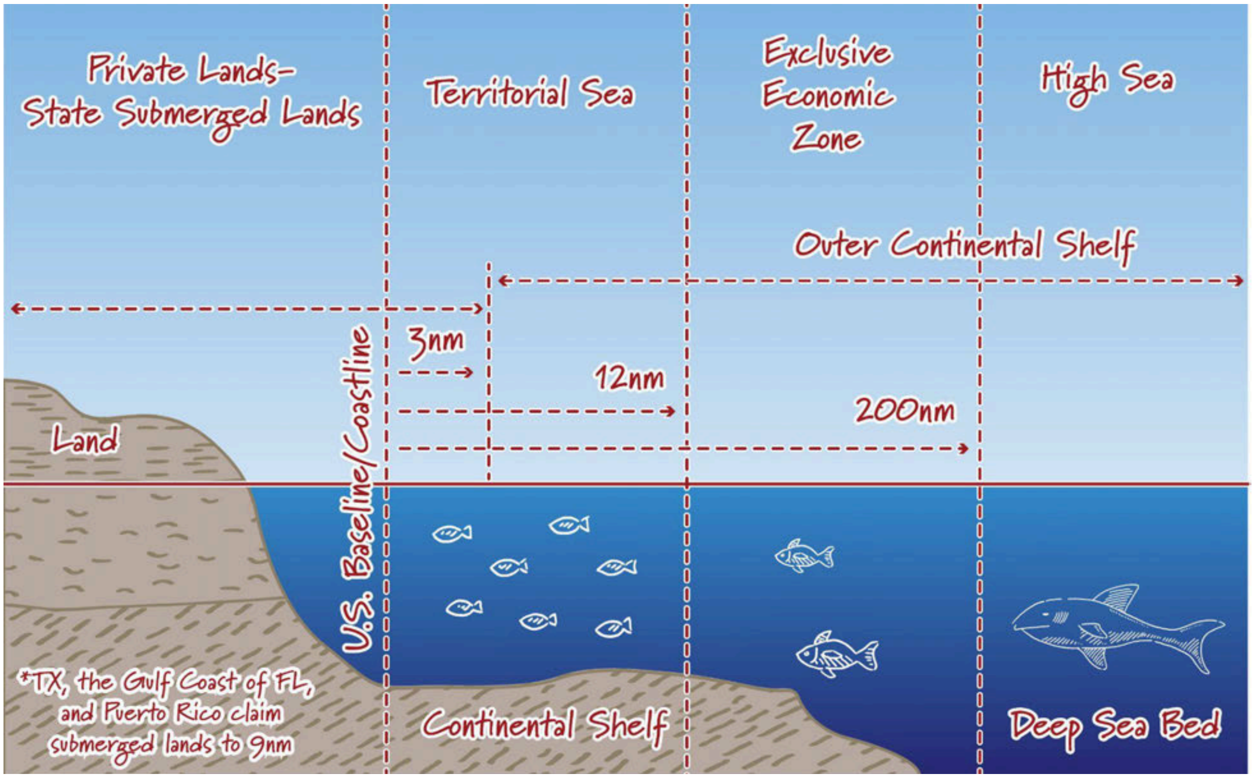
There are a number of promising ocean CDR pathways, **Table 1** compares the different types of innovations. For a full summary of each ocean CDR and storage pathway explore our Carbon Dioxide Removal 101.

However, there is no legal framework specific to ocean CDR RD&D in the United States. Instead, existing projects are shoehorned into several, often outdated, environmental regulations and laws which regulate other activities – such as aquaculture, wastewater or the dumping of hazardous materials into the ocean. Under these laws, ocean CDR projects would be subject to multiple overlapping permitting processes and other requirements (see the **Appendix** for details). Additionally, even within this shoehorning approach, different laws apply to different types of ocean CDR projects.

Some technologies may require the installation of structures onto the seafloor in the Outer Continental Shelf (OCS), outlined in **Figure 1**. Other projects may sink materials to the ocean floor within the U.S. waters but outside the OCS. Each of these pathways is governed by different laws, and innovators lack the clarity needed to proceed with testing. The legal jurisdictions of federal U.S. waters are highlighted in **Figure 2**, and the locations of existing beach nourishment sites described and presented in the **Appendix**.

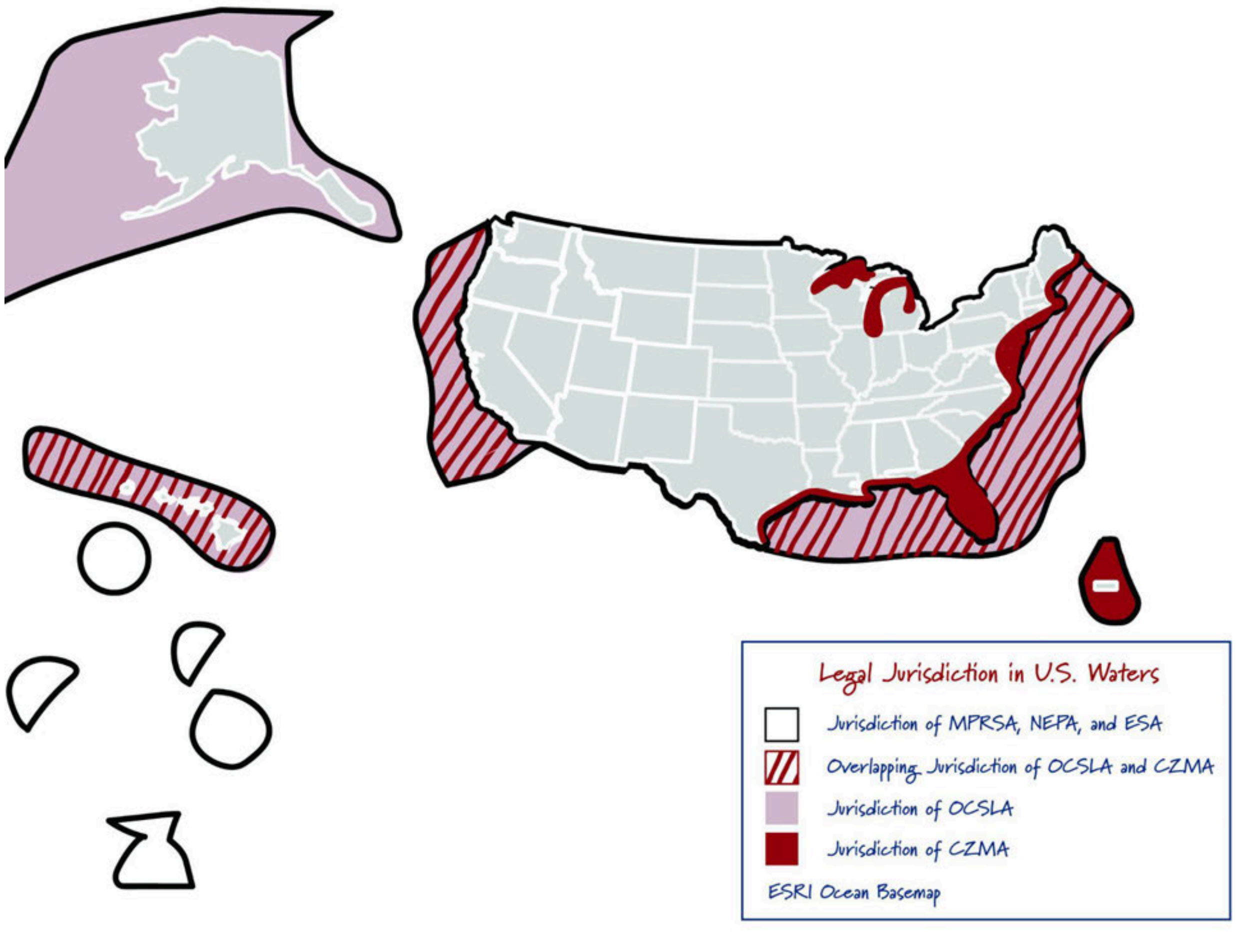
Updates to the regulatory process should be made to ensure timely and transparent regulatory processing while addressing any risks.

Figure 1. Maritime Zones



Source: [NOAA]()

Figure 2. Map of the Legal Jurisdictions of Federal U.S. Waters



The development of clear and streamlined legal frameworks for ocean CDR is also essential for facilitating a better understanding of appropriate legal safeguards to minimize the risks of potential negative environmental and social outcomes. Clearly defined requirements in these legal frameworks simplify the permitting of projects, reduce uncertainties and risks, and help promote greater confidence among investors, policymakers, project developers, other stakeholders, and the general public.

The ocean CDR RD&D regulatory framework could be developed by an interagency rulemaking team to provide comprehensive legal guidance in developing different ocean CDR pathways in U.S. ocean waters. The interagency rulemaking team may comprise experts from federal, state, tribal, and local groups involved in existing ocean regulations, some of which are described in **Table 2** and the **Appendix**.

Ocean CDR testing is already occurring at a small scale in the U.S, early planning for potential large-scale deployment of ocean CDR pathways, by establishing a clear and predictable U.S.

regulatory process is necessary to ensure that America can lead the world in ocean CDR research, development, and deployment.

Table 2. Existing ocean regulations and permitting requirements that may impact scalable deployment of ocean CDR pathways

Purpose for Permitting	Description	Relevant Ocean CDR Pathways	Agencies Involved	Required Approvals (Brackets Indicate the Responsible Agency)
Construction/ Operation of Structures Not Attached to the Seabed	Actions include the installation of nets, lines, or other growing media, moored pipes and other equipment.	Macroalgae cultivation Artificial upwelling/ downwelling	U.S. Coast Guard (USCG) State Environmental Agencies	Aids to Navigation Program (USCG) USCG will also perform environmental reviews under: NEPA, ESA, CZMA
Construction/ Operation of Structures Attached to the Seabed	Co-location with offshore wind turbines to power ocean CDR pathways or floating pipes.	Macroalgae cultivation Ocean alkalinity Electrochemical Ocean CDR/ Direct Ocean Capture Artificial upwelling/ downwelling	Bureau of Ocean Energy Management (BOEM) U.S. Army Corps of Engineers (USACE) USCG State Environmental Agencies	Outer Continental Shelf Lands Act* (BOEM) Aids to Navigation Program (USCG) BOEM will also perform environmental reviews under: NEPA, ESA, CZMA, NHPA, AIRFA If the structure will attach to the seabed: Rivers and Harbors Act (USACE) USACE will also need to perform environmental reviews under: NEPA, CZMA
Discharging of Materials Into Ocean Waters	Actions include the installation of nets, lines, or other growing media.	Macroalgae cultivation Ocean alkalinity	Environmental Protection Agency (EPA) State environmental agencies.	Marine, Protection, Research, and Sanctuaries Act** (EPA) National Pollutant Discharge Elimination System (EPA) EPA will also perform environmental reviews under: NEPA, ESA, CZMA
Electrochemical Ocean CDR/ Direct Ocean Capture Projects on Federal Land	Electrochemical Ocean CDR/ Direct Ocean Capture projects may generate by-products to be transported to land and used in industrial processes.	Electrochemical Ocean CDR/ Direct Ocean Capture	USCG	Materials being transported to land need to be certified and meet design requirements. On-land hydrochloric acid storage may be subject to requirements under the Emergency Planning and Community Right-to-Know Act.

Sources: NASEM, Sabin Center for Climate Change Law reports on Seaweed Cultivation and Ocean Alkalinity.

Implementation of an Ocean CDR Regulatory Framework

Once an ocean CDR RD&D regulatory framework is developed, the responsibility of implementation of the permitting process would benefit from being housed under a single lead federal agency, to ensure a consistent and efficient permitting experience for ocean CDR project researchers and developers. With a designated lead federal agency, permit-seeking applicants would no longer require approval from multiple agencies that may have varied levels of experience on ocean CDR. Additionally, this structure allows the lead federal agency to continuously gain experience to support and update the ocean CDR RD&D permitting process. The lead agency may choose to seek clarification or consultation from other agencies to ensure decisions are made with the most current knowledge of ocean CDR.

Criteria for selecting a lead agency may include extensive experience in ocean regulatory and permitting processes, knowledge about ocean CDR technologies, the capacity to establish and maintain a permitting office for the expanding and evolving ocean CDR industry, and experience with community engagement to establish projects.

Table 3. Agencies Involved in Ocean CDR Research and Permitting

Agency	Ocean CDR Tools	Permitting Experience
Bureau of Ocean Energy Management (BOEM)	Currently performing community engagement to develop a regulatory framework for offshore geologic storage of carbon dioxide with BSEE.[7]	Responsible for permitting all U.S. offshore exploration and developments through OCSLA.
Department of Energy (DOE)	Announced $30 million in funding to remove carbon from the air and oceans and convert it to valuable products.[8] ARPA-E announced $45 million to validate ocean CDR techniques.[9]	Funded and houses an online permitting toolkit for improving the efficiency and effectiveness for marine energy permitting.[10]
Environmental Protection Agency (EPA)	Monitoring ocean chemistry changes over time.[11]	Issues many different permits, including for ocean dumping MPRSA and the Clean Water Act.
Department of Defense (DOD)	The U.S. Naval Research Laboratory performs research on extracting carbon dioxide from seawater.[12]	The U.S. Coast Guard and Army Corps of Engineers are responsible for permitting coastal activities.
National Oceanic and Atmospheric Administration (NOAA)	Highlighted ocean CDR research and MRV capabilities in a recent white paper.[13] Grant opportunities for ocean CDR related to ocean acidification.[14] Upcoming funding opportunities for ocean CDR measurements and accountability.[15]	Issues permits for activities in marine sanctuaries.

Sources: NETL, ARPA-E, DOE-EERE, EPA, U.S Naval Research Lab, NOAA, NOAA-mCDR, NOAA-IOOS.

Policy

A variety of ocean CDR pathways aim to effectively maximize the ocean's carbon removal ability in the early stages of R&D. The development of a streamlined and consolidated legal framework, with the purpose of simplifying the ocean CDR permitting process, would provide clarity to researchers and project developers. Policy priorities in ocean CDR include:

Regulatory Permitting

1. *Interagency Development of a Legal Framework* — The Council on Environmental Quality (CEQ) would lead the development of an ocean CDR legal framework to clarify and streamline existing permitting requirements and laws, and coordinate with relevant agencies to access permitting experience and ocean CDR knowledge. Relevant agencies would include the Bureau of Ocean Energy Management (BOEM), the U.S. Coast Guard (USCG), the Environmental Protection Agency (EPA), the Army Corps of

Engineers (USACE), the National Oceanic and Atmospheric Administration (NOAA), the Department of Energy (DOE) , and the Department of Defense (DOD).

2. *Implementation of the Legal Framework* — The Bureau of Ocean Energy Management (BOEM) would be the lead federal agency to guide the implementation of the ocean CDR legal framework, because of their extensive oceanic permitting experience, that covers the Outer Continental Shelf. Additionally, many ocean CDR pathways may require attachment to the seabed, which is under BOEM's permitting jurisdiction. BOEM is also currently responsible for developing a regulatory framework for offshore geologic storage of carbon dioxide. BOEM would work in coordination with other federal agencies to ensure the accurate permits are issued to ocean CDR projects.
3. *Resolution of Potential Disputes* — CEQ would be the ideal agency to settle disputes between ocean CDR permitting agencies over conflicting interpretations of the ocean CDR legal framework as CEQ would have led the development of the legal framework and best understand the coordination between agencies. A time frame of no longer than 30 days, may be established to resolve any disputes.

Research and Development

4. *Interagency Coordination* — DOE & NOAA would be best suited to coordinate ocean CDR research and development. To date, DOE has led the charge in ocean CDR laboratory research. However, to truly understand applied ocean CDR solutions, NOAA must lead in facilitating research and testing in the ocean. Because ocean CDR is a uniquely diverse solution that ranges from engineered to natural solutions, pathways for research and testing, in addition to relevant permitting, are housed under various agencies. As such, it can be difficult to determine ownership among agencies, and DOE, NOAA, DOI, EPA, NSF, and DOD could ensure robust coordination and collaboration across agencies.

Conclusion

Innovations in ocean CDR pathways have the potential to sequester carbon at scale. However, the absence of a clear regulatory framework specific to ocean CDR RD&D in the U.S, results in ocean CDR projects being shoehorned into several, often outdated, environmental regulations and laws which regulate other activities. Policies for the development and implementation of a streamlined and consolidated legal framework, with the purpose of simplifying the ocean CDR permitting process, would provide clarity to researchers and project developers, and ensure that America can lead the world in ocean CDR RD&D.

Appendix

U.S. Laws Relevant to Ocean CDR

The following laws may impact ocean CDR pathways depending on the location of projects (see Figure 1). Projects within state waters, typically up to three nautical miles from the coast, but nine nautical miles from Texas, Florida, and Puerto Rico, may be subject to state and/or local laws. Federal laws will apply to projects in federal waters, up to 200 nautical miles beyond state waters, while some projects may require additional activity on federal lands.

Seabed Use Laws

- The Outer Continental Shelf Lands Act (OSCLA) authorizes the BOEM to issue leases for energy and mineral development and related activities on the outer continental shelf (OCS). Currently, there is no framework for leasing the OCS for other purposes, like ocean CDR. The Infrastructure Investment and Jobs Act of 2021 directed BOEM to issue a regulatory framework for offshore geologic storage of carbon dioxide, which has not yet been issued, and it is unclear whether that guidance will address ocean CDR in a comprehensive manner.
- Coastal states regulate the use of state waters and generally require a lease for authorization.

Ocean Discharge Laws

- The Marine Protection, Research, and Sanctuaries Act (MPRSA) or the “Ocean Dumping Act” requires a permit for discharges from a vessel, aircraft, or manmade structure within 12 nautical miles from the coast and beyond in other areas where the materials dumped are transported from the U.S. or on a U.S. registered vessel or aircraft.
- The Clean Water Act (CWA) applies to the discharge of “dredge or fill” materials or “pollutants,” including “rock”, within 3 nautical miles of the U.S. coast.
- The National Pollutant Discharge Elimination System (NPDES) regulations, which have authority from the CWA, regulate discharges into the ocean through pipes.

Environmental Review Laws

- The National Environmental Policy Act (NEPA) requires the preparation of an environmental impact statement that analyzes the natural, economic, social, and cultural resource effects of the project and alternatives. This must be developed with public input and possibly consultation with Native American Tribes.
- State NEPA equivalents, where they exist, will regulate ocean CDR in state waters.

Coastal and Ocean Management Laws

- The Coastal Zone Management Act (CZMA) requires federal agency activities that impact the coasts to be consistent with state coastal management plans.
- The National Marine Sanctuaries Act (NMSA) impacts projects conducted in, or affects, areas designated as marine sanctuaries.

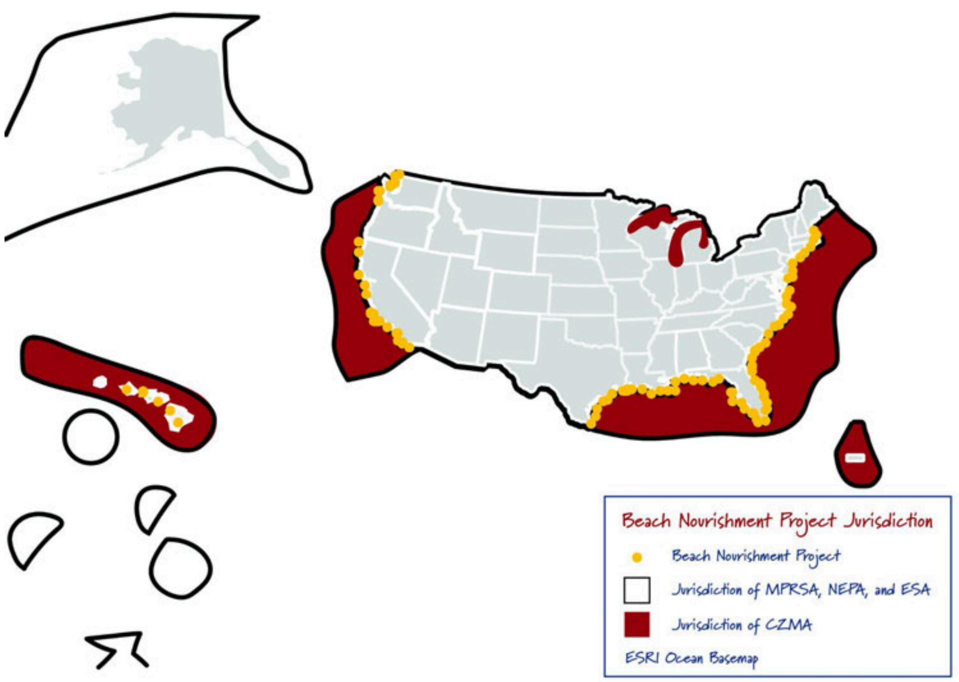
Species Protection Laws

- The Endangered Species Act (ESA) requires federal agencies to ensure actions will not harm the continued existence of any endangered or threatened species.
    - Consultation with the U.S. Fish and Wildlife Service is required for any action that could affect land-based species.
    - Consultation with the National Marine Fisheries Service is required for any action that could affect marine species.
- The Marine Mammal Protection Act (MMPA) prohibits government and private actors from killing, harming, or taking endangered species and marine mammals.
  The Magnuson-Stevens Fishery Conservation Management Act (MSFCMA) designates consultation with NMFS if fish habitats may be harmed and establishes regional fisheries councils to develop fisheries management plans designed to restore depleted stocks and set annual catch limits to prevent overfishing.

Other Laws

- The National Historic Preservation Act (NHPA) requires federal agencies to consider the impact of projects on historic properties and provide opportunities for comment before implementation from the Advisory Council on Historic Preservation.
- The American Indian Religious Freedom Act (AIRFA) protects and preserves American Indian access to sites, use, and possession of sacred objects, and the freedom to worship.

Appendix Figure 1. Beach Nourishment Projects in the U.S. Overlaying Federal U.S. Water Jurisdictions



Source: *https://www.marinecadastre.gov/*

Beach nourishment is the process of adding large quantities of sand or sediment on a beach or in the nearshore, often to combat erosion and increase beach width. The length of total coastlines with beach nourishment is 962.4 miles. Florida has a fifth (~21%) of all projects. The ocean CDR start-up, Vesta, is implementing a beach nourishment project at North Sea Beach in the Town of Southampton. This project includes Coastal Carbon Capture, to advance climate science research, by placing olivine sand onto the North Sea Beach Colony frontage. Olivine is used for enhanced weathering, because it is a common and naturally occurring silicate material that removes carbon dioxide when it dissolves in water, and permanently stores it in the ocean as carbonate and bicarbonate.

From: Frances Simpson-Allen
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Comment from Ebb Carbon in Response to Request for Information on Marine Carbon Dioxide Removal Research Plan, 89 FR 13755
Date: Tuesday, April 23, 2024 5:08:15 PM
Attachments: Comment from Ebb Carbon in Response to Request for Information on Marine Carbon Dioxide Removal Research Plan, 89 FR 13755.pdf

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Dear Tricia,

On behalf of Ebb Carbon, thank you for the opportunity to share our perspective and recommendations for the federal Marine CDR Research Plan.

Please find attached our response. Should you have any questions or points of clarification, please do not hesitate to reach out.

We stand ready to discuss these recommendations in further detail and look forward to working with Members of the MCDR-FTAC to advance its work.

Best,
Frances

Frances Simpson-Allen | Director, Policy & Market Development | ebbcarbon.com

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April 23, 2024

White House Office of Science and Technology Policy
National Science and Technology Council
Marine Carbon Dioxide Removal Fast-Track Action Committee
Executive Office of the President
Eisenhower Executive Office Building
1650 Pennsylvania Avenue
Washington, D.C. 20504

VIA EMAIL: (b) (6) [redacted]

RE: Comment from Ebb Carbon in Response to Request for Information on Marine Carbon Dioxide Removal Research Plan, 89 FR 13755

Dear Members of the FTAC,

On behalf of Ebb Carbon, a marine carbon dioxide removal (mCDR) start-up based in California and pursuing a pilot project in Washington State, thank you for this opportunity to share our perspective and recommendations for the federal Marine CDR Plan ("Plan").

The potential of marine CDR is tremendous and will be an essential component of any carbon removal portfolio needed for the United States to meet its climate goals. We believe that Ebb Carbon's technology has the potential to be one of the most efficient and effective ways to remove carbon dioxide (CO_2) pollution from our atmosphere, and we are committed to the safe and responsible development and deployment of our approach.

Please find enclosed our response to the Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC) detailing the following key recommendations:

1. Develop fit-for-purpose regulatory pathways with general permits tailored to the mCDR industry
2. Invest in shared infrastructure and sites for effective monitoring, reporting and verification (MRV) of mCDR in-situ
3. Enable public-private partnerships to advance the field most safely, effectively and responsibly

We stand ready to discuss these recommendations in further detail and look forward to working with Members of the MCDR-FTAC to advance its work.

Sincerely,

Frances Simpson-Allen
Director, Policy & Market Development

I. Background

A. Ebb Carbon

Built on years of academic research, Ebb Carbon has developed an mCDR technology to safely and permanently remove CO2 from the atmosphere while reducing coastal acidification. Ebb's approach, known as electrochemical ocean alkalinity enhancement (OAE), accelerates the ocean's natural ability to absorb and store CO2 from the atmosphere while keeping critical ocean ecosystems healthy. It works by running seawater through a stack of ion-selective membranes that separate the seawater into acidic and alkaline solutions. Alkaline-enhanced seawater is returned to the ocean, which reduces the acidity of seawater and enables the ocean to draw down and store additional CO2 from the atmosphere. Over time, the alkaline solution reacts with dissolved CO2 in seawater to create bicarbonate (HCO3), a stable form of carbon storage for 10,000+ years.

Since 2023, Ebb Carbon has been operating a 100-tonne/year system at the marine labs at the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL) in Sequim, Washington. This is a unique deployment with public, private, academic and philanthropic partners that is designed to advance the field of mCDR and ensure that future deployments are safe, responsible, and science-driven. The scope of this work includes:

- Running experiments to measure and model CO2 removal via Ebb's process
- Developing advanced ocean modeling tools to better understand how Ebb's process removes carbon and mitigates coastal acidification
- Researching impacts on local marine life including oysters and eelgrass epifauna—important food sources for salmon
- Publishing our research to drive understanding and transparency

In addition, Ebb is in the process of developing a temporary pilot-scale project in Port Angeles Harbor, WA, which suffers from ocean acidification (OA). We've been working with local Indian Tribes and stakeholders to inform site selection and project design, including state and federal agencies, City and Port officials, local utilities, and NGOs. This pilot project is designed to operate Ebb's technology under real-world conditions, support research through scientific and academic collaborations, and gather additional data to inform future deployments. This proposed field trial is conservatively designed to remove 500 net tonnes of CO2 from the atmosphere per year and reduce coastal acidification.

B. Ocean Climate Action Plan

The U.S. Ocean Climate Action Plan (OCAP) calls upon the whole of government to accelerate mCDR and other solutions that further the ability of coastal and ocean systems to absorb and store greenhouse gases (GHG) and protect communities and ecosystems against the worst impacts of climate change. In particular, the OCAP recognizes a nationwide need to significantly and rapidly "ramp up" mCDR research and development, investments, and interagency coordination to ensure safe and effective implementation and regulation of these approaches. The OCAP also recognizes a nationwide need for a coordinated effort to address OA. Ebb's technology appears to be especially promising for drawing down CO2 and addressing coastal OA by restoring the pH of local waters closer to pre-anthropogenic conditions, and Ebb is making headway in advancing each of the OCAP's recommendations for mCDR and OA.

II. Response

The federal government plans to help those implementing OCAP's recommendations through the forthcoming Marine CDR Plan. This Plan could enable Ebb to develop, demonstrate, and scale its technology faster and more cost effectively than it could on its own, unless the Plan comes too late or is practically inactionable. Ebb offers the following responses to help guide and orient this Plan so that it proves valuable to the entities at the front lines of developing and deploying solutions to timely address the dual and interrelated crises of climate change and ocean acidification, consistent with OCAP.

A. Regulatory Compliance and Other Standards and Policies

What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Ebb's primary concern relates to the misalignments between the current regulatory regime and the remedial purpose of, and urgent need for, mCDR. Ebb has followed a science-first approach and has set regulatory compliance as the floor of the standards that it aims to meet. Starting approximately two years ago, before even selecting a site for its proposed pilot project, Ebb hired experienced local counsel and environmental, cultural resource, and community engagement consultants to ensure it obtains all regulatory permits and approvals needed to construct and operate its pilot project. Ebb also has developed, and is continuing to develop, partnerships and collaborations with Pacific Northwest National Laboratory-Sequim, the University of Washington, the Port of Port Angeles, and Indian Tribes with historical and current lands and waters in the project vicinity to test thoroughly the safety and efficacy of Ebb's mCDR system. This work includes development of an ecological safety methodology setting forth an adaptive management plan governing Ebb's pilot-scale operations, for which Ebb has and will continue to seek Tribal, scientific, and academic input.

Ebb has put significant time, effort, and resources into understanding its regulatory requirements and the needs and priorities of Washington's greater Salish Sea community, which is adversely impacted by OA. Ebb's pilot project requires numerous permits and approvals (see annex). Ebb has been fortunate to be assigned local, state, and federal regulators that, like Ebb, recognize the urgency of the climate crisis and are committed to ensuring climate technologies are deployed responsibly. Still, the permitting process has been costly and time-consuming with some redundancies and misalignments in oversight.

For example, it is a mismatch of purpose for an NPDES/SWD permit to set terms and conditions for Ebb's discharge of alkaline-enhanced seawater. An NPDES/SWD permit limits the effluent that a polluter may discharge to waters of the state. Ebb is not a polluter asking permission to discharge effluent waste; rather, Ebb will intentionally release a product for a common beneficial purpose–to address global climate change and improve water quality by lowering the acidity of local waters, restoring them closer to pre-anthropogenic conditions. Ebb cannot meaningfully drawdown CO2 and raise the pH of local waters unless it discharges a highly alkaline solution that will mix with receiving waters. The NPDES/SWD permitting process and state and federal regulations are not designed to encourage releases, nor are they designed to promote restoration, which complicates permitting and may frustrate the success of mCDR-OAE.

We are concerned that unless the permitting process is streamlined and better fit to the purpose of regulating mCDR companies, the process of “ramping up” mCDR research and development may be too slow to stave off the worst impacts of climate change on coastal communities. Ebb’s next deployment, which will be a larger and longer pilot project based on the learnings of this first deployment, could benefit from prompt regulatory reform consistent with OCAP’s recommendations. We respectfully request MCDR–FTAC support:

(1) the USACE in establishing a general, nationwide permit for the construction and operation of mCDR infrastructure deployed along shorelines or over-water in the nearshore environment compliant with Section 404 of the CWA and Section 10 of the RHA and

(2) state governments and the U.S. Environmental Protection Agency (EPA) in establishing a general permit for restorative, non-pollutive discharges under Section 402 of the Clean Water Act. For example, the Department of Ecology in WA has delegated authority to regulate discharges designed to improve water quality under WAC 173-201A-510(2), but no such permit has been developed.

Successful development and implementation of mCDR will require integrated and coordinated action across the federal government, in partnership with many but especially Indian Tribes and coastal states. Developing these general permits would provide mCDR technology developers with increased certainty around timelines and costs, and would reduce both for regulators and project developers. Establishing these general permits also could reassure the public that mCDR projects are uniformly operating responsibly with respect for environmental and cultural resources, as general permits have already undergone interagency and Tribal consultation and public comment. General permits are a defensible, commonplace regulatory pathway within the existing authority of these agencies. Ebb is not proposing to limit or remove stringent regulation, simply that MCDR-FTAC provide capacity support to enable federal and state governments to utilize the equally safe but more expeditious approaches to oversight available to them.

Additionally, Ebb encourages MCDR-FTAC to oppose misguided efforts to expand the authority of the London Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter/the London Protocol and the Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction into national waters to avoid overcomplicating and duplicating regulatory requirements pertinent to mCDR research and commercialization.

MCDR-FTAC should identify mechanisms in its Marine CDR Plan to financially and technically support development of these general permits. MCDR-FTAC should also identify mechanisms for providing capacity support to (1) Indian Tribes either collaborating with mCDR project developers or evaluating proposed mCDR projects in their traditional or current lands and waters, as well as (2) state governments keen to develop either an mCDR protocol for the compliance carbon credit market or sites for expedited permitting. Such financial and technical support could stimulate mCDR research and deployment that is timely, equitable, and just.

B. Federal Research Program

Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

The Federal Government should prioritize funding for research proportionate to the potential of mCDR, and specific approaches within, to deliver permanent, scalable carbon removal at the gigatonne (GT) scale. The National Academies found that mCDR pathways have an outsized ability to remove GT of CO2 by midcentury and that at a minimum, \$125M-\$200M in dedicated funding over the next 5-10 years is needed for OAE research alone. Additionally, a minimum of \$125M is needed for foundational research and coordination efforts that cross mCDR technologies.[1] Funding for development and deployment will need to match that ambition to bring OAE from laboratory and field research up to climate relevance. Electrochemical OAE approaches, such as that developed by Ebb Carbon, have the potential to deliver permanent, scalable and low-cost mCDR with local co-benefits in the mitigation of coastal acidification, and should be a major priority in the FTAC research agenda.

The Plan should emphasize and encourage in-water pilot trials for technologies like OAE that have met basic scientific thresholds of understanding. The basic science around OAE is well established and has been characterized as one of the low risk/high benefit methods by the Secretariat of the Scientific Group of the London Convention/London Protocol, with "well established fundamental rules based on carbonate chemistry"[2]. Among the growing body of research in OAE[3], Ebb's technology has been laboratory-tested in partnership with Pacific Northwest National Laboratory-Sequim and NOAA PMEL scientists to demonstrate CO2 uptake and storage in seawater[4]. Uncertainties in this field stem from extension to the field,

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[1] https://www.nationalacademies.org/our-work/a-research-strategy-for-ocean-carbon-dioxide-removal-and-sequestration

[2] https://climate.law.columbia.edu/sites/default/files/content/LC-SG%2047-3%20-%20London%20ConventionLondon%20Protocol%20joint%20consideration%20of%20risks%20and%20benefits%20ofmarine%20geoeng...%20(Secretariat)%20(2).pdf

[3] Oschlies, A., Stevenson, A., Bach, L. T., Fennel, K., Rickaby, R. E. M., Satterfi eld, T., Webb, R., and Gattuso, J.-P. (Eds.): Guide to Best Practices in Ocean Alkalinity Enhancement Research (OAE Guide 23), Copernicus Publications, State Planet, https://doi.org/10.5194/sp-2-oae2023

[4] Ringham, M., Hirtle, N., Shaw, C., Lu, X., Herndon, J., Carter, B., & Eisaman, M.: A comprehensive assessment of electrochemical ocean alkalinity enhancement in seawater: kinetics, efficiency, and precipitation thresholds. EGUsphere, 1-22, 2024
https://egusphere.copernicus.org/preprints/2024/egusphere-2024-108/
Jones, K., Hemery, L., Ward, N., Regier, P., Ringham, M.C., and Eisaman, M.D.: Biological response of eelgrass epifauna, Taylor's sea hare (Phyllaplysia taylori) and eelgrass isopod (Idotea resecata), to elevated ocean alkalinity. EGUsphere: 1-25, 2024
https://egusphere.copernicus.org/preprints/2024/egusphere-2024-972/
Carter, B.C., Khangaonkar, T., Eisaman, M.D.., Feely, R.A.,, Ward, N., Subban, C., Premathlake, L., Pilcher, D., and Hemery, L.: Electrochemical Acid Sequestration to Ease Ocean Acidification (EASE-OA) In 2024 NOPP PI meeting, New Orleans, LA, USA, Feb. 18, 2024.

where scaled alkalinity releases are necessary to verify model accuracy and to test assumptions of OAE applications. As such, research priorities should focus on the outstanding areas of investigation related to the real-world development and scaling of approaches already proven in lab testing. This should include investigation of the efficacy, permanence, scalability, cost, environmental impacts, and potential co-benefits of mCDR technologies. Critically, OAE research requires in-water pilot trials to advance our collective understanding of each of these targets. While recent federal funding has supported the development of upcoming field experiments (including, through the NOPP program, shipboard releases of alkalinity on the east coast and infrequent releases of alkalinity from coastal infrastructure), one-off mCDR trials are insufficient to address issues of scaling, siting, and environmental justice relating to continuous operations. We stress that operational testing and sustained learning during in-water field deployments from for-purpose mCDR infrastructure are required to advance OAE. Much of this work will be driven by technologies deployed at industrial sites on our coasts, in partnership with academic and government collaborators with data and outcomes shared across stakeholders. However, the lack of robust funding and absence of coordination mechanisms makes this effort challenging.

Federal support for ocean observation ranging across physical, chemical, and biological datasets within the context of industrial pilot sites, with expectations for transparent data sharing in place, would significantly advance our ability to test and improve OAE approaches. The FTAC should focus on ensuring that greater resources flow to key agencies tasked with supporting research efforts in coastal carbon cycling science, specifically NOAA, which is under-resourced in regards to seawater carbon observation infrastructure and personnel, and DOE, which is uniquely positioned to advance such technologies. Critically, Federal agencies must have effective mechanisms for coordination and collaboration, as well as pathways to more flexibly engage with ongoing private sector efforts and at a pace relevant to technology development.

Investment in observational sensing and modeling to assess both the carbon removal potential of mCDR and the environmental impacts proximal to an mCDR site are essential. Ebb's approach is promising because it leverages the ocean's vast surface area and ability to store dissolved carbon, but measurement in an open system has unique requirements. Ebb has invested significant resources in sensing at project sites, but current commercial sensors for seawater carbonate chemistry, nutrients, biological community assessment, and traditional aquatic chemistry are insufficient at scale. The upfront cost of high-quality carbon sensing and sampling is high, and development of or investment in novel sensing methods can be risky and prohibitively expensive for startups. ARPA-E's SEA CO2 program has recently funded investment in novel sensing for mCDR, but many of these sensing methods will come into play years into the future and do not solve the sensing needs of pilot trials and field experiments today critical to understanding which mCDR pathways may be viable. Specifically, most US coastlines are under sampled in regards to seawater carbonate chemistry, significantly limiting

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Khangaonkar, T., Ni, W., Premathilake, L., Yun, S.K., Carter, C.R., Subban, C., and Ringham, M.C.: Modeling the Effects of Alkalinity Enhancement Technology on Sequim Bay and Salish Sea, Marine Water Quality. In 2024 Ocean Sciences Meeting, New Orleans, LA, USA, Feb. 18, 2024.

our understanding of the conditions into which mCDR projects will be deployed. For the best possible outcomes in resolving questions of safety and efficacy of mCDR, federal agencies should be tasked with supporting observational efforts within and proximal to mCDR field sites.

Similarly, because mCDR works in open environments, we must improve the efficacy of ocean modeling to quantify near and far-field OAE efficacy, impacts, and uncertainties. Regional Ocean Models (ROMs) are crucial to evaluating mCDR approaches, but well-validated ROMs are limited in location, limited in inter-model comparisons to evaluate uncertainties in carbon parameters, and can computationally be prohibitively expensive to run at the resolution and range of input parameters required to characterize an mCDR approach. Investment in modeling efforts at the project level, focused on industry methods that have the potential to scale, will be crucial to advancing mCDR datasets.

Taken together, the research priorities for mCDR support the case for creating dedicated test beds where the most promising technologies could be piloted in-situ and at relevant scales. These test beds could facilitate the advancement of necessary sensors and ROMs for mCDR and enable effective data sharing and collaboration between cross-sector stakeholders including Federal agencies, researchers, technology developers, CDR off takers and local communities.

C. Public-Private Partnerships

What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Public-private partnerships, when sufficiently resourced and enabled, have the potential to advance science at a speed and with due precautions that would not otherwise materialize. The effective RD&D of mCDR depends on private sector actors to provide the financing, technology, development and operations for advancement. More than two-thirds of current mCDR field trials involve startups.[5] Any strategy to advance mCDR must build upon the work of the private sector, including recognizing and validating the business models that have allowed most mCDR research to advance to date. The ability of technology developers like Ebb to sell carbon credits and enter into commercial agreements is essential to our viability as a company and ongoing research contributions to the field. While the Plan is focused on advancing research outcomes, it cannot do so in a vacuum.The practical implications of a stark distinction between research and commercialization would risk stalling the encouraging progress made to date and undermining the potential of burgeoning solutions underpinned by promising science, like Ebb's.

Ebb Carbon shares the Biden Administration's perspective of science as possibility. We are at an inflection point where we have a narrow moment to move from possibility to actuality, from pilot-scale research and development to commercial-scale operations. To lead the burgeoning mCDR industry at this critical time, MCDR-FTAC must craft a Marine CDR Plan that paves the way for safe and effective commercial-scale deployments. Replacing redundant and misaligned regulatory pathways with general permits tailored to the mCDR industry, investing in

[5] https://oceanvisions.org/mcdr-field-trials/

shared infrastructure for effective MRV, and enabling public-private partnerships will best position the United States to meet the challenges and opportunities of this moment.

IV. Annex

Permits and Approval Processes for Ebb Pilot Project in Washington State

Permit/Approval	Lead Agency
Federal	
Clean Water Act (CWA), Section 404	U.S. Army Corps of Engineers (USACE), Seattle District
Rivers and Harbors Act (RHA), Section 10 Permit	USACE
National Historic Preservation Act, Sect. 106 Concurrence	USACE in consultation with WA Dept. of Archeology and Historic Preservation / consulting parties
Endangered Species Act, Section 7 Concurrence	USACE in consultation with NOAA Fisheries and U.S. Fish and Wildlife Service
National Environmental Policy Act (NEPA) Review	U.S. Dept. of Energy
State	
CWA, Section 402 National Pollutant Discharge Elimination System / State Waste Discharge (NPDES/SWD) Individual Permit	WA Dept. of Ecology (Ecology)
Clean Water Act, Section 401 Consistency Certification	Ecology
Coastal Zone Management Act (CZMA) Consistency Determination	Ecology via USACE
Hydraulic Project Approval Permit	WA Dept. of Fish and Wildlife
Local	
State Environmental Policy Act Review	Port of Port Angeles
Shoreline Substantial Development Permit	City of Port Angeles
Critical Areas Ordinance Compliance	City of Port Angeles
Building, Grading, and Other Local Permits	City of Port Angeles

From:	Lisa Levin
To:	Light, Tricia M. EOP/OSTP
Subject:	[EXTERNAL] DOSI Input to US mCDR Research Plan
Date:	Tuesday, April 16, 2024 8:25:22 PM
Attachments:	DOSI response Marine Carbon Dioxide Removal Research Plan (US NSF Call for Input).docx

Dear Tricia,

Please find attached input from the Deep Ocean Stewardship Initiative (DOSI) on the Federal Register call for comment on the US mCDR research plan.
Please confirm receipt. Contact is (b) (6) [redacted]

Many thanks for your consideration,

Lisa Levin

Marine Carbon Dioxide Removal Research Plan (US NSF Call for Input)

Input from the Deep Ocean Stewardship Initiative

The Deep Ocean Stewardship Initiative (DOSI) (www.dosi-project.org) is a global network of experts which seeks to integrate science, technology, policy, law, and economics to advise on ecosystem-based management of resource use in the deep sea.

Contributors:

Lisa Levin, Scripps Institution of Oceanography, University of California San Diego

Diva Amon, Benioff Ocean Science Lab, University of California Santa Barbara, SpeSEAS, Trinidad and Tobago

Joan Alfaro, Department of Biology, University of Victoria

Maria Baker, DOSI, University of Southampton

Narissa Bax, Greenland Climate Research Centre, Nuuk, and Institute for Marine and Antarctic Studies, University of Tasmania

Elva Escobar, Universidad Nacional Autónoma de México

Nathalie Hilmi, Centre Scientifique de Monaco, Monaco

Susanna Lidström, KTH Royal Institute of Technology

Moriaki Yasuhara, University of Hong Kong

1. How would a Marine CDR Plan affect you, your organization, or your community?

We represent a scientific network focused on the deep ocean. Many of the proposed mCDR technologies identify the deep ocean as a carbon repository. Our community of scientists and other deep ocean stakeholders (over 3000) has much to offer to understanding the fate of carbon deposited in the deep ocean, consequences for marine ecosystems, and mCDR effectiveness. The research plan may stimulate additional research or reshape existing programs. New mCDR research may help grow the network, create new partnerships and advance open data access.

2. *What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*

We are concerned that insufficient attention and resources has been given to environmental and ecosystem perturbation associated with large-scale mCDR deployment, particularly for the deep ocean. A large-scale research initiative on environmental risk is needed to inform decisions about deployment, involving cross communication and collaboration across mCDR technologies.

Large parts of the vast deep sea are poorly characterized both environmentally and biologically. To fully understand the consequences of the deployment of CDR initiatives and their impacts on the deep-sea environment, environmental and biological baselines will be needed, a task that based on other activities (e.g., environmental and biological assessment for deep-sea mining) could take years if not decades. Additionally, a thorough review is needed of the existing scientific literature that addresses the fate and sequestration of carbon reaching the deep sea/seafloor and factors that affect carbon sequestration. Most existing published knowledge is local and research is required on how to extrapolate this to larger space and time scales. The vast array of existing knowledge (some of these technologies were researched > 20 y ago) should be synthesized and combined with expert advice to enable decision making.

Funding resources are required for (a) experimental, field small-scale and modeling- ecological forecasting marine CDR research; (b) transfer of small-scale field knowledge generation into medium and large scale mCDR deployments. Technical and scientific expertise must be recruited across latitudes (especially in the global south) before engaging in mDCR. The scale of existing knowledge is a snapshot and cannot inform decisions in the immediate time scale about the readiness of any marine mCDR approach for full-scale deployment or commercial application that is large scale.

Finally, we suggest that potential benefits of mCDR for reaching climate goals are carefully weighed in relation to impacts on other aspects of ocean, climate and broader environmental sustainability. We are concerned that a hastened agenda to fast-track enabling regulation for mCDR may have significant negative impacts on deep-ocean ecosystems and species, which also play key roles in Earth systems.

3. W*hich marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?*

We suggest the following priority research themes:

1. Understanding the effective carbon sequestration potential of each proposed technique before mCDR initiatives begin. This issue is intimately linked with the specific locations where CDR initiatives will take place. Location of deployment is key to understanding

the specific ecosystem and biodiversity impacts, and and to enable marine spatial planning.

2. Most mCDR initiatives will need to be scaled up to sequester relevant amounts of carbon for climate mitigation. The consequences of this scale up, including potential negative feedbacks, and impacts on natural ecosystems is a key question. Also, it is essential to understand how ocean processes are affected that lead to changes in public health, coastal communities and their use of resources in the sea.
3. The subsurface injection of liquid CO2 into geological formations (> 100 m below the substrate) or existing wells may pose the least risk to the marine environment of proposed technologies, but the potential for and consequences of leakage for marine ecosystems and the carbon cycle require study. Experiments, field measurements and modeling mCDR approaches should focus on microbial and other processes several hundreds of meters below the substrate.
4. Unintended side effects of mCDR need to be understood, prevented and studied comprehensively (long-term) for ecological monitoring to continuously assess environmental impacts and carbon sequestration effectiveness (which has not been illustrated to date for any technology). Side effects could include potential ocean deoxygenation, acidification and alterations to local food webs. There is a need for comprehensive studies on the long-term impacts on marine chemistry and ecosystems.

4. *What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?*

The public, researchers and policy makers need information that will allow them to evaluate tradeoffs in determining viability of mCDR deployments: environmental, energy, monetary, and social.

The public should be made aware of potential changes in marine ecosystems (biodiversity, community structure, functions and ecosystem services), impacts on marine habitats, ecosystem engineers, fish, fisheries, sediments (and ultimately livelihoods). How will mCDR deployments affect the natural carbon cycle? Ocean productivity and fisheries? How will these affect additionality of Carbon removal actions? What is the energy expenditure per unit carbon sequestered ? How long will the carbon remain sequestered?

The Federal Government should provide a framework or roadmap that represents a way forward in the climate change crisis. This must engage the deep-sea community and stakeholders in guiding long-term response and large spatial scales that will affect future generations. The slow pace of deep sea ocean processes and response must be incorporated. Science is needed to study, describe and forecast geochemical cycles (e.g. Carbon, Nitrogen), their changes in large time and space scales engaging existing observing systems (floats, moorings, ship tracks and observatories) and using new technological approaches.

5. *What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships*?

The Federal Government should call for a large-scale research initiative that combines study of the carbon cycle in the open/deep ocean (> 200 m) and how alteration of marine ecosystems by large-scale mCDR deployment will affect the regulatory, provisioning, supporting and cultural services provided . It would also be relevant to consider the price of carbon related to mCDR on the financial markets (compliance markets and voluntary markets), and compare it to the social cost of carbon.

There are existing programs focusing on OA and mCDR that include industry and academia and have offered an initial funding through NOAA. This should be expanded in amount and time to include the deep ocean. Among the biggest challenges is that enterprises of the scale of mCDR require partnership not just within entities and the Federal Government but with other nations. The vastness of the ocean and its high connectedness requires new approaches that combine disciplines (physical oceanography, biogeochemistry, ecology). Enhanced ocean literacy is also required to expand entities involved in mCDR efforts and to strengthen local, national and international partnerships.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

The deep ocean has been largely missing in action from major reviews (e.g., National Academy, GESAMP), research agendas, industry conversations and presentations. It is harder to study and less is known but remains one of the more pristine sets of ecosystems on the planet. Please ensure that the possible contributions and vulnerabilities of deep-ocean processes and ecosystems are a significant part of any federal mCDR research plan. Please see *Levin, Lisa A., Joan M. Alfaro-Lucas, Ana Colaço, Erik E. Cordes, Neil Craik, Roberto Danovaro, Henk-Jan Hoving, Jeroen Ingels, Nélia C. Mestre, Sarah Seabrook, Andrew R. Thurber, Chris Vivian, Moriaki Yasuhara. 2023. Deep-sea impacts of climate interventions. Science 379: 978-981.* This is available at: https://www.science.org/stoken/author-tokens/ST-1072/full

We need experiments, field work and modeling efforts that include all relevant time and spatial scales and that include depths below 200 m, EEZ and ABNJ in a collaborative effort with different entities, stakeholders and international partnerships. Ocean connectivity guarantees that national mCDR actions will affect waters and ecosystems outside their borders/EEZs. Explore and advance seafloor and subseafloor state of the art sampling capabilities, approaches and critical science questions for the near, intermediate and long-term future. Also, involve existing technologies, map existing legacy data to develop clear forward thinking in CC solutions. Do not wait to consider the deep sea and its seafloor processes as important actors in mCDR research and policy.

The phrasing of the US mCDR Research Plan needs to incorporate ideas of safe mCDR, safe size and location of deployment, and necessary protections and precautions.

We suggest any trade-offs, risks and benefits of mCDR are considered within a holistic framework including not only climate mitigation but also biodiversity protection and ocean sustainability. This may provide a different outcome compared to evaluations in relation to the more narrowly framed goals of the Paris Agreement.

From: Alicia Karspeck
To: Light, Tricia M. EOP/OSTP
Cc: David Ho; Matthew Long
Subject: [EXTERNAL] input to FTAC process from [C}Worthy
Date: Tuesday, April 23, 2024 5:35:14 PM
Attachments: CWorthy-FTAC-Input.pdf

Dear Ms. Light,
Please find attached a .pdf with [C]Worthy's comments to the FTAC.
Please contact me with any questions or concerns.
Warmly,
Alicia

Alicia R. Karspeck, Ph.D. | (b) (6)
co-Founder, Chief Technology Officer
Schedule a meeting | Visit me on LinkedIn

[C]Worthy
CWORTHY.ORG

April 23, 2024

Tricia Light
White House Office of Science and Technology Policy (OSTP)
RE: Marine Carbon Dioxide Removal Research Plan
Submitted via email to (b) (6) [redacted]

Dear Ms. Light and Colleagues:

[C]Worthy is a nonprofit research and development organization that is building the open-source computational and modeling tools needed to enable the emerging marine Carbon Dioxide Removal (mCDR) industry to make scientifically credible assessments of carbon uptake and environmental impact. Our tools are built on biogeochemical and oceanographic models that have been developed over decades with the academic and research sectors and are accepted within the scientific community as the gold-standard for simulating flows of carbon through the ocean. We are jointly funded through philanthropic investments and federal grants and we have no commercial interests.

Our view is that the development of mCDR as a viable option for climate change mitigation requires a deep integration between civil society, regulatory bodies, government policy, the commercial sector, nonprofit organizations, and, of course, science and technology providers. In the first year since [C]Worthy's founding, we have established ourselves as a trusted contributor and arbiter within the subset of the mCDR space called "Monitoring, Reporting, and Verification." We have done this by advancing modeling capabilities in the public domain, while also engaging as an mCDR "field-building" organization. Our core-competencies as ocean modelers, climate scientists, and data/software engineers, combined with our open engagement with market participants, gives us a unique perspective on how to advance a responsible and effective mCDR agenda.

We appreciate the opportunity to respond to the National Science Foundation (NSF) Request for Information (RFI) 89 FR 13755, on behalf of the White House National Science and Technology Council (NSTC) Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC).

Please find below our responses to "Questions to Inform Development of the Strategy," as listed in the RFI (*next page*)

1. How would a Marine CDR Plan affect you, your organization, or your community?

The existence of a Marine CDR Plan developed by the U.S. federal government sends a clear signal to academics, philanthropic funders, and market participants that mCDR has the potential to be an scientifically and economically viable contributor to climate change mitigation efforts. We view this as a positive step toward i) Increasing federal, commercial, and philanthropic funding pools toward mCDR research; ii) Increasing state, regional, and local acceptance for the necessary early-stage mCDR research trials; iii) Garnering interest within CDR market participants for investment in ocean-based removal pathways.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

At [C]Worthy, we recognize that abiotic mCDR approaches (e.g. coastal enhanced weathering, ocean alkalinity enhancement, direct ocean removal) are less likely to impact ocean ecosystems than biotic approaches (e.g. nutrient fertilization) which explicitly seek to perturb biological processes in the ocean. These methods tend to operate with a relatively larger degree of scientific certainty and lower risks of unintended consequences

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR.

NOAA-OAR/NOS/NWS as well as the DOD-NRL all play a role in providing the public with oceanographic reanalysis and forecasts that underpin both public safety considerations as well as help grow the U.S. blue economy. We urge the committee to consider that, with appropriate planning and resourcing, these agencies are in a position to expand their operational and experimental oceanographic products to support the nascent mCDR industry. The MCDR Plan should include a pathway for evaluating the operational oceanographic needs of the emerging industry – which may include i) high resolution (submesoscale) ocean and biogeochemical state estimates (to be used for site-selection, planning, and regional model forcing and validation) ii) regional high-resolution multi-year forecasts (to support carbon uptake quantification) iii) hosting of operational oceanographic data product on open-access cloud servers to ensure fair access by commercial companies.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

A significant effort that is being planned by the mCDR non-profit community is the initiation of a process for developing a Community Quantification Standard (CQS) for abiotic mCDR. Commercial mCDR suppliers and buyers have been consistently calling for a quantification standard that would provide a scientifically credible minimum-bar for how to quantify carbon removal through abiotic pathways. (A CQS development process for enhanced rock weathering is currently being lead by Cascade Climate). Protocols – such as the point source ocean alkalinity enhancement protocol in development by the commercial registry, Isometric, are intended to provide more pathway/deployment specificity and are expected to meet or exceed the criteria presented within the community standard. Thus, the development of a non-commercial CQS allows commercial registries to differentiate through specifying more rigorous quantification processes — creating a race toward higher – rather than lower - quality removals. We see four main roles for the government in this process.

1. Government agencies (for example, NOAA-OAR) should partner with philanthropic organizations to provide funding toward the initial development of an abiotic mCDR CQS by the nonprofit sector. Longer-term maintenance of the CQS may naturally fall within the remit of a dedicated program within NOAA or NIST or be taken on by a federally funded program within an appropriate NGO.

2. Scientists at federal labs should actively participate as disciplinary experts within technical working groups of the CQS. Their service toward this end should be prioritized and incentivized by pay and promotional structures within their organizations.
3. Government agencies should play a leadership role in the development and refinement of environmental and ecosystem protection standards to accompany and complement mCDR CQS. In addition, they should support the development of regulatory processes to enforce those environmental standards.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

All mCDR pathways require the use of numerical models to support:

- Research to inform project-level efficacy and safety
- Research to evaluate the scaled impact of mCDR on the national and global carbon budgets and global ocean ecosystems.
- The design of field-trials and pilot-scale commercial deployments
- Helping permitting organizations understand and evaluate the impacts of mCDR in their jurisdictions
- Providing mCDR market participants quantitative values to support carbon removal claims
- Communicating and educating communities about the physical and biogeochemical processes at work in mCDR

Broadly speaking, the computational tools used within mCDR research and deployment include physical oceanographic models, biogeochemical and ecosystem models, models of particle transport and chemical dissolution processes, and data assimilation system to generate observationally constrained estimates of the oceanographic state.

Through the federal science agencies, the government plays a key role in i) funding the open, scientifically rigorous development of these models (NOAA, NSF, DOE) and ii) providing research access to the high-performance computing (HPC) facilities (NSF, DOE) needed to run these simulations.

However, as the mCDR industry grows and the mCDR research community expands, limited HPC access is an ever-present bottleneck to progress. We urge this committee to include within the MCDR Plan a strategic vision for prepaid, dedicated HPC computing resources for CDR research. This can exist as earmarked allocations within the existing DOE supercomputing facilities and as cloud computing resources through commercial vendors (AWS, Azure, GCP, and smaller cloud services). These infrastructure investments are key to accelerating joint public-private learning within this space.

Thank you, again, for considering our input.

Alicia R. Karspeck, PhD
co-Founder, CTO, [C]Worthy

Matthew C. Long, PhD
co-Founder, CEO, [C]Worthy

David T. Ho, PhD
co-Founder, CSO, [C]Worthy

From: Lundstrom, Craig Campbell
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Plan
Date: Tuesday, March 26, 2024 2:24:44 PM

I would like to add a public comment to the Marine Carbon Dioxide Removal Plan

I will reiterate 2 comments in the NOAA session 2 on research today that have emphasized that the research plans should also include aspects of the deep ocean. Specifically, the ocean chemical composition is directly tied to interaction of seawater with the ocean floor rocks, dominated by basalts which represent the largest reservoir of CaO on the planet—because calcium in silicates reacting with CO2 represents the primary sink of removal of CO2 from the planet, facilitating reactions between the ocean floor basalt and seawater should be considered as another major direction in CDR research.

Reactions between basalt and carbonate water have been put forward in carbon capture research in Iceland and by Canadian research groups. However, as mentioned, mineral reactions at ocean temperatures are exceedingly slow. However, many observations of ocean floor rocks by marine geologists show that the ocean basalt sequesters very large amounts of carbonate by alteration the make CaCO3 minerals—these reactions occur at elevated temperatures associated with magmatic systems. One way to facilitate carbon sequestration on human timescales is to drill into warm ocean crust near ocean crust magmatic systems and promote seawater flow through the warm rock. The process require little energy (natural hydrothermal flow will occur) and could easily be effective at MTonnes of C per year for a single drill station. This process is discussed in an "Ocean Shots" poster for the Ocean Decade US meeting in 2021. It is also discussed in a scientific paper in Journal of Geophysical Research-solid Earth—Lundstrom, 2020.

Thank you—I would be happy to speak more about this with interested program managers

Craig Lundstrom
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From: Loomis, Becca
To: Light, Tricia M. EOP/OSTP
Cc: Suatoni, Lisa
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan - comment from NRDC
Date: Tuesday, April 23, 2024 7:46:38 PM
Attachments: NRDC comment on mCDR NSF RFI 2024.04.23.pdf

Dear Dr. Light,

Attached please find a comment from the Natural Resources Defense Council on the NSF/MCDR-FTAC RFI for a marine CDR research plan (89 Fed. Reg. 13755).

Thank you for the opportunity to comment.

Best wishes,
Becca Loomis

REBECCA LOOMIS
Project Attorney, Oceans Division
Nature Program

NATURAL RESOURCES DEFENSE COUNCIL
(b) (6) [redacted]
WWW.NRDC.ORG

Tricia Light
Office of Science & Technology Policy
Executive Office of the President
1650 Pennsylvania Avenue
Washington, D.C. 20504
(b) (6)

April 23, 2024

Re: Natural Resources Defense Council response to Marine Carbon Dioxide Removal Research Plan

Dear Dr. Light,

On behalf of the Natural Resources Defense Council (NRDC) and our millions of members and activists, we submit these comments on the National Science Foundation (NSF) and White House National Science and Technology Council Marine Carbon Dioxide Removal Fast-Track Action Committee ("the Committee")'s notice of request for information regarding the development of an implementation plan for marine carbon dioxide removal (mCDR) research.[1]

The urgency of the climate crisis demands swift action to address and mitigate climate change, primarily through significant cuts to greenhouse gas emissions. Marine CDR may play a role in addressing the climate crisis, but, as recognized by NSF, these methods are not yet ready for full-scale deployment or commercial use due to significant remaining questions about their efficacy for storing additional carbon over the long term and their potential adverse impacts on the human and ocean environment.[2] We support the Committee's development of a research plan that aims to answer these and other critical questions and that ensures field research is "appropriately regulated."[3]

We urge the Committee to establish a code of conduct to help ensure that mCDR research is conducted responsibly and equitably.[4] Because mCDR technologies are in early stages of development, many of the potential adverse impacts are unclear, and guardrails are needed to ensure that mCDR research does not cause significant adverse impacts to the marine

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[1] 89 Fed. Reg. 13,755 (Feb. 23, 2024).
[2] *Id.* at 13,755.
[3] *Id.*
[4] This comment is in response to Question 2 from the request for information, "What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?" 89 Fed. Reg. at 13,757.

environment[5] or exacerbate existing environmental injustices. Additionally, important questions about the efficacy and safety of mCDR methods can only be answered if research is conducted in a methodologically sound and transparent manner. Adopting a code of conduct that establishes protocols and safeguards is likewise essential to building public trust in mCDR research and, ultimately, technologies.

We recommend the Committee define the scope of the code of conduct to apply to large-scale, *in situ* mCDR experiments. To ensure that the code of conduct is widely adopted, federal agencies should require adherence to the code for all public and private organizations receiving federal funding or support for large-scale, *in situ* mCDR research. The Committee and federal agencies should also encourage organizations and individuals conducting large-scale, *in situ* mCDR research who are not receiving federal support to voluntarily adopt the code by highlighting the benefits of committing to principles of responsible and equitable research. These benefits include increasing public trust and building social license for mCDR research.

An mCDR code of conduct should include principles that advance three overarching goals: thorough consideration and mitigation of significant adverse environmental impacts; robust and meaningful stakeholder engagement; and transparency around funding, methods, and outcomes. The code of conduct can help ensure that significant adverse environmental impacts are considered from the outset of research planning. Prior to conducting large-scale, *in situ* research, project proponents should assess potential significant adverse impacts from research activities on the human, marine, and coastal environment. Research should be sited to avoid areas with sensitive resources and habitat and protected species. Researchers should be required to provide comprehensive monitoring of significant impacts during and after research and to mitigate those impacts. The code of conduct should define environmental impacts broadly to include direct, indirect, and cumulative impacts, when additive or synergistic effects are observed.[6] MCDR activities—including research—may have indirect impacts that are removed in time or location from the project itself.[7] Cumulative impacts are equally important to consider, especially where

[5] Significant adverse impacts would include, for example, harming vulnerable or protected wildlife, depleting populations of marine species, causing long-term shifts in community composition, or degrading important or essential habitat.

[6] See, for example, Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA). These regulations define direct impacts as those "caused by [an] action" that "occur at the same time and place." 40 C.F.R. § 1508.1(g)(1). Indirect impacts are those "caused by [an] action," which "are later in time or farther removed in distance, but are still reasonably foreseeable." *Id.* § 1508.1(g)(2). And cumulative impacts are defined as "effects on the environment that result from the incremental effects of [an] action when added to the effects of other past, present, and reasonably foreseeable actions." *Id.* § 1508.1(g)(3).

[7] For example, ocean fertilization may cause indirect impacts outside of the location where fertilization takes place, like "nutrient robbing," wherein nutrients that support phytoplankton growth in other locations are depleted as a result of the enhanced productivity at the ocean fertilization site. National Academies of Sciences, Engineering, and Medicine, *A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration*. Washington, DC: The National Academies Press, ch. 3, p. 87 (2022); Joo-Eun Yoon et al., "Reviews and Syntheses: Ocean Iron Fertilization Experiments—Past, Present, and Future Looking to a Future Korean Iron Fertilization Experiment in the Southern Ocean (KIFES) Project," Biogeosciences 15, no. 19 (2018): 5847–89, https://doi.org/10.5194/bg-15-5847-2018.

mCDR research has the potential to exacerbate environmental impacts caused by pre-existing industrial uses or multiple mCDR projects operating in an area.[8] Further, the code should require consideration of environmental impacts to be informed by community engagement. If community members raise specific concerns about marine or coastal resources—such as resources that the local economy depends on for subsistence activities, commercial fishing, or tourism and recreation—project proponents should carefully consider whether research may have significant impacts on those resources.

The code of conduct should require mCDR researchers to conduct robust and meaningful stakeholder engagement. Involving stakeholders in project design and implementation is necessary to advance mCDR research in a manner consistent with the Biden administration's goal to "incorporate environmental justice and equity in mCDR research and implementation."[9] The code should require researchers to communicate information on proposed research projects, including potential risks and benefits, in a manner that is clear and accessible to each community of stakeholders. Researchers should design communications that explain research and potential impacts in plain language, keeping in mind that most people do not possess technical expertise in ocean ecology or chemistry. Project proponents should provide ample and accessible opportunities for feedback, including at times outside of regular working hours. Critically, for stakeholder engagement to be meaningful, information received in consultation must actually inform research siting, design, and implementation decisions. Outreach efforts should therefore begin early in the research planning process. Further, stakeholder engagement should not be limited to communications before a study begins. Researchers have an obligation to communicate with stakeholders during research and after a project concludes, particularly regarding any unexpected or adverse outcomes.

Ensuring transparency around all aspects of mCDR research will be critical for advancing the Committee's goals of determining whether mCDR activities can effectively store carbon over the long term and assessing the environmental costs of such activities. The code of conduct should require researchers to transparently report methods, results, adverse impacts, funding sources, and potential conflicts of interest for all mCDR activities. Because mCDR methods have not yet been proven to store additional carbon effectively and durably, project developers must be open about data and results to allow third parties to assess the effectiveness of mCDR technologies and to ensure that additional resources are not directed towards ineffective mCDR methods. This includes prompt publication of results in open-access forums. Additionally, mCDR research may have adverse environmental and social impacts, which could be compounded if mCDR

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[8] For example, marine mammals, sea turtles, and other wildlife can become entangled on underwater lines, causing injury and death. If macroalgae cultivation research is conducted in areas with a high rate of fishing, increased lines in the area could create cumulative impacts, increasing entanglement risk. *See* National Academies of Sciences, Engineering, and Medicine, *A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration*, ch. 5, p. 136.

[9] Ocean Policy Committee, Ocean Climate Action Plan (March 2023) at 20, https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf.

technologies are deployed at scale. Project developers must fully disclose these externalities so that researchers, policymakers, and the public can weigh the risks of mCDR activities against the possible benefits before any technologies are deployed. The code of conduct should also require researchers to disclose all funding sources and potential conflicts of interest in order to maintain research integrity and prevent fraud. In addition to including principles of transparency in a code of conduct, the Committee's implementation plan should direct federal agencies to collect information on research, results, and adverse impacts and make that information publicly available on the internet.

Several existing research codes of conduct elaborate on many of the principles discussed above and could serve as potential models. These include the Geoengineering Research Governance Project's for Responsible Geoengineering Research[10] and NASEM's Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance.[11] The Aspen Institute's code of conduct provides detailed guidance on identifying relevant stakeholders and conducting effective engagement at all stages of mCDR research.[12]

Establishing a strong code of conduct for mCDR research would also support the Committee's efforts to clarify regulatory standards and establish guidelines for mCDR research.[13] As the Committee is aware, there is no single law or set of regulations that applies to mCDR research, so governance is left to a patchwork of existing authorities designed to regulate issues like ocean dumping and impediments to navigation.[14] A code of conduct would help fill the governance gap for mCDR methods by ensuring that all federally-supported research includes adequate environmental protections and stakeholder consultation. Moreover, the research code of conduct could be used as a model or starting point for potential future regulations.

Finally, in "clarify[ing] permitting, regulatory, and other standards and policies" for mCDR research,[15] we urge the Committee to give the Environmental Protection Agency (EPA) and the National Ocean Atmospheric Administration (NOAA) lead roles in establishing and administering mCDR research requirements. Among federal agencies, EPA and NOAA are dedicated to environmental protection and have relevant marine science expertise, which will be essential to advance mCDR research in an environmentally responsible and scientifically rigorous manner.

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[10] Anna-Maria Hubert, *A Code of Conduct for Responsible Geoengineering Research*, 12 Glob. Policy 12 (supp.1), at 82–96 (2021), doi: 10.1111/1758-5899.12845.
[11] National Academies of Sciences, Engineering, and Medicine, *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance*, Washington, DC: National Academies Press (2021).
[12] Miranda Boettcher et al., *A Code of Conduct for Marine Carbon Dioxide Removal Research*, Aspen Institute (Nov. 2023), https://www.aspeninstitute.org/wp-content/uploads/2023/11/110223_Code-of-Conduct_FINAL2.pdf.
[13] 89 Fed. Reg. at 13,757.
[14] National Academies of Sciences, Engineering, and Medicine, *A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration*, ch. 2, pp. 39-40, 52-55.
[15] 89 Fed. Reg. at 13,757.

Thank you for the opportunity to comment. We appreciate NSF and FTAC's attention to this critical topic.

Sincerely,

Rebecca Loomis
Project Attorney
Oceans Division, Nature Program
Natural Resources Defense Council

Lisa Suatoni, PhD
Deputy Director
Oceans Division, Nature Program
Natural Resources Defense Council

From: Paul J Morris <(b) (6) [redacted]
Sent: Tuesday, April 23, 2024 10:10 PM
To: Light, Tricia M. EOP/OSTP
Cc: Ken O Buesseler; Dr. Kilaparti Ramakrishna (he/him); (b) (6) [redacted] Sarah Smith; (b) (6) [redacted]
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan - comments from ExOIS
Attachments: MCDR FTAC listening session comments from ExOIS.pdf

Dear Tricia,

Please find attached a set of written comments in response to the mCDR FTAC listening sessions. These comments were prepared by Ken Buesseler, Senior Scientist at the Woods Hole Oceanographic Institution, and Executive Director of the ExOIS (Exploring Ocean Iron Solutions) program. Those Cc'ed are the steering committee of ExOIS.

At least one representative of ExOIS attended each of the three listening sessions, and some oral comments were made. These written comments follow up and expand on the oral comments that were made. I kindly ask that you can give us a quick acknowledgement of receipt of this email and attachment.

We thank the MCDR FTAC committee for offering the opportunity to submit comments on this topic, and we look forward to seeing the output of the committee's work later this year.

Kind regards,
Paul

EXOIS
EXPLORING OCEAN IRON SOLUTIONS

Paul Morris | ExOIS Project Manager

Marine Chemistry & Geochemistry
Woods Hole Oceanographic Institution
Based in Washington, DC

OceanIron.org

From: Light, Tricia M. EOP/OSTP (b) (6) [redacted]
Sent: Thursday, March 21, 2024 10:02 AM
Subject: [EXTERNAL] mCDR FTAC

Some people who received this message don't often get email from (b) (6) [redacted] Learn why this is important

Hello all,

Thank you for registering for Tuesday's listening session on marine CDR permitting, regulatory, and other standards and policies. The Marine CDR Fast-Track Action Committee appreciates your time and input.

If you would like to provide additional feedback, you may also submit a response to the Federal Register Notice and/or attend the two remaining listening sessions:

Theme 2: Comprehensive Federal MCDR research program. The FTAC seeks feedback on a Federal research program that will accelerate the development of the knowledge needed to understand the effectiveness and safety of MCDR approaches.
March 26th, 12:30 – 2:30 EST
Registration: https:[redacted].zoomgov.com[redacted]

Theme 3: Mechanisms to enable public awareness and public-private cooperation. The FTAC seeks feedback on how to enable public engagement in MCDR research and how to promote cooperation between the Federal government and non-Federal parties on MCDR research, including field tests.
April 9th, 12:30 – 2:30 EST
Registration: http[redacted].zoomgov.com/[redacted]

The slides presented are not yet available to the public, but additional information may be posted to the NOPP website after the final session.

Thank you,
Tricia Light

“Marine Carbon Dioxide Removal Research Plan”

Response to request for information to the Marine Carbon Dioxide Removal Research Plan Fast-Track Action Committee (MCDR–FTAC)

Ken Buesseler, Senior Scientist, Woods Hole Oceanographic Institution, and Executive Director of the ExOIS Program

These comments have been prepared on behalf of “Exploring Ocean Iron Solutions” (ExOIS)

We appreciate the opportunity here to comment on this RFI related to the development of an implementation plan to advance the research of marine carbon dioxide removal (mCDR), and per instructions will separate our comments by the 3 actions described in the RFI. Overall, we agree that the oceans play an outsized role in the global C cycle and climate, which is why the potential for mCDR is so great and important to study.

This response is being submitted on behalf of Exploring Ocean Iron Solutions (ExOIS; https://oceaniron.org), a consortium of 60 scientists from 37 International Institutions who came together in early 2022 to share ideas and move ahead on studies to consider ocean iron fertilization (OIF) as one way to address our climate crisis. In addition to our website, more information on the goals of ExOIS and activities planned over the next 5-10 years have been recently summarized in a “Paths Forward” report (https://oceaniron.org/our-plan/#pathsforward), and is in preparation for peer-reviewed publication. If warranted by the research agenda, the ultimate goal of ExOIS would be to provide an open-source description of the protocols needed for at-scale OIF implementation for future entities.

The perspective of this response is thus from consideration of issues specific to OIF research, but also from the broader understanding of mCDR and R&D opportunities across multiple approaches.

Specific comments on RFI actions:

1) Establish a comprehensive Federal marine CDR research program

Moving ahead requires deliberate field studies that are both guided, and informed, by mechanistic models to demonstrate the efficacy and potential risks of OIF at scale. The end result would be a transformative R&D program that would include a comprehensive assessment of multiple ocean CDR approaches and whether they are scalable and reproducible; have known deployment costs that can be transparent and accurate in terms of carbon accounting; and have known and acceptable ecological consequences with a governance framework and set of responsibilities that are clearly established.

At a minimum, such a research program for OIF would need to include support for the following activities (and by analogy would be similar, at least in part, for other mCDR approaches):

1. Field studies of ocean iron fertilization
2. Modeling the impacts of ocean iron fertilization at different scales (field tests, regional and global)
3. Testing various forms and methods of introducing iron to the surface ocean
4. Monitoring, reporting, and verification (MRV) investments in new technologies and modeling. MRV commonly refers just to tracking carbon, but here it should include tracking both carbon and ecological and environmental impacts (eMRV)
5. Advancing the social science and governance of ocean iron research

With respect to these priorities and this RFI, particular comment is warranted on the organization of the next generation of field studies. These are needed to fill the knowledge gaps, targeting uncertainties in whether OIF is sufficiently effective, durable, scalable, and reproducible for mCDR, and with acceptable consequences for marine ecosystems. This requires **field experiments that are significantly larger (>10 times larger spatial scales) and longer in duration (one year instead of one month) than previous mesoscale iron enrichment studies**. A set of core measurements will be needed to quantify surface ocean CO_2 drawdown and timescales of atmospheric exchange, the sinking transport of organic carbon to depth, and the portion of this flux that results in carbon sequestration for 100 years or more. A combination of remote and *in situ* observations to support modeling for the monitoring, reporting, and verification of these carbon fluxes will be needed.

It is also well established that OIF will have ecological and biogeochemical consequences. Many of these are intended and desirable; at scale, this increased phytoplankton production reduces acidification of the surface ocean and removes atmospheric CO_2. It will cause other changes, such as macronutrient removal from the surface, enhanced deoxygenation of mid-depth waters, potential production of other GHGs (N_2O, CH_4), and secondary impacts on marine ecosystems. Thus far, observations in both natural and deliberate OIF studies suggest the detrimental effects of OIF for mCDR are sufficiently minimal relative to consequence of not deploying OIF. **It is however critical that the ecological and environmental consequences of OIF field studies be given significant attention, which we call "eMRV".**

Details on the these and other activities listed above can be found in the Paths Forward report and are not needed as an RFI comment, but we do want to note that the **social science and governance issues surrounding mCDR will require the establishment of a unique and broader set of program activities being supported** than is found in many traditional science and engineering programs. Identifying lead agencies and incorporating those activities within the science and engineering programs is advised.

With respect to funding needs, ExOIS has estimated it would take on order 5 years, and at a minimum a $160M investment to support the 5 priorities outlined above. Field studies would be the majority, two-thirds of the costs, and should not be underestimated at $25-30M each. Multiple studies (3-4) would be needed at a single site for replication and comparing the consequences of different forms and conditions of Fe delivery (Fe amount, form, duration, patch scale). Moving to multiple HNLC sites (high-nutrient low-chlorophyll) would be needed if early studies are promising as well as consideration of low-nutrient low chlorophyll, LNLC sites where stimulation of nitrogen fixation is a less well studied, but are also a potential C sink. **While it may be tempting to support smaller/shorter and less comprehensive and thus less expensive field work, such studies would set back not only OIF but mCDR in general, as key questions regarding efficacy and impacts could not be adequately addressed.**

2) Clarify permitting, regulatory, and other standards and policies, and establish guidelines for marine CDR research

As laid out in the London Convention/London Protocols, there are a set of guidelines to allow "legitimate scientific research" for OIF in the high seas. We are thus encouraged by US EPA's recent additions to their web pages (https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm) that clarify their role in issuing permits for mCDR studies in both national, and importantly for OIF, international waters beyond national EEZs under the LC/LP. This is a new process for permitting mCDR studies on the high seas, and at least to our knowledge it has not been used, but thus far, we have found EPA staff receptive to providing the information needed to apply, and ExOIS plans to move ahead with a permit application later in 2024. Careful attention to facilitate permitting will thus be essential to support any R&D work in mCDR.

What is more concerning, especially as this committee considers building a new program, is language within a recent CDR Pilot Study program FOA launched by DOE's FECM office (https://www.energy.gov/fecm/articles/doe-announces-100-million-pilot-scale-testing-advanced-carbon-dioxide-removal). This FOA included $100M funding for land-based CDR only, which is a disappointment as mCDR was not funded, but hopefully only a delay as DOE takes further action and this committee better advices on the scope and organization of the broader US mCDR programs. What is concerning is common wording that ***"Specific tests must be conducted in the U.S."*** (from pg 21 and elsewhere). This type of wording on US only locations may be appropriate for land-based CDR, but we wanted to put forth that either directly or indirectly, **marine CDR pilots will need to be conducted in the high seas beyond the US EEZ to be effective**. We say directly as some methods require pilots in the open seas to find the appropriate nutrient conditions, such as lack of iron or macronutrients, or space for scaling up beyond coastal settings (open ocean seaweeds, upwelling tubes). Also indirectly, given ocean currents, so even for example a beach seeding with olivine for ocean alkalinity enhancement will have indirect, but potentially significant impacts beyond the discharge point and beyond EEZ's. **Particularly at scale, all mCDR will impact the open-ocean.** To be clear, the necessary studies could be designed to be conducted by US entities but must allow for working in international waters**. A restriction such as this to any new US programs would be fatal to the establishment of a viable and informative mCDR R&D program.**

3) Establish a Marine CDR Initiative to enable public-private partnerships and establish mechanisms to strengthen interagency coordination and promote public awareness and engagement.

There is no single solution for CDR, as 10's of Gt per year of CO_2 needs to be removed in the coming decades. Likewise, there is no single US agency, philanthropy, private or other source of funding that can support all that is needed. Thus, the encouragement of partnerships for funding is appropriate. **However, ExOIS is concerned that it is too early for commercialization of mCDR, and thus it is premature to include support based upon C credits in the mix of support for a new federal program.** This would certainly introduce a perceived or potential bias in results and public push back on the whole concept of mCDR. Co-funding and gifts by commercial entities for open and transparent research not tied to C credits seems like an alternative way to bring in the larger resources being spun up in the commercial markets. In any case, whatever programs emerge, additional attention and guidance is needed to define these commercial/non-commercial boundaries.

In addition, within the US agencies, it would be beneficial to have a clearer understanding of their respective roles and responsibilities within the mCDR R&D portfolio, particularly when it comes to field studies. For example, in the mission agencies, ocean observations are currently centered at NOAA, and CDR pilots (on land thus far), are currently centered at DOE FECM. Both observations and directed field trials will be needed in any mCDR R&D program, but where would one go to find support? As another example, the research fleets of NSF and NOAA will be important assets to bring to the table – how can that be managed and funded for programs largely supported or led by other agencies or non-government sources? Finally, identifying and supporting a central data management effort for mCDR would be extremely helpful so that all the data can be combined into transparent and useful products and outcomes for mCDR scientists, policy makers and the public.

From:	Geoff Holmes (b) (6) >
Sent:	Tuesday, April 23, 2024 1:37 PM
To:	Light, Tricia M. EOP/OSTP
Subject:	[EXTERNAL] Marine Carbon Dioxide Removal Research Plan - Response from Calcarea
Attachments:	2024 04 23 - Calcarea Response to NSF Marine CDR Research Plan RFI 89FR13755.pdf

Dr. Light and members of the mCDR-FTAC,

Please find attached Calcarea's submission to your 89 FR 13755 request for information. We are available at your convenience to answer questions or discuss matters further.

With best regards,

Geoff Holmes
Director of Government Relations
Calcarea
(b) (6)

CALCAREA

April 23, 2024

White House Office of Science and Technology Policy
RE: Marine Carbon Dioxide Removal Research Plan
Submitted via email to (b) (6) [redacted]

Dear Dr. Light and members of the mCDR-FTAC,

Calcarea is pleased to respond to your request for information on the development of a Marine Carbon Dioxide Removal Research Plan. This response will outline our view of the climate & energy context in which the mCDR Research Plan will exist, the technology that Calcarea is developing for mCDR and shipping decarbonization (which we believe is relevant to the development of the plan), and our specific responses to RFI questions. Our key recommendations are two-fold:

1. Consider the integration of technologies such as ours, which straddle the worlds of maritime decarbonization and mCDR, and which sequester carbon dioxide as safe and durable oceanic bi-carbonate ions.
2. Create an overall policy and regulatory environment, which promotes R&D, demonstration, and commercialization of mCDR technologies, and which regulates them to maximize environmental benefits while avoiding ecosystem and social harms.

We hope that our response is of use in your efforts, and welcome members of the mCDR-FTAC to reach out to us at any time with questions.

Sincerely,
Dr. Jess Adkins, Founder & CEO, Calcarea
Pierre Forin, Co-Founder, Calcarea
Geoff Holmes, Director of Government Relations, Calcarea. Contact: (b) (6) [redacted]

Context & Overview of Calcarea Technology

The United States has set aggressive targets for the reduction of greenhouse gasses, and in recent years Administrations and members of both Congressional Parties have passed legislation to accelerate America's deployment of climate-relevant and clean energy technologies. The global maritime transportation sector will be critical to tackling the climate and energy challenge, for three key reasons, among others: First, as a significant emitter itself (>1 Gt/yr globally) the maritime sector must reduce its GHGs. Second, as a conduit for global trade the maritime sector will play a key role in the deployment of all climate and clean energy technologies and infrastructure; in fact, no global transition will be possible without it. And third, as the oceans are one of the largest carbon reservoirs on Earth, their use to absorb and sequester carbon dioxide – while maintaining ecological integrity – may offer another tool in the climate toolbox. For these reasons, we at Calcarea are strongly supportive of the development of an mCDR research agenda, and we encourage efforts to cover all three aspects we highlight here.

At Calcarea, we have developed and are now commercializing technology that is relevant to both the decarbonization of maritime shipping, and to future mCDR efforts. Furthermore, we believe that our group and our academic peers have an understanding of the basic ocean geochemical cycle which is likely relevant to the development of research plans, and to the creation of high-integrity MRV and permitting systems for mCDR.

Calcarea was founded in 2022 by Dr. Jess Adkins, who is the Smits Family Professor of Geochemistry and Global Environmental Science at the California Institute of Technology (CalTech). Based upon a fundamental understanding of the basic chemical kinetics of ocean carbonate / bicarbonate reactions, which - surprisingly - is not broadly disseminated among the field, Calcarea has developed a technology that can react limestone (calcium carbonate) with carbon dioxide (either from combustion or from atmospheric origin) to produce bi-carbonate ions which are stable and benign in the natural ocean environment. While the calcium carbonate to bi-carbonate reaction is widely known in many fields of science, Calcarea's key advancement rests upon the prior decades of oceanographic research in Dr. Adkins' (CalTech) and Dr. Will Berelson's (USC) labs, to produce a technology that reliably conducts, measures, and verifies this reaction at large scale, and which lends itself to commercial deployment for ship-board carbon capture and mCDR.

By using low-cost and ubiquitously available limestone as a reactant and seawater as the facilitating medium, Calcarea's technology allows the use of highly-scalable equipment already in common use in the marine engineering sector to achieve low-cost high-efficacy carbon dioxide capture. Also, by converting the captured carbon dioxide to stable bi-carbonate, Calcarea's system allows the discharge of the carbon-carrying seawater into the open ocean within pH, DIC, and turbidity ranges already allowed for marine discharge. The resulting bicarbonate seawater solution can then be released into the ocean, as it can be demonstrated to have little impact on ocean chemistry and is non-toxic. The calcium and bicarbonate ions mix with ambient surface waters and dilute via ocean mixing processes and the ship's turbulent wake. This process can store captured carbon dioxide in the vast upper ocean water column as harmless bicarbonate ions, as it simulates the earth's natural carbon and alkalinity cycle – but is many orders of magnitude faster.

Our process effectively sequesters the captured carbon dioxide – whether captured from ship-board combustion, from the atmosphere, or both – "in the wake", thus obviating the need for highly expensive and difficult-to-retrofit infrastructure to handle liquified carbon dioxide at ports. Furthermore, sequestration of carbon dioxide as oceanic bi-carbonate offers a new degree of freedom for the carbon management and carbon removal sectors, by offering a complementary means of long-term high-durability sequestration to pre-existing methods of sedimentary injection and mineralization.

Calcarea is already gaining rapid traction within the shipping sector for this technology, and we believe it can add to America's efforts to decarbonize. We encourage members of the mCDR-FTAC to create a research plan and advocate for a policy environment which incorporates technologies like ours which straddle the worlds of mCDR and maritime decarbonization, and which sequester carbon dioxide as stable oceanic bi-carbonate. We believe that incorporating a broad suite of mCDR technologies in this manner will maximize America's opportunities to cut greenhouse gas emissions, to create clean growth and jobs, to enhance America's energy competitiveness, and to advance goals of environmental justice.

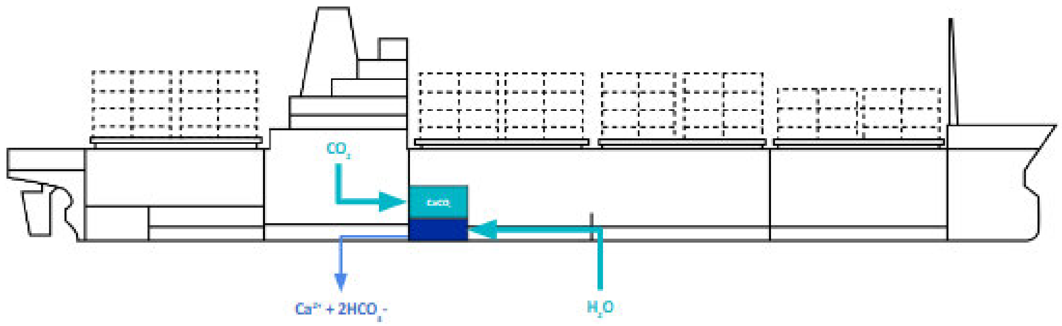


Figure 1: A representative diagram of Calcarea's technology, installed in a configuration to scrub carbon dioxide from ship-board combustion. The technology can also be configured to sequester carbon dioxide captured from the atmosphere.

Responses to RFI Questions

1. How would a Marine CDR Plan affect you, your organization, or your community?

Calcarea is developing a technology that can capture and sequester carbon dioxide by aqueous reaction with limestone to form stable bi-carbonate ions. This technology has three main uses to the climate & energy challenge:

1. It can be configured to scrub exhaust from ship-board combustion, such that the captured carbon dioxide can be safely and durable sequestered "in the wake" of a ship under way. This will give the maritime shipping sector a much needed additional tool to accelerate decarbonization.
2. Calcarea's technology can be configured to take CO_2 captured from point-sources in order to sequester it "in the wake" of purpose-built 'sequestration vessels'. This may be a useful alternative means of sequestration to sedimentary injection or mineralization, that could prove particularly useful for regions which would require long distance pipelines to transport captured CO_2 to areas with appropriate geology for terrestrial sequestration. Calcarea has conducted a GIS exercise comparing total costs to transport CO_2 from point sources to either sedimentary basins, or ports where bicarbonate sequestration vessels could be based, and has found that the latter category offers lower total cost in many areas.
3. It can be configured to sequester CO_2 captured from the atmosphere – via a technology like DAC or BECCS – to enable large-scale ocean sequestration of atmospheric CO_2. To our knowledge, this is a novel mCDR pathway which is not yet being broadly discussed in the CDR community, and could add an additional degree of freedom to CDR efforts.

For these reasons, we expect the development of an mCDR Plan to be highly impactful on Calcarea's current work to scale-up the technology, and for our mid-term prospects to deploy the technology in America.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and

effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

The United States needs a fit-for-purpose policy environment that both promotes maritime decarbonization and mCDR, but also applies effective regulation and MRV to ensure that activities are generating real quantifiable environmental benefits while avoiding harms to the environment and communities. Our observation is that the United States has many of the right ingredients to start the process of creating such a policy environment, but that much work remains. Calcarea would welcome the evaluation of where our bi-carbonate sequestration technology could fit within such an environment.

We also note that the Calcarea process lends itself to quantitative, real-time documentation of data streams for MRV. By capturing and sequestering CO_2 in a chemical reactor we can measure the difference between water flowing in and water flowing out to know exactly how much CO_2 has been converted to biocarbon ions. In association with the sensor company Alphazeta, we have created a 'box' with optical sensors that measures the pH/Alk/DIC triple on small volumes of flowing water streams. This new measurement technology should be broadly useful in the mCDR ecosystem, for use with other technologies as well as our own, as protocols for MRV are developed. Similarly, we would welcome the opportunity to discuss our expertise in measurement with regulators.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

While it is beyond our scope of expertise to offer ranked priorities, we do note that the technology we are pursuing - sequestration of captured carbon dioxide as bi-carbonate - is presently under-appreciated in the technical and policy communities, especially given its potential to deliver high-volume, high-durability, low-cost emissions reductions and CDR.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Our observation at Calcarea is that successful deployment of mCDR to help address the climate challenge will rest upon a transparent and trusting relationship between developers of projects and technologies, the Government, and civil society. We believe that Government should play an active role in helping to build trust with communities, while also listening to their concerns and needs. Of specific importance to our own technology, is that while it is well known among the Oceanographic community that ocean bicarbonate is a stable, permanent, and safe means for sequestration of CO_2, this view is not widely appreciated among the public or interest groups such as environmental NGO's. Since many forms of mCDR - and also most forms of enhanced rock weathering - ultimately result in the conversion of atmospheric CO_2 into ocean bicarbonate, an active role by Government in communicating this point would pay dividends for the fields overall.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, nongovernmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Please see answer to #3.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

We believe the Government's mCDR plan should address several goals:

1. It should support early-stage R&D for promising decarbonization and mCDR technologies.
2. It should support scale-up and deployment of these technologies through a combination of grants, incentives, and market mechanisms.
    a. A key action that would benefit mCDR and maritime decarbonization efforts would be the expansion of decarbonization tax incentives such as 45Q to cover such activities. The MCDR-FTAC could highlight this opportunity in the mCDR Plan.
    b. Further, as a Flag State participant in the IMO, the United States could help the IMO recognize conversion to bicarbonate as a valid mechanism of carbon dioxide sequestration. Since individual companies like Calcarea have limited access to IMO policy-making, this would be a particularly critical role for the US Government.
3. It should prioritize and support work to develop high-integrity MRV systems for all forms of maritime decarbonization and mCDR.
4. It should clarify permitting standards for mCDR research and deployment. This effort should also promote environmental justice, and seek to avoid both potential environmental and social harms that could arise from the use of these technologies.

From: Katie Lebling (b) (6)
Sent: Tuesday, April 23, 2024 11:20 AM
To: Light, Tricia M. EOP/OSTP
Cc: Carolyn Savoldelli (She/Her/Hers)
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan - WRI response
Attachments: Marine CDR Research Plan RFI_WRI response.pdf

Dear Ms. Light,

Please see the attached comments from the World Resources Institute in response to the RFI on a Marine Carbon Dioxide Removal Research Plan.

Thank you,
Katie Lebling

Katie Lebling
Associate II, Carbon Removal and Industrial Decarbonization

World Resources Institute
WRI.org
Direct: (b) (6)
(b) (6)

WORLD RESOURCES INSTITUTE

10 G Street, NE Suite 800 Washington, DC 20002 +1 (202) 729-7600 www.WRI.org

April 23, 2024

Thank you for the opportunity to provide comments on this request for information, document number 2024-03758, *Marine Carbon Dioxide Removal Research Plan*. The following responses are submitted on behalf of World Resources Institute (WRI), a global non-profit research organization. WRI works on global challenges at the intersection of climate change, human well-being, and environmental protection. We recognize that the science is clear on the need for carbon dioxide removal (CDR), including marine CDR, to complement deep and rapid emissions reductions. Our work in this area focuses on identifying policy options and other ways to enable responsible development and deployment of carbon removal, within the scientifically outlined need.

1. How would a Marine CDR Plan affect you, your organization, or your community?

WRI conducts rigorous research to apply evidence-based solutions for global challenges at the intersection of climate, nature, and people. In collaboration with public and private sector stakeholders, we strive to identify solutions that benefit all three. We hope that any mCDR research plan also strives for this balance of addressing climate impacts while providing benefits and minimizing harms to people and nature.

We recognize that scaling up carbon removal – including marine CDR – will be critical to meeting our climate goals. A well-designed mCDR research plan would provide the funding and direction to help advance the research needed to enable decisions around large-scale deployment, which would contribute to meeting national and global climate goals. If research and eventual deployment is not designed in an inclusive, equitable, and thoughtful way, public pushback could set the field back and hinder the development and advancement we expect to rely on in coming decades. Further, it could have cascading detrimental effects for the people most vulnerable to climate impacts.

WRI convenes partners from national and city governments, businesses, civil society groups, and more that could be impacted by mCDR research and implementation. As WRI's focus is global, the development and implementation of an equitable, inclusive, and strategic research plan for mCDR in the U.S. could also serve as a model for other countries that are beginning to delve into this topic.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what

additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Questions and concerns about regulation: In terms of regulation for marine CDR, a key question and concern we see is whether the current regulatory regime is sufficient to regulate ocean CDR, or whether it needs reformulation to be more comprehensive, proactive, and fit-for-purpose. Since ocean CDR is a relatively new field that has developed after existing regulatory frameworks were established, ocean CDR approaches are being slotted into regulations that were not designed with them in mind. This can create both duplicative and burdensome processes while also not comprehensively regulating mCDR processes. It will be important to understand where government agencies stand on this issue and what plans are underway to improve regulatory frameworks to be more robust and fit-for-purpose.

In WRI's 2022 report, *Toward Responsible and Informed Ocean-based Carbon Dioxide Removal: Research and Governance Priorities*, we emphasize the importance of a proactive and comprehensive regulatory regime that would help avoid the complexity and confusion we've already seen around permitting research or other types of projects in U.S. waters. Without a more robust, clear regulatory regime, companies are likely to focus their efforts in other countries, some of which have weaker regulatory regimes that could allow environmentally damaging projects to take place. U.S.-based mCDR start-ups like Running Tide and Planetary are already looking to countries like Iceland, the United Kingdom, and Canada in part due to insufficient clarity or difficulty obtaining project permits in the United States. While international coordination and collaboration in marine CDR research will help accelerate development of robust, harmonized solutions, U.S. based companies looking to conduct their research outside the country could risk the U.S. losing its leading position as a technology developer and innovator in the climate space.

Along these lines, it will be important for regulation, specifically permitting processes, to differentiate between projects that are focused on research compared to projects that are meant for commercial deployment (or a combination of commercial deployment and research). While we recognize that building the necessary knowledge base to advance mCDR will require public and private sector efforts working together, incentives for commercial deployment are different than for pure research. Permitting processes should recognize that. Incentivizing as much data sharing as possible, perhaps with incentives tied to permitting, could be helpful to increasing transparency and development in the field. This type of transparency is important since mCDR is ultimately a public good of atmospheric clean-up.

Tools the government could provide: An intermediate step on the way to developing a more robust regulatory framework could be the adoption of a code of conduct for ocean CDR research supported by federal funding. Several efforts have been made in this space already that could be built upon – including by the Aspen Institute, the American Geophysical Union and a group of academics. Additional steps should be taken to make the code of conduct actionable – for example, making it clear how researchers can show that they're adhering to the code and clarifying what benefits or incentives are provided for successful adherence.

Additionally, the government could help facilitate interagency and international cooperation, especially in sharing transparent and standardized research outputs to enable efficient knowledge exchange. Developing a standardized data reporting and sharing system with comprehensive metadata that encourages replicability would help make research information more accessible and actionable for other researchers.

<u>Knowledge gaps for regulation</u>: One of the main concerns regarding the ability of the current regulatory frameworks to govern marine CDR approaches is that they are focused on the prohibition of harm, rather than also on proactively managing how marine CDR approaches are developed and deployed within a robust governance framework that considers the full lifecycle of an mCDR project. As such, the existing regulatory frameworks under which mCDR is being regulated today (namely the Marine Protection, Research and Sanctuaries Act and the Clean Water Act) would need to be revised to consider not just the potential harms of marine CDR approaches to marine ecosystems but also the potential benefits they would provide to the climate. And ultimately, these harms and benefits would need to be considered in relation to potential harms of climate change in a scenario where mCDR is not pursued.

A knowledge gap that could be filled to support both decisions around deployment and permitting would be identification of acceptable limits of negative environmental and social impact by approach, location, and scale. These limits or thresholds may also change over time as impacts of the climate crisis worsen and our knowledge of ocean CDR approaches improves.

<u>Knowledge gaps for deployment</u>: Overall, a better understanding is needed in terms of both efficacy and ancillary impacts (both ecological and social) of each approach – and how this varies under different circumstances (for example in different locations, at different scales, in different seasons, etc.). Communities adjacent to and reliant on marine resources should be meaningfully involved in research efforts to holistically evaluate social and environmental impacts. Measuring efficacy of carbon removed in terms of net tons – as well as removal capacity of different approaches – is a key component of the measurement, reporting, and verification process, and in many cases measuring non-carbon impacts is as well. Improving ocean modeling capabilities and increasing access to that computing power, as well as improving and expanding autonomous sensors and other instruments that can directly monitor in the ocean, will all help build a better understanding of the holistic benefits of each mCDR process. This information – along with the impact thresholds mentioned above – should be used to create decision-making criteria to guide decisions on which approaches under which circumstances are most safe and effective for deployment.

3. **Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?**

The severity and risks of the current and growing climate crisis mandate that we research all possible solutions to determine their viability. Therefore, all marine CDR approaches should be further researched, including lab research and rigorously monitored at-sea tests. As laid out in the National Academies' 2022 report, research should be iterative and stage-gated such that it only continues if certain criteria for success are met. As we understand more about relative risks and benefits, levels of federal support should be increased or decreased accordingly.

At this early stage, there is no conclusive answer to which approaches are most promising and most risky. There are knowledge gaps tied to project-specific factors, such as location, scale, and motivation or objective of the project. We can, however, broadly categorize some types of risks as associated with biotic and abiotic approaches respectively. These are well laid out in reports by the National Academies and other organizations.

In the near term, it could also be helpful to work towards characterizing approaches based on their directionality of efficacy and impact. For example, an approach with high confidence and robust documentation around the positive directionality of efficacy and uncertainty around impact is likely more promising to pursue than an approach where directionality of efficacy and directionality of impact could both be either positive or negative. Approaches with proven storage permanence and those that provide co-benefits for people and nature, such as biodiversity conservation and fisheries productivity, should also be prioritized. These general metrics for success are likely to vary widely across locations, and therefore research is unlikely to conclude a single top-priority approach.

4. **What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?**

Types of information that the federal government could provide: It will be important to have public information about any projects that have requested and have received permits for at-sea research and testing. Such a tracker could be similar to the EPA's recently launched tracker for Class VI well applications, which lists the step each project is at in the application process and is updated regularly. As part of this tracker, it would be useful to include basic project information for each proposed project, such as location, duration, scale, type of mCDR approach, actors involved, and, if possible, expected environmental and social impacts.

As noted above, as projects progress and are completed, sharing as much of the data and learnings as possible will be helpful to advance knowledge generation and efficient technological development in the field.

How the government could engage mCDR stakeholders: In terms of engaging with marine CDR stakeholders, including the public, Indigenous communities, and other communities that may be affected, we suggest using the thoughtful recommendations included in the Aspen Institute's Code of Conduct. It recommends establishing inclusive decision-making processes and emphasizes that the appropriate model of engagement for any project will depend on "scale, scope, and levels of uncertainty and/or risks of the project". Identifying and meaningfully including vulnerable populations, such as those reliant on potentially impacted marine ecosystems, will mitigate risks they might otherwise face and improve likelihood of success in implementation. Engagement should include stakeholders from potentially impacted sectors such as tourism, energy, and shipping, in addition to artisanal and commercial fishing. Specific methods of engagement could include stakeholder advisory councils, sufficient public review periods, public forums, and stakeholder workshops.

As with all types of CDR projects, researchers and/or project developers should clearly communicate the basics of the project (location, duration, etc.) as well as anticipated impacts of the project (both positive and negative) and should gather feedback on stakeholder concerns and questions. An early part of the engagement process should include establishment of the desired level of engagement with communities and other interested parties including how often information will be shared, through what channels, how involved external stakeholders will be in influencing the development of the project (e.g., co-development, information sharing).

We recognize that in some cases it can be difficult to identify which stakeholders should be engaged for a given marine CDR project. For example, as projects take place further from the coastlines and toward the high seas, it becomes more difficult to identify which communities may be affected. However, as most projects are sited in coastal areas in the near-term, we can expand our knowledge base around impacts and engagement to better inform practices for projects that are located further out at sea. It would be helpful for government agencies to share best practices and lessons learned from community engagement efforts to inform the field – including on how to identify relevant stakeholders for different types, locations, and scales of project.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

As part of any mCDR research plan, we believe it will be important to explain how marine CDR (and investments in its development) fits into a broader portfolio of carbon removal and how that all fits with a broader portfolio of emissions reduction and climate action. There is scientific consensus that we will need CDR, but also that CDR needs to be accompanied by significant emissions reductions – and only with significant emissions reductions is its value maximized. Given concerns around mitigation deterrence, it will be helpful to address this broader strategy in any mCDR research plan to avoid these concerns and criticisms.

Likewise, it is important to continue existing research efforts in actionable blue carbon ecosystems, such as mangroves and seagrasses, as nature-based climate solutions should be foundational to but not conflated with mCDR research efforts across diverse biotic and abiotic approaches.

That said, we are supportive of increased federal funding for research and at-sea testing to address the knowledge gaps in the mCDR field. Federal funding for terrestrial CDR increased from almost nothing in 2019 to several billion dollars today. Marine CDR has received very little funding to date, and recommendations from the National Academies of Sciences, Engineering and Medicine in their 2022 ocean CDR report recommend at least $1.3 billion to address priority research areas and up to $2.5 billion to cover all marine CDR research recommendations over ten years.

From: Meg Chadsey (b) (6)
Sent: Tuesday, April 23, 2024 11:36 PM
To: Light, Tricia M. EOP/OSTP
Cc: Meg Chadsey
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: FTAC mCDR RFI_Chadsey.docx

Dear Tricia,

I respectfully submit this input (attached) in response to the National Science Foundation's Request for Information to inform the development of a marine carbon dioxide removal implementation plan by the mCDR Fast-Track Action Committee.

Specifically, in answer to the question "*How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?*", I propose the following:

The government should create and fund a new national carbon-focused extension program modeled after the National Sea Grant College Program. This program, which I suggest calling 'C Grant', would serve the same 3-part research/education/outreach function as the well-known and successful national Sea Grant program after that its name references. The scope of C Grant would be greater than just mCDR (its broader mission would encompass the entirety of our country's decarbonization and carbon capture goals), but like its namesake, it would serve as a trusted source of information and extension agents capable of providing reliable technical and science-based information about mCDR to coastal constituents while also transferring research priorities back to their universities. **A carbon-focused program styled after Sea Grant could be a highly effective way to engage coastal communities and support informed public decision making about mCDR.**

Sincerely,

Dr. Meg Chadsey

Meg Chadsey
Pronouns she/her/hers (what is this?)
Carbon Specialist & WSG Liaison to NOAA Pacific Marine Environmental Lab
Washington Sea Grant College of the Environment | University of Washington
T (b) (6) (office line; messages forwarded to my cell) | M-F 8am - 5pm
Sign up For WSG News

April 23, 2024

Tricia Light
Office of Science & Technology Policy
Executive Office of the President

By email: (b) (6)

Re: National Science Foundation Request for Information on Development of Marine Carbon Dioxide Removal Research Plan

Dear Ms. Light,

I respectfully submit this input in response to the National Science Foundation's Request for Information to inform the development of a marine carbon dioxide removal implementation plan by the mCDR Fast-Track Action Committee.

Specifically, in answer to the question "*How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?*", I propose the following:

The government should create and fund a new national carbon-focused extension program modeled after the National Sea Grant College Program. This program, which I suggest calling 'C Grant', would serve the same 3-part research/education/outreach function as the well-known and successful national Sea Grant program after that its name references. The scope of C Grant would be greater than just mCDR (its broader mission would encompass the entirety of our country's decarbonization and carbon capture goals), but like its namesake, it would serve as a trusted source of information and extension agents capable of providing reliable technical and science-based information about mCDR to coastal constituents while also transferring research priorities back to their universities. **A carbon-focused program styled after Sea Grant could be a highly effective way to engage coastal communities and support informed public decision making about mCDR.**

Sincerely,

Dr. Meg Chadsey
Carbon Specialist, Washington Sea Grant
(b) (6)

From: Mahmud Farooque (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 11:30 PM
To: Light, Tricia M. EOP/OSTP
Cc: Nicholas Weller; Amanda Borth; Emily Hostetler; David Sittenfeld; Darlene Cavalier; David Tomblin
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: ECAST RFI Response - Marine Carbon Dioxide Removal Research Plan.pdf

Dear Tricia,

On behalf of my colleagues at the Expert and Citizen Assessment of Science and Technology (ECAST) network, I am pleased to submit the attached response to the Marine Carbon Dioxide Removal Research Plan RFI.

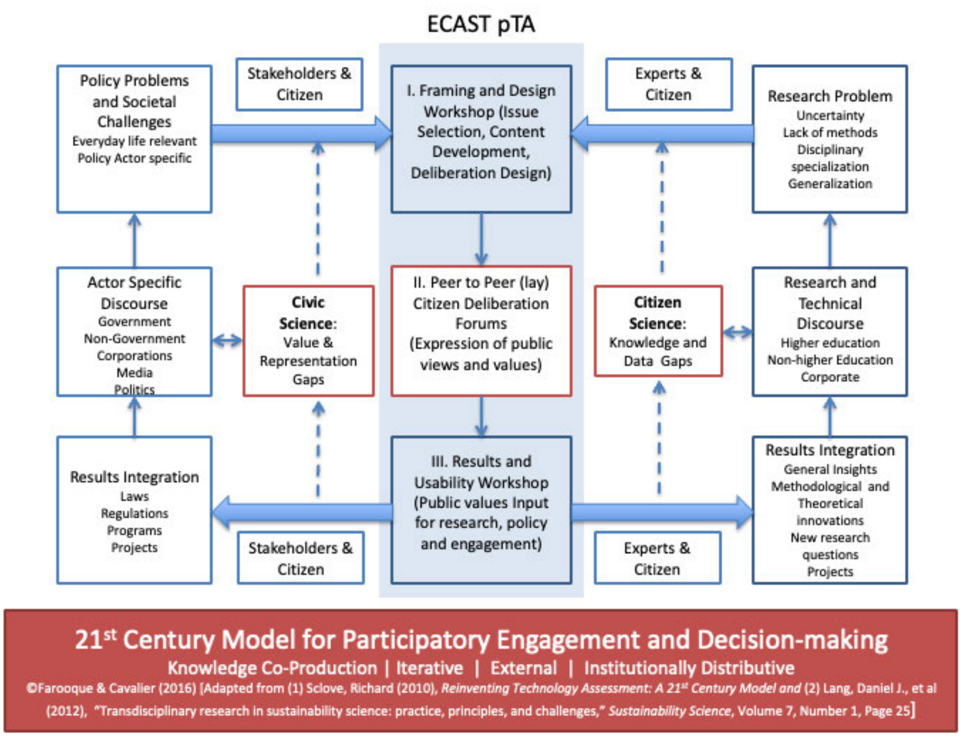
Sincerely,
Mahmud

--
Mahmud Farooque
Associate Director, Consortium for Science, Policy & Outcomes (CSPO)
Clinical Professor, School for the Future of Innovation in Society (SFIS)
Senior Global Futures Scholar, Julie Ann Wrigley Global Futures Laboratory (GFL)
Principal Coordinator, Expert and Citizen Assessment of Science and Technology (ECAST)
ASU Washington Center; (b) (6) [redacted]; (b) (6) [redacted]

Marine Carbon Dioxide Removal (mCDR) Research Plan RFI

About us:
We are submitting this response as a group of social science, public engagement and science policy scholars and practitioners representing the Expert and Citizen Assessment of Science and Technology (ECAST) network led by the Consortium for Science, Policy and Outcomes (CSPO) at Arizona State University (ASU), Museum of Science, Boston and SciStarter. ECAST combines expert and social assessment of science and technology with community, stakeholder, and public participation to inform policy and decision-making through a reflexive, inclusive and adaptable engagement methodology called participatory technology assessment (pTA).

Since 2010, Federal agencies including NASA, NOAA, DOE, NSF and the NIH have sponsored ECAST partners to conduct pTA for a variety of topics (i.e., biodiversity, planetary defense, community resilience, and spent nuclear fuel disposal) for a variety of purposes (research, education, and decision support). The ECAST pTA methodology has been cited in OMB report on equity and PCAST letter on public engagement. It is built around three integrated layers of engagements: (i) academic partner-led layer of problem framing engagement with experts, stakeholders and lay publics to co-define the topics, contents and publics for engagement, (ii) museum partner-led layer of inclusive, informed and deliberative engagement with target publics to produce useable outcomes for different academic, education and decision-making audiences, and a (iii) policy think tank partner-led final layer of results integration engagement with the intended audience.



1. How would a Marine CDR Plan affect you, your organization, or your community?

- Given our pTA expertise, portfolio of past projects, and current efforts specific to participatory and democratic governance of climate intervention technologies in general and CDR in particular, we are confident that our methodology and expertise will be called upon in some shape or form to help adapt and scale social and participatory assessment of mCDR technology research and development.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

- There remains a high degree of uncertainty about whether mCDR technologies would work at scale, who would benefit and who would suffer from the deployment of such technologies, where such technologies might be located, what their effects would be on surrounding populations, and what their impact would be to those already most vulnerable in society.
- The significant potential for disruption and contestation surrounding mCDR resource utilization magnifies the importance of exploring the social dimensions of such questions and how they factor into the development of governance frameworks from research to field testing to deployment.
- Adding to the governance challenge is the high likelihood of uneven rate of progress in research and development. As evidenced in the case of land-based CDR technologies, the governance challenge is likely to cover the entire spectrum, from research and testing to development and deployment, which in turn will require different participatory engagements with different types of communities, stakeholders, rightsholders, and publics.
- The tools or resources available for conducting social assessments of mCDR are scarce, underdeveloped, and not fit for purpose. For example, the origins of the ECAST pTA methodology in use today can be traced to NSF's support of research on social implication and informal science education alongside its funding of nanotechnology research centers in the early 2000s, all of which were coordinated through the national nanotechnology coordination office (NNCO).
- The scale of research needed to advance mCDR from laboratory research to field testing and deployment will far outstrip the scale of research investments made to advance nanoscale research and development. We believe a proportionate level of coordinated and targeted investments in social science research and informal science education will be needed to advance the tools and methodologies needed for participatory assessment of mCDR technologies and anticipatory, polycentric

and responsible governance and decision making around research and development.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

- Not enough is known to answer any of these questions with empirical evidence and high degree of confidence. We maintain that pTA methodology is most suited to generate useful and actionable answers to these questions that would be usable and fit for purpose.
- As evidence of what kind of answers could be generated through a pTA process involving mCDR, we offer the following preliminary findings from our current Alfred P. Sloan Foundation funded pTA project on CDR.
    - The lay publics are:
        - Cautiously optimistic about CDR, but they require more information and transparency about how the technology will influence the environment and communities,
        - Very much in the "upstream" phase of thinking about CDR and the development and deployment of CDR technologies is outpacing their ability to establish informed value judgments,
        - Conceptualizing environmental concerns and solutions in terms of individual and community actions/behaviors more than CDR technologies, and
        - Seldom viewing CDR as addressing their immediate concerns about the environment.
    - The expert stakeholders are concerned about CDR:
        - Being done for the 'wrong' reasons driven by vested interests and distracting from steep emissions reductions,
        - Being effective in terms of scale, long-term storage, and costs,
        - Causing environmental harms in terms of cascading effects across ecosystem, geography, and time,
        - Causing harms to human health, livelihood, and well-being,
        - Causing harm to vulnerable communities,
        - Governance structures as being not suitable,
        - Lacking means for rigorous measurement, reporting, and verification, and
        - Lacking transparency, accountability, and trust building.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, nongovernmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the

Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

- As NSF develops an mCDR research plan, it is valuable to begin by assessing perhaps the most adjacent federal program: the Department of Energy's Direct Air Capture Hubs demonstration program. Though this program focuses on demonstration rather than research, it offers insights into where the federal government has seen success with public engagement and where its limitations can inspire NSF research in mCDR.
- The DAC Hubs program has made strides in its (1) requirement of community benefits plans, (2) the creation of shared principles for community collaboration, and (3) opportunities for communities to provide input at each project phase. However, as with many innovations, particularly CDR, community and stakeholder insights were asked for only after those in decision-making power set a research agenda and development plan.
- DOE has also made strides in their recent efforts to seed community, stakeholder and public engagement, map public values, and develop community capacities for designing and implementing a fair, just, and equitable process for consent-based siting for interim storage of spent nuclear fuel. This effort takes to heart two concerns that are applicable to mCDR:
    - The perpetuation of historical injustices toward communities where science and technology projects are placed in communities without the consent of all relevant stakeholders and community members.
    - Opportunities for engagement are determined by those in positions of decision-making power rather than in collaboration with communities and stakeholders to be designed in a way that works best for those actors.
- The resulting 12-member Consortia for Consent Based Siting will provide tools, methods, and best practices for engaging with diverse communities on complex science and technology issues such as mCDR.

From: Marc von Keitz <(b) (6)
Sent: Tuesday, April 23, 2024 11:12 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Response to Marine Carbon Dioxide Removal Research Plan RFI.pdf

Please see my response to the Marine Carbon Dioxide Removal Research Plan attached.

Let me know if you have any questions.

Best regards,

Marc

--
Marc von Keitz | Grantham Foundation for the Protection of the Environment
(b) (6)
(b) (6)

Response to Marine Carbon Dioxide Removal Research Plan RFI, dated 2/22/2024

Provided by: *Marc von Keitz, Ph.D., The Grantham Foundation for the Protection of the Environment*

1. How would a Marine CDR Plan affect you, your organization, or your community?

As a philanthropic organization dedicated to advancing climate change solutions, having an effective federal Marine CDR Plan will help focus and align funding to rapidly advance our understanding the most promising mCDR solutions.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

To advance mCDR research in a timely manner, it will be important that the process of issuing the necessary research permits for field work is very clear and transparent. While local conditions will need to be considered, it is also important to put any perturbations of the marine environment that could result from mCDR field experiment into context with naturally occurring perturbations or those from other permitted marine activities.

Well instrumented and pre-permitted test sites representative of ocean environments that are suitable for scaling individual mCDR approaches are still in very short supply and federal support for the establishment of these test sites would be very helpful in advancing the evaluation of these technologies as well as the assessment of potential effects on the environment (positive or negative).

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

The criteria for prioritizing individual CDR techniques need to include safety (for people and environment), cost, critical resource requirements and opportunity cost (i.e. could these resources be more effectively used with another CDR technology), scalability and speed-to-scale (CapEx needs, permitting, supply chains, human resources, etc). Building an overarching assessment framework that allows the systematic comparison of not just individual marine CDR techniques, but also comparison to other CDR technologies (e.g. DACC or BiCRS) will be critical to guide funding decisions for the federal government, as well as for philanthropic funders and private investors. Such an assessment framework needs to make all the underlying assumptions explicit and should try to unify them, as much as possible, across the various CDR technologies. A good example for a comprehensive approach to developing such an assessment framework is the ASMASYS initiative (https://asmasys.cdrmare.de/en/), which is being led by the GEOMAR research institute in Kiel, Germany.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

It is important to be fully transparent about all the work that the federal government is supporting in marine CDR. All the results of this work should be made available in a timely manner, including negative results (i.e. results that did not support the outlined hypothesis) and failed experiments (as long as their methods are clearly described). This will help the research and development community learn from mistakes and minimizes the risk that we pay for the same mistake twice.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Some relevant philanthropically supported mCDR initiatives include:

- Ocean Visions (https://oceanvisions.org): field building organization for mCDR
- Carbon-to-Sea (https://carbontosea.org): focused on advancing ocean alkalinity enhancement
- C-Worthy (https://cworthy.org): developing advanced mCDR modeling tools required for effective MRV

Two-way open communication is critical for these and other organizations active in the mCDR field to be fully aware what the federal government is planning to do and for the federal government to understand what work has already been done. This way we can focus efforts and resources on the key bottlenecks and minimize duplications of work.

From: Zach Cockrum (b) (6) >
Sent: Tuesday, April 23, 2024 9:54 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Vesta mCDR FTAC Comments - FINAL.pdf

Ms. Light -

Please see the attached comments from Vesta, PBC for the MCDR-FTAC RFI.

Thank you,

--
Zach Cockrum
Vice President of Policy and Partnerships

>https://www.vesta.earth/<

VESTA

April 23, 2024

Members of the Fast Track Action Committee for Marine Carbon Dioxide Removal,

Vesta deeply appreciates the leadership of the Biden Administration, and the members of the Fast Track Action Committee in their work to develop a Marine CDR Plan. A carefully crafted Marine CDR Plan will enable the responsible growth of this industry by supporting, among other things, public-private partnerships, coordinated research across sectors, and establishing safe, effective, and timely permitting pathways. Existing science is clear: the world needs high-quality, durable carbon removal to reduce the impacts of climate change. These solutions should minimize environmental impacts and maximize community benefits wherever possible. Vesta's Coastal Carbon Capture (CCC) approach, which deploys carbon-removing olivine sand in coastal protection projects, shows great promise in meeting these goals. The development of a Marine CDR Plan will greatly accelerate our ability to pursue research and development. To maximize the opportunity for mCDR research and development, the Marine CDR Plan should accomplish the following goals:

- Articulate that commercialized research is a core part of the success of public-private partnerships and that the sale of verified carbon removal credits or advanced market commitments can be a key part of funding advanced research and development for mCDR.
- Recommend that this perspective informs not only domestic but also international regulatory policy positions of the United States.
- Recommend that mCDR approaches follow the permitting regime of existing activities they most closely resemble.
- Within permitting regimes, recommend the creation of permitting categories specific to mCDR.
- Continue to support effective public-private partnerships through increased funding opportunities across federal agencies.
- Encourage the use of Community Benefit Agreements for all federally supported projects.
- Support further investigation into Coastal Carbon Capture as a promising mCDR solution that can remove carbon while adding to coastal protection efforts that protect vulnerable communities from sea level rise.

In addition, we suggest that the FTAC should evolve into a standing interagency coordinating body to execute the plan, and, among other duties:

- Develop and update common permitting guidelines and criteria that apply across mCDR approaches and permitting regimes.
- Serve as a pre-permitting consultative body to help unearth questions and concerns across the breadth of the Federal Government and facilitate resolution of them to expedite permitting review.
- Provide technical assistance to states and local regulators as requested when they lack mCDR-specific knowledge and expertise, including on a funded basis if possible.
- Coordinate research objectives across the suite of federal mCDR investments and with academic, non-profit, and industry researchers.
- Develop and disseminate educational materials through federal outreach entities.

Once again, we thank you for your work in developing this plan and for the opportunity to comment. Below we elaborate on why these actions can support the responsible research and development of Vesta's and other promising marine carbon dioxide removal approaches. We acknowledge the Request for Information suggested limiting responses to five pages. To balance the detail needed to articulate our positions and provide actionable and concise recommendations, we have provided key points that summarize our responses to each question.

1. How would a Marine CDR Plan affect you, your organization, or your community?

Key Points:

- *Because Vesta's Coastal Carbon Capture approach integrates with coastal protection efforts, it is a unique solution that leverages an existing industry in its deployment and provides multiple benefits beyond carbon removal.*
- *A federal Marine CDR Plan could greatly enhance the coordination among government actors to support research and development in Coastal Carbon Capture and mCDR more generally, largely through public-private partnerships.*
- *A federal Marine CDR Plan could clarify and simplify the permitting process for mCDR solutions to ensure rigorous regulatory oversight can be provided while avoiding unnecessary delays to progress.*
- *This strategy is essential to the development of safe, large-scale mCDR approaches, including Coastal Carbon Capture.*

Vesta is a public benefit corporation with the mission "to further the science of Coastal Carbon Capture and galvanize global deployment." Vesta uses the abundant mineral olivine to accelerate the Earth's natural carbon removal processes and protect coastlines. Through our Coastal Carbon Capture approach, we mill olivine into beach-compatible sand and place it in coastal settings to enhance coastal resiliency while removing carbon dioxide from the atmosphere. As olivine sand dissolves in seawater it reacts with carbonic acid, resulting in long-lasting bicarbonate and permanent carbon removal on human timescales.

We have conducted one field trial in Southampton, New York, and we have another planned and permitted for Duck, North Carolina that will likely be deployed this spring. Throughout our development pathway, we have furthered the science underpinning our approach by sharing the results of our research publicly, including through submissions to peer-reviewed publications and the sharing of monitoring results through publicly accessible reports to regulators. We also consider community engagement a core part of our work to develop understanding and support for our project deployments.

In short, we take very seriously the *responsibility* to research, develop, and - if appropriate - scale this approach; we are developing a company model for solving the climate crisis that is different from the models that created it.

The development of a Marine CDR Plan will be particularly helpful to Vesta as we continue research and development into Coastal Carbon Capture at our planned field trial in Duck and beyond. Across the board, the Biden administration should pursue a technology-neutral approach to carbon removal that includes open-system solutions like mCDR as we try to identify the suite of low-cost, safe, and effective forms of carbon removal. The development of a Marine CDR Plan will greatly advance the sector in a positive direction.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?

Key Points:

- *Coastal Carbon Capture is a unique approach for which there are conflicting views within the Federal Government on the appropriate permitting pathway. This lack of clarity directly contributed to a significant delay in Vesta's permit application for its project in Duck, North Carolina which nearly jeopardized the project and Vesta's continued existence.*
- *The Marine CDR Plan should encourage regulatory agencies to apply permitting regimes to mCDR approaches based on which existing permitted activities these approaches most closely resemble.*
- *Section 404 of the Clean Water Act should continue to be the pathway under which Coastal Carbon Capture is regulated because olivine sand is placed as a coastal-protection fill material and alters the bottom of the ocean in a way that impacts navigation; using the Marine Protection, Research and Sanctuary Act (MPRSA) as a further permitting regime would add a duplicative permitting process for the olivine portion of a coastal protection project.*
- *For open-ocean deployment of fine-grained olivine which would dissolve quickly, the application of the MPRSA is the appropriate pathway, but it still lacks clarity on how specific provisions of this statute intended to regulate harmful waste disposal would apply to mCDR techniques that have both risks and benefits*.
- *The FTAC should continue its work by evolving into a standing interagency coordinating body, which should develop standard permitting criteria for mCDR that transcend*

approach and regulatory regime. These standards should form the basis of official guidance or new "general" permit categories under the Clean Water Act or MPRSA.

The Federal Government can help advance the responsible research and development of marine carbon dioxide removal by further clarifying and simplifying the permitting process, especially for low-impact and appropriately sized pilot projects. Vesta's experience in permitting its pilot project for Duck, North Carolina illustrates the challenges facing first actors in this space. Our permit was submitted for state and federal review in July of 2022, with our federal permit submitted under section 404 of the Clean Water Act, which traditionally regulates the deposition of sand for beneficial use in coastal environments (such as beach nourishment and coastal protection activities). After significant dialog with North Carolina's Department of Environmental Quality and modifications to the project design, our permit entered abeyance pending further federal review. After continued inaction from the Federal Government, we learned that our permit application had triggered a jurisdictional disagreement between the United States Army Corps of Engineers (USACE) which processes Clean Water Act 404 permits, and the Environmental Protection Agency (EPA), which believed that marine carbon dioxide removal projects should be subject to marine dumping regulations under the MPRSA.

While this conflict was ultimately resolved in favor of permitting this project under the Clean Water Act, the 18-month-long permitting process caused by this delay nearly jeopardized the viability of our company. Potential investors in Vesta have expressed concern about permitting uncertainty and see this as a key risk for the industry as a whole. Moving forward, the Clean Water Act section 404 should be the permitting regime under which Coastal Carbon Capture is regulated. It is clear that whenever the deposition of materials into the ocean would result in impacts on navigation, Congress gave significant authority to USACE, both under the Clean Water Act *and* MPRSA (under which USACE regulates, with assistance from the EPA, the disposal of dredged materials in offshore dumping sites).

Because Coastal Carbon Capture is intended to integrate into coastal protection projects, regulating the approach under the MPRSA would create further permitting and regulatory hurdles for communities that want to use olivine sand as a small portion of their planned coastal protection projects. Integrating into existing coastal protection efforts is essential to the scalability of Coastal Carbon Capture, so timely, permanent resolution of this issue is critical for the future development of our approach.

Beach protection efforts, in particular, are increasingly made more expensive due to the lack of reliable sand sources. This is a particular challenge for lower-income areas. The integration of olivine can help address both cost and sand-sourcing challenges while addressing the root cause of climate change. However, if integrating a relatively small amount of olivine triggers a different regulatory pathway than the project would otherwise go through and requires a dumping site to be designated, it would likely significantly undermine community interest. Vesta recognizes that the addition of olivine to an otherwise typical Clean Water Act 404 coastal protection project will and should entail extra scrutiny beyond what a community may be accustomed to, but this is notably short of requiring an entirely different framework than they have utilized for similar past projects.

In the future, Vesta or other entities may lead or assist in pilot projects for finer-grained olivine deposition in the open ocean which would necessarily be regulated under MPRSA. Because this activity is not designed to integrate with coastal protection features, there is no jurisdictional question between regulatory approaches. Within MPRSA, however, there are still questions about how the existing "special" and "research" permit categories would apply to mCDR, and questions of how specific considerations within those permit categories would apply to mCDR. For any approaches that utilize MPRSA, we strongly encourage the development of a general permit category that accommodates the unique risks and opportunities inherent in mCDR.

The Biden Administration's policy, as expressed through the Marine CDR Plan, should be that mCDR approaches follow the permitting pathways for existing activities that they most closely resemble. This would mean that approaches that utilize existing outflows would be regulated under the Clean Water Act's National Pollution Discharge Elimination System, and that Coastal Carbon Capture should likewise follow the Clean Water Act 404 pathway. Approaches intended to dissolve rapidly and not change the profile of the ocean, that otherwise resemble historic dumping activities, and/or for which there is no conflicting jurisdiction with other statutes should be permitted under MPRSA.

In addition to clarifying jurisdictional applicability, the Marine CDR Plan should ensure consistency across regulatory pathways by leveraging the expertise of the FTAC, other agency experts, and the stakeholder community to develop regulatory guidelines that would form the basis of permitting standards for pilot-scale projects regardless of the statute under which they are regulated. For example, criteria could include:

- Approving projects with sufficient laboratory or field evidence that demonstrates the size of the proposed activity is unlikely to result in significant or long-lasting ecological impacts.
- Requiring a commitment to transparent publication of findings, including via peer-reviewed publications where necessary.
- The use of independent third-party monitoring of MRV and/or ecological impacts with robust monitoring plans.
- Requiring public-private partnerships in the execution of pilot projects.
- Encouraging robust community benefit agreements and engagement.
- Requiring an adaptive management plan for unforeseen impacts.

Stepping back to look at the key issues facing mCDR - the benefits, impacts, risks, and need for transparency - should be the first-order priority ahead of jurisdiction. The Federal Government should ensure standardization across approaches, agencies, and relevant statutes by developing written guidelines for consideration during any permitting regime. Such guidelines could form the basis of a Clean Water Act NPDES General Permit, a Clean Water Act 404 Nationwide Permit, and the creation of an mCDR-specific general permit under MPRSA. Recognizing that these individual "general permits" would take time to go through an official development and public comment process, such guidelines could informally guide permitting, or form the basis of permit conditions that could be utilized across regimes in the interim.

Relatedly, the FTAC should evolve into a standing interagency coordinating body, that among other tasks, could measure proposed pilot projects against these general criteria, giving permit applicants a broad perspective during pre-permitting consultation, unearthing issues across agencies early in the process, and, ideally, expediting interagency review. Once again, this would have the effect of standardizing the Federal Government's treatment of mCDR across approaches and permitting regimes.

The urgency of the climate crisis and the need to find sound scientific solutions to addressing it necessitates such outside-the-box coordination among federal agencies. While it is clear there are current pathways to permitting mCDR pilot projects, further alignment across regimes allows mCDR companies to follow pathways that make the most practical sense for their approach while ensuring safety regardless of technique and location.

What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?

Key Points:

- *mCDR is under-supported relative to other CDR solutions. Increasing funding for research and pilot-scale demonstration projects is the best way to determine safety and effectiveness.*
- *The mCDR Plan should recommend more funding to support public-private partnerships to lead pilot projects across the board, including providing resources specifically for the USACE, National Oceanic and Atmospheric Administration (NOAA), and United States Geological Survey (USGS) to engage more deeply in research and development for Coastal Enhanced Weathering.*
- *Federal agencies should leverage the existing work of private companies conducting field trials to develop MRV standards.*

The Federal Government can play a particularly important role by supporting public-private partnership-led research in areas which crosscut mCDR approaches, including improving measurement, reporting, and verification techniques as well as modeling. In particular, agencies such as NOAA could help develop or inform the development of MRV standards, including requirements for data archival and facilitating data sharing. The mCDR industry is rapidly gaining firsthand knowledge in improving and refining MRV techniques and should be called upon by NOAA or other agencies as they develop standards.

Whenever providing resources for a specific approach, these resources should support public-private partnerships across industry, academics, and other researchers, with assurances that non-proprietary findings be publicly shared through multiple venues, including scientific publications.

Specific to Coastal Enhanced Weathering, USACE's Engineering Research and Development Center and Engineering With Nature Program are collaborating with us in Duck, North Carolina. USACE should play an even greater role in the research and development of Coastal Enhanced

Weathering, including sediment transport modeling, ecotoxicology modeling, and integration of olivine into coastal protection projects to help evaluate and quantify its potential benefits regarding coastal protection.

Federal agencies should also support Coastal Enhanced Weathering research and development opportunities in which companies and researchers work together to investigate the risks and benefits of the addition of fine-grained olivine into open ocean waters with the intent of olivine dissolving quickly and maximizing its climate benefits. While Vesta's near-term research and development goals remain focused on Coastal Enhanced Weathering, we are considering partnering with other organizations to leverage our growing expertise in olivine deployment logistics to assist in Ocean Alkalinity Enhancement field trials that include open-ocean deployments.

What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Key Points:

- *Results to date, including from laboratory testing and our first field pilot project in Southampton, NY, provide positive evidence of the safety and efficacy of Coastal Carbon Capture.*
- *Our larger pilot project in Duck will provide the world with important information about the real-world safety and effectiveness of Coastal Carbon Capture.*
- *Beyond Duck, we will continue research and development, moving towards deployments at larger scales and in different environmental conditions, and continuing to share these findings with the public and other researchers.*
- *Our project in Duck and subsequent projects will generate additional knowledge on the safety profile and efficacy of CCC at increasing scales, which will be critical for informing decisions about the readiness of CCC for full-scale deployment.*
- *Framing research and commercialization as a dichotomy obfuscates the key rationale behind leveraging public-private partnerships to pursue research and development of mCDR; the Marine CDR Plan should articulate that appropriately verified carbon removal credits and advanced market commitments are essential tools in the public-private partnership funding toolkit.*
- *Early deployments can have both commercial and research objectives. Regulatory review via permit applications is the appropriate mechanism for ensuring that deployments are appropriately sized to balance risks and benefits. The London Protocol, which in some cases restricts research to non-commercial interests, could, if interpreted domestically through permitting, prevent critically needed, privately funded research from proceeding.*

- *The Marine CDR Plan should support responsible, step-wise scaling based on knowledge of risks and impacts, and the dissemination of knowledge gained from these projects, regardless of the ability to generate revenue from a project.*
- *The United States' treatment of commercialization and public-private partnerships seems incompatible with the direction of the London Protocol.*

Within Coastal Enhanced Weathering, existing laboratory and small-scale field trials continue to indicate this approach has the promise to provide safe, durable, and effective carbon removal. Research goals for our Coastal Carbon Capture pilot in Duck, NC, include:

- Further enhancing our ability to measure changes in ocean chemistry that indicate carbon capture in real-world settings.
- Better learning how olivine dissolves and moves in a coastal environment.
- The presence and risks of trace metals, particularly in highly dynamic and energetic environments like those in the Duck nearshore area.
- How native flora and fauna are affected by olivine placements.

Beyond Duck, we must address other knowledge gaps as we continue to plan deployments in different environments. These include:

- Identifying the factors that most greatly influence olivine dissolution rates.
- Measuring ocean chemistry changes in highly organic or carbonate-rich environments.
- Risk factors for key species at new sites and minimizing environmental risk from olivine deployments

Commercialization is an essential financing mechanism to execute future deployments where we would address these knowledge gaps, which would be safely sized and informed by our results from Duck. The ability to verify carbon removal and sell carbon credits does not mean Coastal Carbon Capture is ready for "full-scale deployment" per se but, instead, allows us to fund our research and development by selling carbon credits while continuing to investigate questions that determine the extent of how and if the approach can continue to scale safely.

Rather than continuing to frame mCDR pilot projects in a research versus commercialization dichotomy, the Marine CDR Plan should recognize that *commercialized research* is at the heart of the public-private partnerships driving mCDR research and development. The plan should define how public-private partnerships can advance scientific knowledge and maximize societal benefits while allowing for commercialization by private actors. There is substantial precedent for federal policy supporting similar outcomes in other industry sectors like pharmaceuticals and technology. Instead of this dichotomy, the Marine CDR Plan should focus on supporting a step-wise increase in project sizes that existing data demonstrates are reasonably safe, and which through public dissemination of results, advances the world's understanding of the risks and benefits of mCDR approaches.

Indeed, this is the status quo policy for the Federal Government, where, to our knowledge, there has been no prohibition on or plans to ban commercialization of permitted mCDR research activities.

This same research “versus” commercialization dichotomy is particularly apparent in efforts to potentially list mCDR approaches under Annex 4 of the London Protocol. This international treaty, which underpins regulation on the disposal of marine waste, was expanded in the last decade to include the placement of material of purpose other than mere dumping after a flawed and poorly regulated ocean iron fertilization experiment. The International Maritime Organization which administers the treaty created a new annex for regulating marine carbon removal, added iron fertilization to that list, and is now considering whether or not to add other mCDR approaches to this geoengineering list.

Many of the implications of being added to the annex are not only unobjectionable but impose criteria that help define research in the context of mCDR field trials in ways Vesta welcomes. However, prohibitions on economic or financial gain arising from a project, which could be imposed upon being listed in the annex, would undermine the ability of Vesta to use carbon credits or other financing mechanisms to conduct basic research and development. Most importantly, this stance is contrary to the status quo policy of the United States government, which has been supporting carbon dioxide removal research and development across multiple pathways, terrestrial and marine, without any prohibition on commercialization. Most concerning is that it has taken multiple years to deliberate whether or not to even place these approaches on the London Protocol annex, and there appears to be a lack of discussion about the thresholds that should be met before an approach is allowed to commercialize, or how long it would take to remove a commercialization ban.

Vesta is aligned with many stakeholders concerned about the possibility of industry actors moving too quickly without strong science or environmental protection to inappropriately monetize marine carbon removal. However, when managing against this theoretical outcome, it may make it more difficult for responsible companies like Vesta to survive in the early, critical stages of research and development. Ultimately, it will also do nothing to dissuade irresponsible actors from “forum shopping” by developing projects in or emanating from countries with weak or nonexistent regulatory regimes, and which are not party to the London Protocol. The best way to prevent rogue actors in mCDR is to develop permitting regimes that allow commercialization as part of a research pathway, in collaboration with academics, other researchers, and government actors. Once again, articulating that carbon credit sales and advanced market commitments can be a significant driver of commercialized research would clarify the United States' domestic and international stance on this critically important discussion.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR

approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Key points:

- *Coastal Carbon Capture is one of the most promising CDR approaches across a wide range of factors, including cost, scalability, energy efficiency, impact on communities, and co-benefits.*
- *No other solution has the potential for gigatonne-scale permanent CDR at <$50/t, with no investment in additional energy infrastructure, land use changes, or freshwater consumption.*
- *Coastal Carbon Capture integrates with and enhances coastal protection efforts and has the co-benefit of helping to protect coastal communities, assets, and ecosystems from coastal erosion.*

Vesta research and analyses indicate that, at scale, Coastal Carbon Capture could remove carbon for under $50/ton and that a cost under $100/ton is achievable by the end of the decade. The majority of the reduction in cost from small-scale pilots to large-scale deployments can be delivered by leveraging economies of scale that already exist in the coastal protection industry supply chain rather than requiring any new inventions.

Energy inputs for Coastal Carbon Capture are low, approximately 40 kWh/t CO_2, which is a fraction of the energy requirements of highly engineered approaches. Moreover, decarbonization of the supply chain through renewable electricity generation has already begun. For example, the olivine that will be used in our Duck deployment was milled to sand with 100% renewable electricity.

Coastal Carbon Capture can integrate with existing-planned coastal protection projects involving the deployment of sand near coastlines to provide physical protection against coastal erosion. By selling carbon credits, the cost of the sand for such projects can be subsidized, helping coastal communities to reduce the cost of coastal protection projects and/or make them longer-lasting. Given the increasing shortage of available sand for coastal protection and its resultant recent and projected increases in cost, this could provide a significant financial benefit to coastal communities, especially lower-income ones which find it difficult to afford to protect their coastlines effectively.

By adding alkalinity to seawater, Coastal Carbon Capture could locally mitigate ocean acidification and its harmful effects on ecosystems.

The abundance of olivine and relative simplicity of the Coastal Carbon Capture process make it a highly scalable solution - potentially over 1 gigatonne annually. This, combined with its low cost, makes Coastal Carbon Capture a very high potential solution for climate mitigation that warrants continued and additional support from the Federal Government.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other

stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Key Points:

- *The work of the FTAC and federal agencies has already helped validate the need to pursue responsibly-sized field trials.*
- *The Marine CDR Plan should encourage information sharing with state and local regulators, especially regarding mCDR approaches, benefits, risks, and knowledge gaps through interaction with entities like the Coastal States Organization.*
- *The Federal Government should invest in stakeholder outreach and education with a prioritization of at-risk and marginalized communities through existing programs like NOAA's SeaGrant.*
- *The Marine CDR Plan should encourage the use of Community Benefit Agreements across federally supported projects.*

Previous work by federal agencies has helped advance understanding and acceptance of the need to pursue responsibly sized mCDR field trials. This includes prioritizing this work through the Ocean Climate Action Plan, NOAA's research strategy, and the creation of the FTAC itself. Many stakeholders, including local environmental groups, regulators, and communities are just beginning to learn about mCDR, and documents such as these from the Federal Government validate the basic science behind and need to further evaluate these approaches.

The Federal Government could further enhance these successes by providing more resources to state regulators and local communities. NOAA's SeaGrant program is an excellent example of how federal agencies can support local decision-makers and communities. SeaGrant staff should be equipped with the resources necessary to help support mCDR research.

Consistent with our recommendation that the FTAC evolve into a standing interagency coordinating committee, this body could also liaise with states to help educate regulators and resource managers through the Coastal States Organization.

Similarly, Vesta saw firsthand how mCDR permit applications can burden state agencies. We encourage the Federal Government to make formal technical assistance available to states considering mCDR permits for which they lack relevant subject matter expertise.

Finally, the Marine CDR Plan should recommend embedding requirements for Community Benefit Agreements into funding opportunities wherever they support field trials to advance the development and application of mCDR. Community Benefit Agreements have become a staple of Department of Energy programs, and other agencies have generally integrated community engagement and benefit as core parts of grant funding opportunities. The Federal Government should continue these efforts and expand them wherever possible, ensuring that communities are at the heart of mCDR pilot projects.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Key Points:

- *Vesta is one of the leading marine CDR organizations in the USA and internationally. Vesta has demonstrated consistent leadership in permitting first-of-its-kind field pilot experiments, conducting public outreach, and conducting transparent ecological and geochemical research to support the marine CDR community.*
- *To best foster private sector innovation and R&D into marine CDR, the Federal Government needs to adopt programs and policies that can align with typical 12-24 month planning and growth horizons of early stage companies. Faster research grant cycles benefit both private sector companies and the broader marine CDR community by providing a regular stream of results and information which can be used to iterate and adjust ideas and concepts with reduced risk of technological lock-in or unnecessary sunk costs.*
- *Ensuring effective permitting timelines while providing ecological safety would facilitate research necessary to develop robust marine CDR science and eventually industrial capacity.*
- *The Federal Government and its agencies can support the private sector by providing consistent affirmative messaging and agile federal support for marine CDR efforts. By signaling support and leadership, federal agencies can play a decisive role in securing stakeholder support and project permits at the state and federal level. This support is critical to the success of pilot and startup-scale R&D efforts.*
- *FTAC and the Federal Government can act to ensure that federal CDR funding is technology agnostic and includes marine CDR alongside other terrestrial and engineered technologies such as DAC.*
- *Funding for Marine CDR should target both relevant public and private-sector research organizations as well as explicit funding for relevant federal agencies such as USACE, NOAA, and USGS.*

Vesta, in collaboration with our partner organizations, is leading some of the most important mCDR work in the country. In 2022, we led the world's first pilot-scale Coastal Enhanced Weathering project in Long Island, New York, totaling 650 tons of olivine (with the potential to capture up to 500 tons of CO_2). The fieldwork for this project is now complete and we are in the process of analyzing the data and preparing results for publication. In late spring to early summer, 2024, we are planning to execute our field trial in Duck, North Carolina, by placing 9000 tons of olivine 1500 feet offshore of Duck, North Carolina.

Vesta has conducted more than a dozen ecological studies into the environmental safety of olivine, conducted extensive modeling-based studies of the fate and transport of olivine and olivine dissolution products in the marine environment, and conducted and published social acceptance studies of Coastal Enhanced Weathering. These efforts have involved scores of academic, non-profit, and industrial partners, supported 5 undergraduate theses, and 3 Master's Thesis projects, and resulted in the publication of 2 papers to date, with an additional 14 papers currently in preparation or press.

A key factor the Federal Government should take into account when considering potential partnerships with leading mCDR companies is the potential for efficiency. As startup companies, we can move very quickly to bring significant resources to bear on research questions and challenges. By leveraging minimal logistical and bureaucratic overhead with a full-time, permanent scientific staff, we can pivot to cover new areas and execute new research quickly. To leverage the resources of the private sector, we recommend a range of funding and partnership opportunities that include funding on 12 to 24-month grant cycles at which the private sector excels in delivering results. If private investors see a favorable government/regulatory environment, they are likely to invest heavily in the space, as we have seen with Direct Air Capture.

In addition to leveraging the efficiency of the private sector, the Federal Government can expand upon successful partnerships like existing ones in which Vesta is collaborating with numerous partners. This includes our pilot project in Duck, North Carolina planned for this spring. This pilot will engage other researchers in monitoring the project including the Coastal Studies Institute, federal entities like the USACE Engineering and Research Development Center, and the independent scientific research non-profit Hourglass.

The second example of an outstanding private-federal partnership is the ongoing National Oceanographic Partnership Program-funded collaboration between Vesta, USGS, NOAA, Woods Hole Oceanographic Institute, and the National Park Service to conduct a pilot study of olivine enhanced weathering in coastal salt marsh ecosystems on Cape Cod. In 2022, Vesta, in collaboration with our federal partners, conducted a successful pilot study amending salt marsh sediment with 5 cm of olivine sand to understand how salt marsh ecosystems will tolerate the incorporation of olivine. This work led to a larger-scale NOAA-funded project to study the incorporation of olivine sand into a 0.5-acre portion of the Herring River Estuary currently undergoing restoration led by the National Park Service. In this case, collaboration with our federal partners and the National Park Service as the main project proponent allowed this research to proceed safely, at an appropriate scale, for a fraction of the time and cost that would have been incurred if the project occurred purely in either the private sector or federal government alone.

Finally, when federal CDR-funding opportunities arise, they sometimes omit marine CDR in favor of land-based or highly engineered techniques. The Marine CDR Plan should recommend federal carbon removal research funding is truly technology-neutral and includes eligibility for marine CDR. Open system CDR techniques, including mCDR approaches such as Coastal Enhanced Weathering, show promise to deliver CDR benefits with a tiny fraction of the demand for renewable energy, making marine CDR approaches a critical component of a robust and diversified national CDR strategy. Funding for marine CDR can be explicitly supported through a diverse array of private and public research organizations and financial support for Federal agencies such as USACE, NOAA, and USGS.

In short, the Federal Government is already supporting exemplary public-private partnerships that are executing responsibly-sized field trials that are increasingly being encouraged by scientists across the globe. The Marine CDR Plan should build on this success by recommending mCDR funding should be on equal footing with other CDR approaches and should work to align permitting to provide certainty to partnerships executing these projects.

6. ***What else would you like the Federal Government to consider as it develops a Marine CDR Plan?***

Across the board, many of the recommendations included here would impose more responsibilities and duties upon federal agencies. The Marine CDR Plan should also acknowledge the need to dedicate more resources to programs across the Federal Government, especially the agencies and programs participating in the FTAC, regulatory programs, and federal outreach programs like SeaGrant.

Thank you for considering our suggestions for the mCDR plan, and once again, for the work of the FTAC in addressing these issues that are critical to the safe, responsible and effective scaling of Coastal Carbon Capture and other mCDR approaches.

Sincerely,

Zach Cockrum
Vice President of Policy and Partnerships
Vesta, PBC

From: Helena McMonagle (b) (6)
Sent: Tuesday, April 23, 2024 9:09 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Public Comment McMonagle mCDR Research.pdf

Dear Tricia,

Thank you for the work you are doing to collect public comment related to mCDR research. Please find my public comment attached, along with a one-pager at the end of the PDF about my research for policy makers in case this could be relevant. I'm sharing the one-pager because I think that research on the role that the biological carbon pump plays on carbon dioxide removal is still grappling with many uncertainties. Therefore, I'd imagine that research on the impacts that artificial marine CDR will have on the ocean's existing biological carbon pump is still in very early stages yet.

Best regards,
Helena

Helena McMonagle | she/her
Graduate Student
Essington Lab and Hilborn Lab
School of Aquatic and Fishery Sciences
University of Washington, Seattle, WA

Helena McMonagle
NSF Graduate Student Fellow and PhD Candidate
School of Aquatic and Fishery Sciences
University of Washington
Seattle, WA 98195

April 23, 2024

To whom it may concern,

Thank you to the National Science Foundation and the White House Office of Science and Technology Policy for this opportunity for public comment. I am in the 5th and final year of my PhD at University of Washington. I am responding to Questions 1 and 2.

Question 1: How would a Marine CDR Plan affect you, your organization, or your community?

A Marine CDR Plan would affect me personally because I am currently applying to science research and science policy positions, including postdoctoral research positions related to marine carbon dioxide removal (mCDR) research. Additional funding for this area of research may allow me to pursue work on the verification of mCDR approaches and evaluating how much carbon they will sequester in the ocean and for how long. I would also be interested in researching whether there are unintended, costly, unethical or unlawful implications of mCDR approaches. For example, there are concerns that iron fertilization could result in low oxygen zones where some organisms can no longer survive due to resulting decomposition that strips seawater of dissolved oxygen. Verification, monitoring, and rigorous assessment of environmental impacts is crucial as mCDR research and industry advances (Levin *et al.*, 2023).

Question 2: What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? … What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

My main question related to mCDR research is how these proposed technologies and approaches will impact existing carbon dioxide removal that the ocean provides already. My dissertation investigates and quantifies ecosystem services associated with mesopelagic fishes, such as lanternfish and bristlemouths. These are extremely abundant fish that live in the ocean layer from ~200-1000 m deep during the day. At night, many mesopelagic fishes migrate toward the sea surface to feed before swimming back down to the mesopelagic zone to hide from visual predators during the day. In the process of this daily vertical migration, they move carbon from near the sea surface to many hundreds of meters deep. They can also be involved in moving carbon deeper than their deepest migration depths if their waste or carcasses sink even deeper, or if they are consumed by predators that move that carbon deeper. In this way, mesopelagic fishes provide a “free” process of marine carbon dioxide removal.

These fishes are just one of they are just one of many organisms that make up the biological carbon pump, which is responsible for a large proportion of the ocean’s ability to absorb carbon dioxide from the atmosphere. Without the biological carbon pump, some carbon dioxide would still be absorbed into the ocean via the solubility pump, a series of chemical and physical processes that sequester carbon. However, with no biological carbon pump, atmospheric carbon dioxide concentrations would be higher than they are now (Volk and Hoffert, 1985). The biological carbon pump allows surface waters to continue absorbing more carbon dioxide from the atmosphere by absorbing carbon dioxide in the form of phytoplankton and moving some of that carbon in to the deep ocean. In the deep ocean, this biologically transported carbon can be sequestered for hundreds to thousands of years, even if only a small fraction of that carbon reaches the seafloor (where it can be stored on even longer, geologic time scales). If we did not know how this biological pump worked, we might unknowingly make decisions that interrupt these processes and lead to unintended and costly consequences for climate change mitigation.

My research has found high uncertainty in the role that fishes play in both carbon transport and climate-relevant (longer term) carbon sequestration in the ocean (McMonagle *et al.*, 2023). Quantifying and understanding such nature-based carbon dioxide removal processes seems to be a precursor for understanding the impacts of artificial mCDR on them. Uncertainties in fish-mediated carbon transport arise from several highly influential and uncertainty parameters that are used in calculations of fish carbon transport. Some of the most influential parameter uncertainties, and how these parameters relate to fish carbon transport, are as follows:

1) Biomass of these fishes: more fish will generally transport more carbon. However, biomass is uncertain due to challenges in converting active acoustic data into mesopelagic fish biomass (Proud *et al.*, 2019), and there are also high uncertainties associated with net-based estimates of mesopelagic fish carbon flux (Davison *et al.*, 2015, McMonagle et al., *in prep*)
2) Respiration rates and activity levels: these rates influence how much carbon dioxide these fishes are releasing throughout a 24-hour cycle, and at which depths (deeper transport generally translates to long sequestration timelines, though these timelines vary greatly throughout the world ocean). These respiration rates are challenging to collect because these fish (such as lanternfish) are fragile and thus not conducive to respirometry experiments that measure respiration rates as oxygen utilization and/or carbon dioxide production. However, we are currently working on a manuscript where we did measure these rates for a handful of lanternfish, and other such measurements are available in the literature (Ikeda, 2016). These measurements are also expensive because mesopelagic fishes generally live offshore, and thus sampling them is expensive.
3) Percentage of mesopelagic fish prey that originates from near the sea surface, versus deeper depths: if this percentage is small, these fish may not play as large a role in carbon transport because the carbon they consume may have made it down to deeper depths in their absence. However, this percentage is likely high for migrating fishes like lanternfish, because their migration to the sea surface is thought to be beneficial for finding greater prey availability.
4) Fate of their fecal waste: particularly if this waste sinks much deeper than they migrate, before decomposition and remineralization turns this waste back into dissolved carbon dioxide, then this solid waste may sequester carbon in the ocean on long time scales.

The science around how much carbon these fishes and other organisms transport and sequester in the ocean is in early stages, and these estimates of carbon transport are still highly uncertain. Similar to the state of our understanding of the impacts of mesopelagic fishing and deep seabed mining on deep sea ecosystems and ecosystem services (Bisson *et al.*, 2023), the impacts of artificial (as opposed to nature-based) mCDR approaches are also still highly uncertain. More fully understanding how mCDR approaches will impact the baseline biological carbon pump would likely require many years or decades of further research. Implementing mCDR technologies and approaches on a large scale may be most useful if we are reasonably certain that these approaches will not reduce the ocean's natural (and cost-free) absorption and sequestration of carbon dioxide from the atmosphere.

Furthermore, given the value of the seafood industry in the U.S. and the importance of wild capture fisheries for food security in the U.S. and around the world, it would also be helpful to know how mCDR approaches would impact commercial, recreational and subsistence fisheries before large-scale implementation begins. Besides species that are consumed by humans, for mCDR approaches to be legal, they will also need to comply with protections for endangered species and marine mammals. These impacts are highly uncertainty at this point too.

I wanted to highlight this publication by Dr. Lisa Levin and colleagues, which relates directly to this public comment request: "Deep-sea impacts of climate interventions", published in *Science* last year (Levin *et al.*, 2023). This publication directly addresses several of the questions in this call for public comment.

Finally, below the Bibliography section is a one-pager about the role that fishes play in marine carbon dioxide removal via the biological carbon pump. I created this for sharing with policy makers, in case this could be useful for understanding just one of many mechanisms in which the ocean already transports and sequesters carbon.

Thank you for again for this opportunity to provide public comment.

Sincerely,
Helena McMonagle

PhD Candidate
School of Aquatic and Fishery Sciences
University of Washington

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Fish Play a Role in Carbon Sequestration in the Ocean

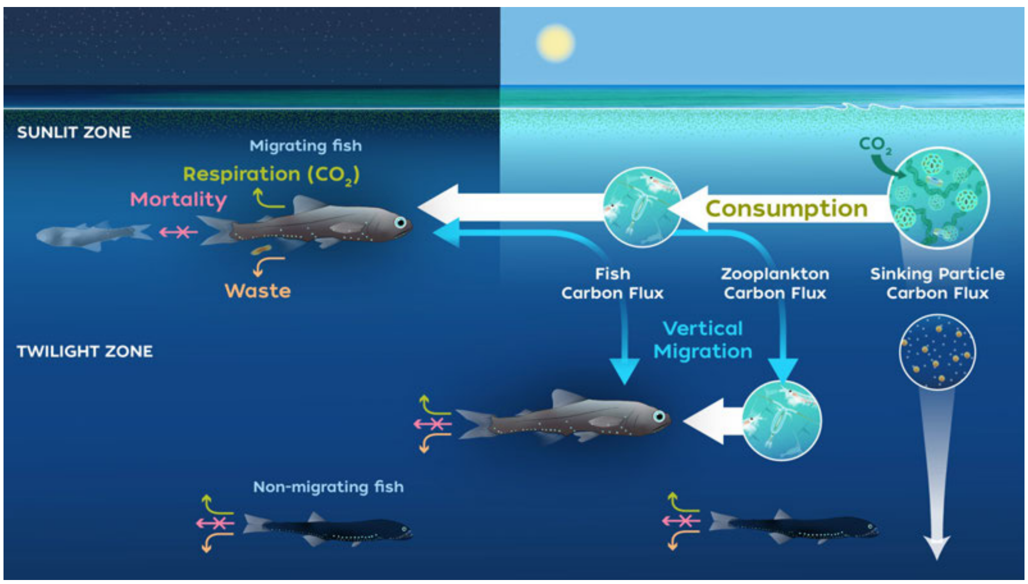
Helena McMonagle, National Science Foundation Graduate Research Fellow
University of Washington and Woods Hole Oceanographic Institution

The Ocean's Role in Mitigating Climate Change

- The **oceans absorb about a quarter of our carbon dioxide emissions**
- Every year, **two to six billion tonnes of carbon move through the Ocean Twilight Zone**, a layer of the ocean from 650-3300 feet deep

Lanternfish and Their Role in Carbon Sequestration

- An important way that carbon becomes absorbed in the ocean is by microscopic plants; like trees on land, these **microscopic plants in the ocean absorb carbon dioxide**
- Carbon moves up the food chain to lanternfish, which are some of the most abundant fish
- Every night, lanternfish migrate from the Twilight Zone to the surface to eat, and then migrate back down the next day. **This migration moves carbon deep into the ocean**, where it can be kept out of the atmosphere for hundreds of years



Benefits of Lanternfish to Humans

- These **fish provide marine carbon dioxide removal**, for free. This benefit of nature to human society is also known as an ecosystem service
- Another ecosystem service is that **lanternfish feed many of our commercial, subsistence, and recreational fisheries**, such as salmon, tuna and swordfish
- There is **new interest in commercially harvesting lanternfish**. How would a lanternfish fishery impact carbon sequestration, and sustaining our existing fisheries?

Funding Basic Science Research

- **This PhD research measures these ecosystem services of lanternfish** by addressing how much carbon they transport, and how important they are for other species like salmon
- **This research will help policy makers make more informed decisions** about harvesting lanternfish for fishmeal, versus leaving them in the ocean to perform ecosystem services
- **This research is funded by the National Science Foundation** (NSF). NSF is an essential source of funding for higher education, STEM workforce development, and basic science research, which keeps the U.S. competitive in science research and innovation

From: Chan, Francis T (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 8:59 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: mcdr_ftac_letter_chan.docx

Dear Tricia,

Please find attached my comments to the mCDR FTAC.

Thank you,

-Francis

Director, Cooperative Institute for Marine Ecosystem and Resources Studies

Oregon State University

The Cooperative Institute for Marine Ecosystem and Resources Studies
Oregon State University
Hatfield Marine Science Center, 2030 SE Marine Science Dr.
Newport, Oregon 97365-5229

P (b) (6)
F 541-867-7044

April 23rd 2024

Dear Members of the Marine Carbon Dioxide Removal Fast-Track Action Committee,

mCDR represents an extraordinary use of the ocean. It is extraordinary in terms of the potential to manage our climate future. It is extraordinary in terms of the potential for the growth of a new global industry. It is further extraordinary in terms of the rapid demands for scientific information to ensure efficacy and ecological and social benefits, particularly given the resources currently available to rapidly close crucial knowledge gaps. The risk that the enabling science necessary to ensure the proper national and global growth of a positive mCDR industry is not available is high.

It is becoming ever more clear that absent timely, salient, and trusted scientific knowledge, ocean-based climate solutions, however well-intentioned, can generate social distrust and uncertainties that give rise to roadblocks that are difficult to overcome or reverse. It is vital that the nation's research enterprise is empowered and resourced to deliver essential knowledge for sound decision-making. The challenge of standing up the kind of research program needed at scale is daunting. As the director of a joint NOAA-university Cooperative Institute, I see agency-academic partnership as an important path forward. Through such partnerships, we have the ability to nimbly develop and test innovations, train and credential the critically-needed blue-tech workforce, and implement operational ocean testbeds and supporting observing and modeling systems at scale. These are key enabling components for mCDR going forward. Already, world-class expertise in ocean carbon chemistry, ecosystem, fisheries, and social sciences can be found at Oregon State University, NOAA's Pacific Marine Environmental Laboratory, and NOAA's Northwest Fishery Science Center. This is expertise that can be leveraged to rapidly grow mCDR research capacity regionally. Further partnership with DOE's Pacific Northwest National Laboratory can expand on complementary expertise and capabilities necessary to deliver truly timely, salient, and trusted knowledge. The needs are great and I would urge utmost attention to exploiting the already in place Cooperative Institute enterprise and associated partnerships to ensure that the extraordinary opportunities ahead are fully realized by our nation.

Francis Chan

Francis Chan, PhD
Associate Professor, Department of Integrative Biology
Director, Cooperative Institute for Marine Ecosystem and Resources Studies
Oregon State University

From: Jennifer E Bender (b) (6)
Sent: Tuesday, April 23, 2024 8:09 PM
To: Light, Tricia M. EOP/OSTP
Cc: Elizabeth Francis
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: NSF MCDR.docx

Ms. Light,

Please find attached a brief response to the ROI from NSF on Marine Carbon Dioxide Removal frameworks.

Thank you,

Jennifer Bender
Elizabeth Francis

Jennifer Bender, PhD
School for the Environment, UMass Boston
Program Director, Sustainable Aquaculture Program
Environmental Innovation Clinic
W:(b) (6)

Introduction:

The Marine Carbon Dioxide Removal (CDR) Plan serves as a strategic framework to advance research and implementation efforts aimed at mitigating climate change through marine carbon removal initiatives. Recognizing the critical role of carbon dioxide removal in achieving climate goals, the plan outlines specific actions to be taken in collaboration with various stakeholders.

The National Science Foundation (NSF) and the White House National Science and Technology Council (NSTC) play key roles in the implementation of the Marine CDR Plan. The NSF provides support for scientific research and innovation, while the NSTC coordinates federal efforts to advance science, technology, and innovation across agencies.

The plan focuses on three primary actions outlined in the Ocean Climate Action Plan:

Establishing a comprehensive Federal marine CDR research program to support scientific research and innovation in marine carbon removal techniques.

Clarifying permitting, regulatory, and other standards and policies to provide a clear regulatory framework for marine CDR research and implementation.

Establishing a Marine CDR Initiative to facilitate public-private partnerships, enhance interagency coordination, and promote public awareness and engagement in marine carbon removal efforts.

Through these actions, the Marine CDR Plan aims to accelerate progress towards developing and deploying safe and effective marine carbon removal approaches, thereby contributing to global efforts to combat climate change.

Question 1: Effects of Marine CDR Plan on stakeholders and Background on Marine CDR and Question 2: Regulation, resources, and knowledge requirements of marine CDR research

Marine Carbon Dioxide Removal (CDR) refers to the process of capturing, sequestering, and storing carbon dioxide from the atmosphere within marine environments. This can include various techniques such as enhancing the productivity of marine ecosystems like mangroves, seagrasses, and tidal salt marshes, or directly capturing and storing carbon dioxide in the ocean through engineered methods.

The significance of marine CDR lies in its potential to mitigate climate change by reducing the concentration of carbon dioxide in the atmosphere. As a greenhouse gas, carbon dioxide contributes to global warming and climate change by trapping heat in the Earth's atmosphere. By removing carbon dioxide from the atmosphere and storing it in marine ecosystems or oceanic compartments, marine CDR can help offset anthropogenic carbon emissions and reduce the impacts of climate change.

Blue Carbon, a subset of marine CDR, specifically focuses on the carbon sequestration potential of coastal and marine ecosystems such as mangroves, seagrasses, and tidal salt marshes. These ecosystems could capture and store large amounts of carbon in their biomass and sediments, making them valuable natural carbon sinks. Incorporating blue carbon strategies into climate mitigation efforts can make a significant contribution to achieving the goals outlined in the Paris Agreement.

However, successful implementation of marine CDR initiatives requires careful consideration of various factors, including environmental sustainability, social equity, and transparency. Accountability is a crucial aspect often overlooked in blue carbon entrepreneurship. Agencies or companies involved in marine CDR projects must be held accountable for their actions, including making relevant information, data, and decision-making processes publicly available. This accountability ensures transparency, fosters trust among stakeholders, and enables effective monitoring and remediation of any adverse impacts associated with marine CDR activities.

Marine Carbon Dioxide Removal (CDR), particularly through blue carbon sequestration in coastal ecosystems, plays a crucial role in addressing climate goals by effectively removing carbon dioxide from the atmosphere and storing it in marine environments. Here's how it contributes:

Carbon Sequestration: Coastal blue carbon ecosystems, including mangroves, seagrasses, and tidal salt marshes, act as natural carbon sinks, capturing and storing large amounts of carbon dioxide from the atmosphere in their biomass and sediments. This process, known as blue carbon sequestration, helps reduce the concentration of greenhouse gases in the atmosphere, mitigating climate change.

Long-Term Carbon Storage: Unlike some other marine CDR approaches that may offer short-term benefits, blue carbon sequestration provides long-term carbon storage solutions. These ecosystems have the capacity to store carbon for significant periods, often over 100 years or more, making them valuable assets in efforts to combat climate change.

Sustainable Pathways: Blue carbon ecosystems offer proven and sustainable pathways for carbon sequestration, providing multiple co-benefits beyond carbon storage. Restoration and protection of these ecosystems not only help mitigate climate change but also improve water quality, support biodiversity conservation, and enhance coastal resilience to natural disasters such as storms and sea-level rise.

Precautionary Approach: Adopting a precautionary, inclusive approach to marine CDR, particularly focusing on sustainable, long-term solutions like blue carbon sequestration, ensures that efforts to address climate change are conducted responsibly and with consideration for equity, justice, and environmental sustainability. This approach helps minimize risks and maximize benefits for both ecosystems and communities.

By prioritizing the restoration and protection of coastal blue carbon ecosystems and leveraging existing supply chains, methodologies, and resources, marine CDR initiatives can make significant contributions to achieving climate goals. Investing in sustainable, long-term solutions while considering the needs and rights of all stakeholders ensures that marine CDR efforts are effective, equitable, and environmentally sustainable in the long run.

Key Recommendations from the Ocean Climate Action Plan (OCAP)

Highlight the specific recommendation related to marine CDR research.

Emphasize the need for safe and effective CDR approaches.

Components of the Marine CDR Plan. Describe the three key actions proposed by the Marine CDR Plan:

Establish a comprehensive Federal marine CDR research program.

Clarify permitting, regulatory, and other standards and policies for marine CDR research.

Create a Marine CDR Initiative for public-private partnerships and interagency coordination.

Question 3: What are the Priorities, benefits, and risks of marine CDR techniques.

Priorities:

Climate Mitigation: The primary goal of marine carbon dioxide removal (CDR) techniques is to mitigate climate change by removing carbon dioxide from the atmosphere and storing it in marine ecosystems.

Ecosystem Restoration: Restoration and protection of coastal blue carbon ecosystems, including mangroves, seagrasses, and tidal salt marshes, are essential priorities as they provide habitat for biodiversity and support ecosystem services.

Community Engagement: Prioritizing community engagement and consultation ensures that local stakeholders are involved in decision-making processes and that projects align with community needs and values.

Environmental Sustainability: Sustainable management and conservation of marine ecosystems are critical priorities to ensure the long-term health and resilience of coastal environments and the services they provide.

Benefits:

Carbon Sequestration: Marine CDR techniques offer significant potential for carbon sequestration, helping to mitigate climate change by removing carbon dioxide from the atmosphere and storing it in marine ecosystems.

Biodiversity Conservation: Restoration and protection of coastal blue carbon ecosystems provide habitat for a diverse range of marine species, contributing to biodiversity conservation and ecosystem resilience.

Coastal Protection: Healthy coastal ecosystems, such as mangroves and tidal salt marshes, act as natural buffers against coastal erosion, storm surges, and sea-level rise, providing valuable coastal protection and reducing the risk of natural disasters.

Water Quality Improvement: Coastal blue carbon ecosystems play a crucial role in filtering water and removing excess nutrients and sediment, thereby improving water quality, and supporting the health of marine environments.

Risks:

Environmental Impact: Marine CDR techniques may have unintended environmental consequences, including habitat degradation, altered nutrient cycles, and changes in ecosystem dynamics, which could harm marine biodiversity and ecosystem health.

Regulatory Challenges: Lack of clear regulatory frameworks and guidelines for marine CDR research and implementation may lead to inadequate oversight and management of potential risks, posing challenges for effective governance and accountability.

Social and Economic Impacts: Marine CDR projects may have socio-economic impacts on local communities, including changes in livelihoods, cultural practices, and access to resources, which must be carefully considered and managed to ensure equitable outcomes.

Technological Uncertainty: Some marine CDR techniques, such as ocean fertilization and artificial upwelling, involve technological uncertainties and potential risks, including disruption of marine ecosystems and unknown long-term consequences, requiring thorough research and precautionary measures.

Precautionary Approach: Regulations for marine CDR should integrate the precautionary approach with a high sensitivity threshold, emphasizing proactive measures to mitigate potential risks and uncertainties. This includes robust scientific research, stakeholder engagement, and transparent decision-making processes to ensure responsible and sustainable implementation of marine CDR techniques.

Disclosure and Engagement: Guidelines for marine CDR research must prioritize community engagement at all phases and steps, ensuring community buy-in and minimizing impacts to the environment. This includes soliciting feedback from stakeholders, providing transparency in decision-making, and allowing communities to decline participation in marine CDR activities within their area. Free, Prior, Informed Consent (FPIC) should guide initial engagement with coastal and Indigenous communities, empowering them to make informed decisions that impact their environment and ensuring long-term community buy-in and support. Additionally, agencies or companies engaging in marine CDR must be accountable for their actions, making information, data, and decision-making processes publicly available to foster transparency and accountability.

D. Question 4: Helpful Information, Stakeholder Engagement, and Communication:

Scientific Validation: Reliable scientific studies, research, and examinations are essential to validate claims about the effectiveness of Marine Carbon Dioxide Removal (mCDR) initiatives in removing carbon from the atmosphere. Replicated studies and peer-reviewed research can provide credible evidence to support or refute these claims.

Carbon Market Standards: Borrowing from carbon market approaches, the establishment of third-party independent organizations, such as Validation and Verification Bodies (VVBs), can help validate the science and methods used in mCDR projects, ensuring transparency and accountability.

Public Access to Information: Ensuring that information about mCDR projects, including methodologies, results, and potential risks, is publicly available promotes transparency and allows for informed decision-making by stakeholders and the general public.

Stakeholder Engagement:

Public-Private Partnerships: Enabling public-private partnerships can drive innovation and development in mCDR research and implementation. However, it's crucial to involve stakeholders, including local communities, environmental organizations, and Indigenous groups, to mitigate risks and ensure alignment with public interests.

Transparency and Accountability: Stakeholder engagement should prioritize transparency, with opportunities for public input and feedback on mCDR projects. Transparency builds trust and allows stakeholders to raise concerns, contribute insights, and hold project developers accountable for their actions.

Communication:

Transparency: Transparent communication is essential for mCDR initiatives to build public trust and address potential risks effectively. Openly sharing information about project objectives, methodologies, potential impacts, and mitigation measures fosters trust and ensures accountability.

Public Engagement: Engaging with the public through outreach efforts, community meetings, and educational initiatives can increase awareness and understanding of mCDR projects. Meaningful public engagement enables stakeholders to participate in decision-making processes and ensures that projects align with community values and priorities.

Ethical Considerations: Communication efforts should uphold ethical principles, prioritizing the public interest over private interests. mCDR initiatives should be driven by transparent and inclusive processes that prioritize environmental sustainability, social equity, and public welfare.

In summary, providing reliable scientific information, engaging stakeholders, and promoting transparent communication are essential elements of responsible marine carbon dioxide removal initiatives. By prioritizing public interest, fostering stakeholder participation, and upholding ethical standards, mCDR projects can effectively address climate change while minimizing risks and maximizing benefits for both ecosystems and communities.

F. Question 6: Additional considerations for developing a Marine CDR Plan: DNA

From: Kristin Butler (b) (6)
Sent: Tuesday, April 23, 2024 7:51 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Earthjustice mCDR Comments.pdf

Hi Tricia,

Attached are comments on the mCDR RFI from Earthjustice.

Thank you for the opportunity to engage!

Thanks,
Kristin

Kristin Butler (she/her)
Associate Legislative Representative
Lands, Wildlife, and Oceans
Earthjustice
O:(b) (6)
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April 23, 2024

Re: Marine Carbon Dioxide Removal Plan

Dear Director Panchanathan,

Thank you for the opportunity to comment on the development of a marine carbon dioxide removal (mCDR) plan. Earthjustice respectfully submits the following comments.

1. Earthjustice is a nonprofit legal organization that specializes in using the law to push back against polluting industries, protect wildlife and wild places, and combat the climate crisis. We work with our partners and clients to achieve these goals, and we support climate solutions that are equitable and community-driven. As such, we are concerned about some methods of mCDR given the lack of a clear legal framework or governing law that comprehensively covers these activities. As Federal Agencies navigate the patchwork of laws to regulate mCDR, we want to ensure that all applicable laws are implemented and complied with to ensure that there are no adverse impacts to people and ecosystems, decisions are based on the best available science, and that the precautionary principle is applied to every step of research and permitting.

We are concerned about drawing focus and resources away from conserving and restoring places that already sequester carbon, such as wetlands and mangroves, and putting it towards artificial solutions the lean more toward geoengineering than nature-based solutions. mCDR risks creating a false sense that we can keep up the status quo by addressing our carbon emissions from the back end, instead of tackling the root causes of climate change.

Some forms of mCDR are setting up participation in carbon market systems that do not currently exist, and that may well exacerbate inequity and perpetuate our addiction to oil and gas. We have spent decades fighting for our clients and partners that have seen financially driven projects harm their communities. While the mCDR plan is focused on research, companies are eager to get their projects into deployment and this profit motive has historically led to neglecting and harming communities.

Any research must center communities and be rigorously studied and consented to prior to field trials and deployment. Additionally, carbon markets must be part of this research. The Federal Government must ask key questions around the efficacy and effectiveness of carbon markets to solve climate change, consider on what markets carbon credits created by mCDR might be sold, and whether that would be beneficial to the United States and our climate goals.

Furthermore, we work with our partners on ocean access, and are concerned about the hazards of mCDR leading to the privatization of the ocean. The U.S. ocean belongs to all of us and there are fundamental issues that arise with any new use, particularly one that aims to do so at scale.

2. It is critical that the federal government identify, publicize, and ensure compliance with the full suite of applicable laws when considering individual mCDR proposals, including research. We are deeply concerned, however, that the agency's current regulatory approach is far more narrow than the kind of "whole-of-government" approach that this novel activity demands. EPA, for example, has identified a limited subset of these regulatory requirements on its "Permitting for mCDR and mSRM" website. https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm. We agree that compliance with both the Marine Protection, Research, and Sanctuaries Act (MPRSA) and the Clean Water Act (CWA) are vital for projects that may discharge materials into the marine environment. But this is an incomplete list – even with respect to EPA's authorities.

For example, EPA permits issued under the CWA or MPRSA would themselves trigger compliance with the duty to avoid jeopardy and the interagency consultation requirements of Section 7 of the Endangered Species Act ("ESA"), 16 U.S.C. § 1536(a)(2). This consultation process includes important substantive and procedural requirements to ensure that any action authorized, funded, or carried out by the federal government does not jeopardize the continued existence of listed endangered and threatened species or adversely modify their critical habitats. In addition, Section 9 of the ESA prohibits the "take" of listed species, unless the expert wildlife agency authorizes a limited exception for take incidental to an otherwise lawful activity after considering the effect of that take through the Section 7 consultation process (for federal actions) or the Section 10 permit process (for non-federal parties). 16 U.S.C. §§ 1538(a); 1536(o); 1539(a). Any permitted take must be minimized and mitigated and may not jeopardize the existence of the listed species. The take prohibition applies broadly to "any person," including federal and non-federal proponents of mCDR projects with the potential to harm or harass listed species or their habitats.

Similarly, the National Environmental Policy Act, 42 U.S.C. §§ 4321 et seq., our nation's bedrock environmental law, requires agencies to look before they leap to ensure that they consider all of the environmental impacts – and alternatives that would mitigate those impacts – of federal agency decisions. NEPA's action-forcing procedural requirements ensure that agencies consider "every significant aspect of the environmental impact of a proposed action" and that "the agency will inform the public that it has indeed considered environmental concerns in its decision-making process." Kern v. U.S. Bureau of Land Mgmt., 284 F.3d 1062, 1066 (9th Cir. 2002). NEPA applies to federal permitting decisions, including EPA's decisions under Sections 402 and 404 of the CWA, as well as to decisions under many of the statutes addressed below and to funding and other federal support implicated by mCDR projects.

Given the potential scope and intensity of mCDR proposals, there are a host of other federal agencies and federal legal requirements that likely apply to these projects. To name just a few:

Magnuson-Stevens Fishery Conservation and Management Act ("Magnuson-Stevens Act" or "MSA") 16 U.S.C. §§ 1801-1891d

The Magnuson-Stevens Act is designed to conserve and manage fish populations in the United States' territorial waters and in the exclusive economic zone. The Act includes a requirement to protect "Essential Fish Habitat," recognizing that "[o]ne of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats." 16 U.S.C. § 1801(a)(9). Any agency that authorizes, funds, or undertakes an action that may adversely affect EFH must at a minimum engage with the National Marine Fisheries Service ("NMFS") to conserve that habitat. 16 U.S.C. § 1855(b)(2). Adverse effects include "any impact that reduces quality and/or quality of EFH," and may include "direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH." 50 C.F.R. § 600.810(a). The MSA includes a consultation process to implement these requirements that provides for NMFS to recommend measures to conserve EFH and requires the relevant federal agency to respond by describing the measures it will follow to avoid, mitigate, or offset any adverse effects. 16 U.S.C. § 1855 (b)(4)(A), (B). At a minimum, approval of an mCDR project in EFH triggers this consultation process.

Marine Mammal Protection Act ("MMPA") 16 U.S.C. §§ 1361-1423h
The MMPA protects all marine mammals, regardless if they are separately or also listed as threatened or endangered under the ESA. Similar to the ESA, the MMPA prohibits the unauthorized take of a marine mammal by any person, including acts that have the potential to disrupt behavioral patterns such as migration, breathing, breeding, or feeding. 16 U.S.C. §§ 1362(13), (18) 1371(a), 1372(a). The MMPA provides a limited exception allowing NMFS to issue permits authorizing the incidental take of a marine mammal if it determines that the taking of "small numbers" of mammals will have no more than a negligible impact on the relevant population. 16 U.S.C. § 1371(a)(5)(D)(i)(I). For activities other than commercial fishing, NMFS may authorize incidental take of "small numbers" of marine mammals of a species through a one-year incidental harassment authorization. 16 U.S.C. § 1371(a)(5)(D). If activities exceed one year, or if the project is expected to seriously injure or kill marine mammals, NMFS can only authorize the take by promulgating a regulation and issuing a letter of authorization. 16 U.S.C. § 1371(a)(5)(A)(i); 50 C.F.R. §§ 216.105-06. Because of its broadly defined prohibition on take (including by harassment) and the broad distribution of marine mammals, the MMPA presumptively applies to any mCDR project in marine mammal habitats.

Outer Continental Shelf Lands Act ("OCSLA") 43 U.S.C. §§ 1331-1356b
OCSLA governs the leasing, exploration, and development of oil and gas deposits, other minerals and the development of renewable energy projects on the Outer Continental Shelf (from the three-mile state boundaries to the outer limits of the EEZ). The Bureau of Ocean Energy Management ("BOEM") and Bureau of Safety and Environmental Enforcement ("BSEE") within the Department of the Interior have been delegated the authority to manage leasing, exploration, development, and production of oil and gas resources under OCSLA and enforce safety and environmental standards. mCDR projects occurring within waters leased for oil and gas or other energy of resources extraction would require, at the very least, coordination with the Department of the Interior.

Depending on the location and potential effects of an mCDR proposal, the following laws may also apply.

- Rivers and Harbors Act (RHA)
- National Historic Preservation Act (NHPA)
- Coastal Zone Management Act
- Other state or local requirements

Finally, the process of reviewing mCDR proposals must meaningfully center Tribal expertise and leadership, recognize Tribal interests, and honor Tribes' fundamental rights as sovereign nations. For thousands of years, Tribes have been stewards of the areas affected by mCDR activities and any proposals and approvals must be informed by Tribal science, cultural practices, and traditional knowledge respect Tribal sovereignty and enact co-leadership and co-management mechanisms meaningfully. Federal agencies are obligated to conduct government-to-government consultation with federally recognized Indian Tribes. Presidential Executive Order No. 13175, Consultation and Coordination with Indian Tribal Governments, 65 Fed. Reg. 67249 (November 6, 2000). In addition to these mandates, the process to review mCDR proposals must advance the growing practice of obtaining Free, Prior, and Informed Consent (FPIC) and incorporate such values within government-to-government relations with Tribes.

Overall, how the permitting moves forward on an initial set of mCDR research applications will set precedent for future projects, so it is vital that EPA and multiple other federal agencies coordinate early, transparently, and effectively to ensure compliance with these and other applicable laws and to protect the marine environment.

3. When discussing mCDR techniques, it's critical that the Federal Government differentiates between nature-based solutions and mCDR. Currently, the Ocean Climate Action Plan discusses chemical methods (e.g., alkalinity enhancement and electrochemical direct ocean uptake) and biological methods (e.g., ocean ecosystem and marine life recovery, seaweed cultivation, and enhancement of marine biological carbon pump by iron/nutrient fertilization and artificial upwelling). Ocean ecosystem and marine life recovery, however, should not be grouped in the same category as every other mCDR method because the practices for achieving this (e.g. wetland, seagrass, and coral restoration) already have clear agency authority and permitting structures within natural resource management law. Lumping these efforts in with large scale geoengineering of the ocean, which fundamentally lacks agency authority and permitting structures, will only risk complication and confusion. This will hurt restoration efforts that provide co-benefits for people and ecosystems.

Similarly, the Federal Government needs to consider the benefits of mCDR in addition to carbon sequestration when determining which projects to support and pursue. If the primary co-benefit of a carbon sequestration project that impacts federal ocean waters is the ability of a private actor to financially profit from it on a carbon market, agencies must set the highest possible standards for determining what impacts and risks, if any, are acceptable. The bar must also be high for ensuring real climate benefits and not approving projects that merely provide offsets for new emissions. This is especially true given there are so many nature-based climate solutions utilizing federal ocean waters that provide measurable co-benefits for people and communities and that would benefit from federal support at scale.

For example, seaweed cultivation has been practiced by Indigenous communities and other farmers for years. It provides co-benefits of food for people and habitat for species while sequestering carbon that can be measured as part of U.S. climate initiatives. Conversely, iron/nutrient fertilization and artificial upwelling have not been practiced at temporal or spatial scale. Here, the primary co-benefit is to private companies that are interested in experimenting with our ocean because they could, possibly, profit from it in a carbon market and the project could, possibly, provide a net carbon reduction via that market scheme. We cannot clearly determine ecosystem or community benefits in these projects without evaluating the enormous risks such experimental endeavors pose. We are skeptical of the value of these more experimental, industry driven mCDR strategies with unclear co-benefits given the enormous opportunity to focus on nature-based solutions with co-benefits to communities, like seaweed cultivation.

In determining project risk, it's worth noting that strategies, like dumping iron in the ocean, pose enormous governance and ecological risks. Iron dumping, for example, will likely implicate other countries, especially if conducted on the high seas. It also could disrupt multiple ecosystems. Due to iron dumping altering the ecological processes of a marine environment, it is much harder, if not impossible, to halt or reverse potential damage. This could have cascading negative impacts to marine life and coastal communities. Ultimately, all projects will need to adhere to strict lab testing, underpinned by a precautionary approach, before any field trials are considered.

4. Transparency is necessary for all stages of mCDR research, deployment, and regulation. All research must be available to the public, including the research proposal, methods, funding sources, conflicts of interest, and data itself. Further, this information should be shared and easily accessible to the public, particularly in the communities that will be impacted by projects. Additionally, the Federal Government needs to be transparent with the public about how they are moving forward on establishing authority to regulate and permit mCDR activities and who has decision-making authority about how this work moves forward.

When engaging with communities, it's critical that they are centered from the earliest stage. Communities should have a primary role in decision-making, and in the case of Tribes, it's imperative that there is Free, Prior, and Informed Consent. Additionally, there should be ample and diverse opportunities for public engagement that include in-person, virtual, and written options and accommodate for language, accessibility, and time constraints.

5. Before developing strong partnerships, the Federal Government must consider the implications of this research plan. The purpose of mCDR research is to test whether a technique is safe, effective, and responsible for deployment. Ultimately, companies are waiting for approval so they can move forward with their projects rapidly and at scale. Even if mCDR research proves safe and effective, the scale at which it must occur to actually remove carbon at the level needed to achieve our climate goals would be enormous. As such, it's critical that the Federal Government think deeply about how we value the ocean.

The U.S. Ocean is a public resource that many people depend on for food, livelihoods, wellbeing, and cultural and spiritual benefits. The Federal Government's mandate must be to ensure the protection of the marine environment from harmful effects that may arise from mCDR activities, including by providing strict liability for companies and researchers. This same level of protection should be afforded to communities that may suffer from mCDR impacts. Based on this approach, the Federal Government should be wary of industry partnerships that rely on the success of mCDR research because their priority is not centered around ecological and societal impacts. Instead, partnerships that result in unbiased and transparent research are critical and will provide sound information about the realities of deploying mCDR beyond its ability to sequester carbon, including the impacts on all of the other benefits the ocean provides.

Ultimately, the partnerships that the Federal Government should be prioritizing are ocean justice communities (see Ocean Justice Policy Platform). Developing these partnerships will take time, money, a recognition of past harms, and should adhere to principles stated in the Ocean Justice Strategy. The research plan should emphasize the need to consult ocean justice communities now. They cannot be an afterthought.

6. While we know climate change poses an enormous threat to people and the planet, it's important that we consider this research in context. The Federal Government must not only think about whether we *can* do mCDR, but also whether we *should*. Any research must answer this question and make abundantly clear that we are not ready and may never be ready for deployment of geoengineering projects, and that success from a climate standpoint will depend on the quality and efficacy of carbon markets that the U.S. alone may not control.

Additionally, it's critical that the Federal Government differentiates between types of mCDR projects. Projects that involve biologically and chemically altering a marine environment are risky, poorly understood at temporal and spatial scales, and not ready for deployment. Instead of scaling up geoengineering research and deployment, we should be prioritizing solutions that we know work (e.g. habitat restoration) and provide co-benefits to people and ecosystems. These projects need funding and are ready for deployment now. We should be focusing funds on these efforts, not pouring it into venture capital projects that gamble with our marine health and peoples' lives.

Thank you for considering our comments.

Sincerely,
Earthjustice

From:	Erika McPhee-Shaw
To:	Light, Tricia M. EOP/OSTP
Cc:	Erika McPhee-Shaw
Subject:	[EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Date:	Tuesday, April 23, 2024 7:18:28 PM

Dear MS Light

I was asked by a colleague to provide a few comments on the above topic for at White House Fast-track Action Committee

I will address the following two questions:

1. **How would a Marine CDR Plan affect you**, your organization, or your community?

2. Which marine CDR techniques or **what aspects of marine CDR do you believe the Federal Government should prioritize for research?**

1. A marine CRD plan would help our community (state, region, country) by providing jobs for young people interested in helping solve climate and energy problems. (CDR can be related to energy via,for example, carbon capture and energy re-use possible scenarios). Jobs might be technical and engineering related, or chemical – people building materials and inventing components, or figuring out how to make autonomous vehicles to make new measurements, or they may involve developing new data analysis and modeling techniques to understand what is in the ocean and predict details of the ocean,atmosphere, and ecosystem responses to various scenarios envisioned. I teach at a university with a large Environmental Science program and students studying data science would be excited to work in this field – I suspect they would prefer using burgeoning AI skills for climate than in jobs developing new content for web advertising! **I am all in favor of new workforce development in the climate and energy sector**

2. How could the federal government prioritize research?

Academic-Industry "Fulbright-like" Think Tanks. As an academic researcher, I think a great thing the government could do is sponsor collaborations and "think tanks" – maybe two or three-year long appointments between industry and faculty to work on these problems without requirements to produce patents for market. Why the focused time scale? The two sectors have different incentives. Industry moves quickly while academia moves slowly. Giving a small number of people from both groups a job position where they talk and think intensely at the same pace and in the same space and truly work on these problems could be very fruitful: Academics use their expertise using data sets and modeling and understanding of how the ocean really works (if it's a think tank this probably does not mean going out and doing new experiments, such work might be funded for other groups) while industry team members bring their understanding of how business, funding cycles, and implementation time scales really work.

There is a new initiative to start MCDR Regional Nodes. Giving funding to make these work would be preferable to letting them grow organically without financial support.

Thank you! Erika McPhee-Shaw

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Dr. Erika McPhee-Shaw
Professor – Ocean Physics
Department of Environmental Sciences
Western Washington University
Bellingham, WA 98225
(b) (6)

From:	Ruszkowski, Shelley P (b) (6) [redacted] >
Sent:	Tuesday, April 23, 2024 6:36 PM
To:	Light, Tricia M. EOP/OSTP
Subject:	[EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments:	ExxonMobil Low Carbon Solutions Response to Marine CDR RFI 2024-03758.pdf

Dear Ms. Light:

Please find attached ExxonMobil Low Carbon Solutions' response to the Marine CDR Request for Information (2024-03758). Please do not hesitate to contact us if you have any questions or would like to discuss further. Thank you for the opportunity to respond.

Sincerely,

Shelley Ruszkowski

Shelley P. Ruszkowski
Regulatory Finance Advisor
Low Carbon Solutions

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Marine Carbon Dioxide Removal Research Plan Request for Information
2024-03758

Respondent:
ExxonMobil Low Carbon Solutions
22777 Springwoods Village Pkwy
Spring, TX 77389
Contact: Shelley Ruszkowski
(b) (6) (b) (6)

April 23, 2024

Thank you for the opportunity to respond to this Request for Information. Please do not hesitate to contact us if you have any questions or would like to discuss our responses in more detail.

1. How would a Marine Carbon Dioxide Removal (mCDR) Plan affect you, your organization, or your community?

A mCDR Plan would enable development of pathways for high quality CDR beyond Direct Air Capture (DAC). The mCDR Plan could help qualify various CDR methodologies and assess their quality against a standard like DAC. There is still uncertainty around the applicability and commercial viability of most CDR methodology at a larger scale. Research to support the applicability of CDR at a large scale could provide additional solutions to achieve climate goals.

Having a federal Marine CDR Plan would signal the U.S. government's support for CDR options beyond Direct Air Capture. Such signals are important to creating a new market.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?

Currently there is no legal framework designed specifically for marine carbon dioxide removal Research Development & Deployment (RD&D) in the United States, which could result in research projects seeking multiple approvals under environmental laws and regulations designed for non-mCDR activities; these activities include, but are not limited to, aquaculture, wastewater discharge, and ocean dumping.[1] Additionally, depending on the location of the project, mCDR research may be subject to local/state, federal, and international regimes. Consequently, different mCDR research projects could be subject to overlapping permitting procedures and requirements and be permitted and regulated differently due to the wide range in applicability of

[1] 2 Crosscutting Considerations on Ocean-based CDR R&D | A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration | The National Academies Press

different sets of laws and procedures. Because of the significant role mCDR could play in reducing anthropogenic emissions[2]

Establishing lead agency designated to oversee mCDR research or commercial deployment could facilitate deployment This lead agency could address any potential coordination between agencies to crosswalk the various permitting applications (if applicable) through their respective agencies (e.g., USACE, EPA, NOAA, DOD, and BOEM). Given the extensive experience with oceanic permitting, Bureau of Ocean Energy Management (BOEM) is the most qualified federal agency to lead the implementation of an mCDR regulatory framework. BOEM has been the regulatory jurisdiction for developing a regulatory framework for offshore geologic storage of carbon dioxide and is anticipated to provide a Notice of Proposed Rulemaking (NOPR) for said regulations.

To maximize the benefit of the forthcoming NOPR, it would be expeditious and prudent to explicitly incorporate mCDR technologies, such as direct ocean capture with storage (eDOC or DOC), into the procedural guidance. Specifically, because DOC will utilize similar processes to carbon capture and storage (CCS), and permanent geologic storage, all forms of carbon capture and storage should be considered including Ocean CDR. There may be opportunities to incorporate other approaches to mCDR such as Ocean Alkalinity Enhancement as well.

In addition to regulatory coherency, consideration must be given to explicit environmental monitoring plans, including potential changes in the ambient oceanic environment during most mCDR activities, as well as the intake and outlet locations for DOC facilities specifically. Due to the nascency of mCDR technology, ExxonMobil believes the technologies should be required to contemplate a holistic approach to environmental impact assessments. For example, ExxonMobil performs an Environmental, Socioeconomic, and Health Impact assessment for major capital projects, which is evaluated using our Environmental Aspects Guide[3]. In the process of our assessments, we consider water use, biodiversity, invasive species, air emissions and water discharge, amongst other aspects. This holistic approach allows us to develop management plans to avoid, reduce, or address any issues.

As with any robust impact management process, ExxonMobil believes in stakeholder feedback, which includes local communities, as part of the assessment cycle[4]. In places where environmental impacts assessment oversight is ambiguous, we recommend mCDR regulations remain consistent with ISO14001 Environmental Management System[5].

Finally, it would be beneficial for any mCDR regulatory framework to clearly distinguish between ocean removal research projects and full-scale or commercial deployment. It may be useful to have targeted, or limited scope, permitting for mCDR research projects that are below a certain removal size (e.g., a certain number of metric tons or less of carbon dioxide removal) to

[2] AR6 Synthesis Report: Climate Change 2023 (ipcc.ch) and IPCC, *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. P. R. Shukla, et al., 2022, Cambridge University Press, Cambridge, UK and New York, USA.

[3] Managing environmental performance and compliance | ExxonMobil

[4] Standards of Business Conduct | ExxonMobil

[5] Sustainability Management: Environmental Aspects Guide (exxonmobil.com)

ensure RD&D proceeds on pace to reach commercial deployment before 2030; one such mechanism to consider would be standardized permits for research purposes issued through a lead agency (as described above).

What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research?

Current knowledge on mCDR pathways is based on decades of fundamental research in marine biogeochemistry and oceanography, as well as coupled biogeochemical/physical models developed for fundamental science. Additional knowledge on ecosystem impacts of specific CDR pathways, coupled with public engagement and communication will be needed for safe and effective regulation. This could be a focus of mCDR hubs that could be set up by the federal government.

What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

The U.S. Government can play a vital role in supporting mCDR project developers' push to full-scale deployment by signaling demand certainty, specifically by securing commercial offtakes through government-funded outlet, like the Carbon Dioxide Removal Purchase Pilot Prize issued in September 2023. For emerging full-scale deployment programs, a U.S. government procurement program for mCDR-derived offsets would also create the opportunity for the U.S. to uniformly define minimum specifications for high-integrity marine carbon credits to trade in a voluntary marketplace. This type of demand signal is vital to stimulating further technology RD&D to drive down deployment costs, while also increasing the effectiveness and efficiency of mCDR.

To secure high-integrity marine carbon credits, a robust measurement, reporting, and verification (MRV) standard is of paramount importance both in the credit generation phase and in the tracking phase of these credits, from issuance to retirement. Therefore, before full-scale deployment or commercial application of mCDR technology would be possible, additional research should be dedicated to testing and validating field-based mCDR monitoring and verification activities (e.g., deployed carbon sensors, mass balance calculations, or other measurement methods) that would be applicable to high-integrity marine carbon credits. New research may be required to improve accuracy and precision of proposed measurement methodologies, for which Department of Energy and the National Labs should collaborate on funding under their Carbon Negative Shot remit.

3. ***Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?***

ExxonMobil advocates for a technology-neutral approach that is based on sound science. Research is needed to ensure the quality of carbon credits generated from Marine CDR in terms of efficiency of atmospheric CO_2 drawdown as a function of mCDR applied, durability of CO_2 removal, ecosystem impacts, additionality, and ability to quantify, among others. Given the complexity of the carbon cycle, it is critical that subject matter experts from academia, industry, and national labs are involved in assessing the validity of specific approaches rather than categories of approaches.

Potential focus areas for research could be in the following areas:

- Improving models
    - Computational support, build out of regional ocean models.
    - R&D support to understanding the limitations of modeling and where data is needed to ensure robust MRV.
- Improving data on air-sea gas exchange and ocean circulation – increase funding for monitoring and measurement.
- Support research to understand downstream effects of alkalinity, secondary precipitation, ecosystem impacts.
- The development of Marine CDR hubs could enable collaboration across stakeholders and leverage common infrastructure. Additionally, it could be used as an opportunity for community engagement to demonstrate to the public the benefits and limited risks of mCDR.
- Programs to encourage cross disciplinary engagement (e.g., physics, engineering) to promote development of new measurement tools, like the SEA CO_2 ARPA-E program.

Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits?

Chemical approaches like ocean alkalinity enhancement and direct ocean capture generate the most durable forms of carbon removal. They may have benefit for ocean acidification as well, though MRV must account for any additional carbonate precipitation that results from application of these approaches, as it will counteract the CO_2 removal.

Biological approaches in the offshore environment, such as seaweed sinking, may have potential as an expansion of the natural biological pump. For these approaches, a comprehensive approach to MRV is even more important to ensure additionality (no nutrient robbing), efficiency (quantifying the carbon sink), and durability (based on the disposition of the produced biomass). They may have other ecosystem benefits and as they scale up, they can be integrated into existing value chains for seaweed.

Coastal blue carbon approaches may have ecosystem benefits, though they are more limited in durability, prone to reversals, and limited in scalability due to the area available in coastal systems and competing uses.

Given the complexity of biogeochemical cycles, special attention is needed to ensure that downstream biogeochemical effects are considered when assessing the efficacy of approaches for mCDR. For example, approaches that precipitate carbonate minerals, either through the enhanced mineralization by organisms living in coastal systems, or as a form of CO_2 storage through mineralization, may cause increased production of CO_2 rather than removal, due to removal of alkalinity from seawater. As another example, approaches that stimulate biological production must include a full accounting of downstream effects of nutrient consumption to ensure additionality.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders?

There are many public concerns about impacts on ecosystems, so transparency and public engagement around ecosystem impacts is critical to having a social license to progress any of these approaches. Fit for purpose transparency around MRV is also critical to ensure the integrity of carbon credits generated in marine systems.

Data from field trials can be helpful to inform market development.

How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Frequent and transparent engagement with local communities and stakeholders is essential to deploying a successful mCDR field pilot project. Outreach should be undertaken to ensure that local communities understand the purpose and impacts of the research project and how that will inform the potential for future commercial development. As with any robust socioeconomic management framework, the government should work with research teams and project developers to identify ways in which local communities would benefit from project development; for example, through local economic development, training, and employment opportunities, or other local benefits that may be derived.

Consideration should be given to both the ecological and cultural impacts of any mCDR project that is conducted nearshore, or that could impact coastal communities, including Indigenous communities and local aquaculture-dependent economies. Often, this means there must be a systematic process to identify, assess, manage, and monitor environmental and socioeconomic risks and opportunities across the project’s life cycle.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non- governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Some significant efforts include:

- Ocean Visions – road maps, communications info, pilot database
- Carbon to Sea – philanthropic funding
- ARPA-E SEA CO2
- American Geophysical Union – Annual Meeting and Ocean Sciences U.S. Carbon Cycle Science Program's Ocean Carbon & Biogeochemistry mCDR MRV Workshop
- NASA's Earth Science Division's research on various aspect of climate change including ocean fertilization.
- NOAA's oceanic process related to carbon update and storage and impact of ocean acidification on marine ecosystem.
- Institute of Electrical and Electronics Engineers (IEEE) – ocean solutions including ocean CDR

From: Diane Hoskins (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 5:49 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: FINAL_Carbon to Sea - FTAC comments.pdf

Hi Tricia,
On behalf of Carbon to Sea Initiative, I am writing to share our response to the request for information.
Thank you,
Diane Hoskins
Director, Global Policy
Carbon to Sea Initiative

Carbon to Sea Initiative

April 23, 2024

Input to U.S. Marine Carbon Dioxide Removal Research Plan

The Carbon to Sea Initiative (CTS) is a nonprofit effort whose mission is to systematically assess the conditions under which ocean alkalinity enhancement (OAE) can deliver safe, cost-effective, and permanent CO_2 removal at scale. We are guided by a set of core principles that emphasize transparent outcomes, strong and clear governance standards, and sincere stakeholder engagement.

We are delivering on our mission by funding research to close knowledge gaps; advancing relevant technology and policy development; and engaging in community-building to support the emergence of a responsible and sustainable ocean-based CDR sector, should that be appropriate. **Last year, we awarded more than $23 million to scientists and engineering teams** to ask and answer open questions associated with: measurability, efficacy and permanence, environmental safety, economics, utility of byproducts, monitoring, alkalinity delivery, alkalinity generation, and measurement, reporting and verification (MRV).

We greatly appreciate the Administration's establishment of the Fast Track Action Committee to facilitate and advance relevant policy and research on marine CDR (mCDR), and offer the following responses to the questions you posed in the Notice of Request for Information issued on February 23, 2024.

1. How would a Marine CDR Plan affect you, your organization, or your community?

Private investors and philanthropies are stepping up to advance promising mCDR technologies, but those investments will not be sufficient to determine whether and which mCDR approaches can safely and permanently reduce atmospheric CO_2 and do so at the scale that is needed. A well-structured and appropriately funded federal plan for research, development, and demonstration (RD&D) of mCDR is needed to:

- Identify environmental and social considerations that need to be assessed and addressed before mCDR can be deployed at a large scale,
- Signal to private investors that the federal government will be a substantial and committed partner in advancing the technological readiness of safe and effective pathways,
- Clarify permitting of field research and demonstrations to evaluate environmental safety and the potential for net-negative emissions of various approaches, and
- Provide knowledge needed to inform regulatory processes.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?

We are encouraged by the recent guidance on mCDR permitting issued by EPA and were further encouraged to learn that the USACE recently permitted a project led by Vesta. There are many great signs that mCDR research efforts can move forward under existing laws. We're optimistic that responsible research can advance under existing authorities. At the same time, we recognize that current laws were not created with ocean-based carbon removal approaches in mind, especially given these projects are intended to generate a net positive environmental benefit.

We encourage the FTAC to assess what regulatory or statutory changes will be needed to permit safe and timely field research of mCDR technologies. Consistent with the President's Ocean Climate Action Plan and the FTAC Charter, the Committee's regulatory review should also include consideration of changes that may be required to eventually evaluate and permit large projects.

Since regulated impacts are largely a function of scale, not the intent of a project, it seems counterproductive to draw a sharp distinction between research and commercial activity when considering changes in the regulatory regime. Properly structured public-private partnerships can share the burden in financing innovation by bringing the combined expertise and resources of the research community and the private sector to solve challenging technological problems, like development of negative-emissions technologies. Permitting of mCDR projects should support these goals, subject to protection of the environment and the public interest. Notably, it is already U.S. practice to support research conducted in partnership between academic entities and the private sector, for example at least nine of the NOPP awards involved partnerships among university researchers, commercial enterprises, or private, non-profit research institutions and ARPA-E's mCDR grants involved small and large businesses, national labs, and universities.

Timeliness of decision making is an important factor towards ensuring a supportive regulatory environment which will lead to increased private sector investment and help the United States maintain its global leadership in advancing climate solutions. Finally, for mCDR to contribute to negative emissions on the timeline and at the scale that the Administration envisions in its Carbon Negative Shot, the federal regulatory agencies will need clear direction to prioritize efficient permitting of the field research and monitoring needed to evaluate the additionality, durability, and environmental effects of the various approaches.

2a. What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?

Given the number of laws and federal agencies potentially involved, we suggest the creation of a standing interagency working group on mCDR permitting that lives beyond the duration of the FTAC. Its functions should include:

- Issuing integrated guidance to assist project developers in project design and permit application,
- Providing a one-stop initial point of contact for field research site developers,
- Improving communication and ensuring coordination, both among the agencies and between the agencies and project developers, and
- Minimizing, consistent with sound evaluation of impacts, duplication and delay in permitting.

Also, as mentioned above, we appreciate the recently issued guidance from EPA about mCDR permitting under the MPRSA and the Clean Water Act (CWA). Further clarification on certain permitting matters would be helpful, including:

- The conditions under which an mCDR project utilizing an existing wastewater outfall would be able to operate under an existing NPDES permit, require a permit modification, or require a new permit.
- Guidance regarding design and scale factors affecting a determination of whether projects that propose to place matter into ocean waters wholly or partially for the purpose of ocean alkalinity enhancement require permits under section 102 of the MPRSA or section 404 of the Clean Water Act.
- Guidance from the Army Corps of Engineers regarding the materials that may be used in beach renourishment and other coastal restoration projects permitted under the Rivers and Harbors Act that provide a co-benefit of ocean alkalinity enhancement.

In addition to greater clarity on regulation, substantial and consistent federal funding is vital to drive the field forward. FY 23 funding through the National Oceanographic Partnership Program, and DOE's ARPA-E program and the Office of Fossil Energy and Carbon Management (FECM) provides a valuable down payment. Ongoing and increasing support for research and development of this kind is needed. In 2022, the National Academies of Science, Engineering and Medicine called for at least $1.3 billion in spending over 10 years to fully evaluate and determine which mCDR approaches may be ready for deployment at gigaton scale. CTS recently recommended a significant increase in federal funding for FY25 to put the U.S. on track for this level of investment in mCDR.

A wide variety of technologies to deliver mCDR are under development. A growing number of these technologies are at the point where research in the real world is needed to test theory and laboratory results in situ, evaluating how mCDR interacts with ocean physics and the carbon cycle in situ and assessing collateral environmental effects.

A main reason there's significant need for additional federal funding is that philanthropic *and* private sector funding will be insufficient to support early innovation, let alone advancement to commercial viability — should that be appropriate for any given pathway. Long timelines, high-costs and uncertainties largely prevent significant private capital, which could prevent the real-world testing of promising technologies.

Critical knowledge gaps that need to be filled for the safe and effective regulation of mCDR research include:

- The additionality, permanence, and scale potential of carbon removal produced by the various technologies;
- The magnitude and time scale of environmental benefit (in addition to the hoped-for effect of net carbon dioxide removal) or harm caused by the various technologies;
- As for all CDR pathways, life cycle assessments covering all inputs, outputs, and associated processes, to evaluate the additionality and sustainability of the different mCDR pathways; and
- Information and technology needs to ensure regulatory and public confidence in MRV for mCDR so that it can gain not just regulatory approval but also social license to operate in the public ocean.

We anticipate that national accounting of the effects of mCDR will require increased investment in ocean observations, especially building out the global biogeochemical Argo array (BGC-Argo). The biogeochemical data delivered by this array is critical not only to establish environmental and oceanographic baselines against which the effects of mCDR deployment can be measured, but also to monitor and verify long-term effects of alkalinity and ocean carbon sequestration.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?

To achieve the levels of carbon removal anticipated to be necessary, at this early stage, it's important to advance the knowledge base of a variety of ocean-based approaches. The National Academies report highlighted that mCDR approaches have different costs, benefits, and risk profiles. Notably, that report made a point to say that there is high scientific confidence that Ocean Alkalinity Enhancement could be an immensely scalable approach and it is plausible that it could become much cheaper than direct air capture, for example.

We urge the program to prioritize allocating significant resources to safety, field research, and stakeholder and community engagement. Across mCDR, the federal government should do more than close knowledge gaps. It has an opportunity to encourage a "race to the top" in terms of best practices by directly incentivizing project developers to pursue the highest levels of safety, environmental stewardship, accountability, community engagement, and maximization of societal benefits.

OAE and other open-system mCDR approaches face challenges with MRV and assessment of the permanence of carbon removal but a federal research plan is uniquely positioned to provide financial support for field trials with highly rigorous MRV to help evaluate environmental safety, quantify CDR, and assess the durability of carbon removals in open ocean systems. A federal research plan is also best positioned to support long-term monitoring at time horizons unlikely for privately funded efforts.

In terms of stakeholder engagement, research teams need support and dedicated resources for best practices. This means ensuring adequate resources are available to bring in external partners, collaborations, host workshops, among other activities to increase public engagement.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders?

As it becomes available, it will be important for the Federal Government to make as much information as possible available to the public, in forms that are accessible and comprehensible to non-experts, so that individuals and communities can judge for themselves which forms of mCDR are most sustainable and effective. It will also be essential for the federal government to support research and disseminate information about the direct and indirect economic impact of mCDR, especially as some technologies approach deployment at scale. Public access to federal research results will help ensure ocean-based CDR can earn public trust necessary for safe, effective and permanent technologies to operate in the public ocean space.

In preparation for possible large-scale deployment of mCDR, the FTAC should engage the Ocean Policy Committee and the regional ocean partnerships to begin discussion about the use of ocean space for mCDR and how it can best be accommodated while minimizing conflict with other users of ocean space and resources.

4a. How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

CTS is encouraged by recent efforts to elucidate stakeholder engagement as outlined by Guide to Best Practices in Ocean Alkalinity Enhancement Research and the Code of Conduct for Marine Carbon Dioxide Removal Research. Both of these resources offer considerable guidance on the nature and extent of stakeholder engagement necessary to earn support for mCDR research.

Given the federal government's experience regulating and supporting new ocean industries, **it would be valuable for federal agencies to share examples of past, productive public engagement for other industries.** In particular, what can we learn about how public engagement efforts generally grow and evolve over time to help ensure we're meeting high standards for public engagement while also ensuring we're setting a vision that's achievable for various scales of field research and allocating the necessary resources.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of?

Carbon to Sea, a non-profit effort, is the largest private funder of OAE RD&D. In 2023 we awarded more than $23 million to scientists and engineering teams that span 5 countries and include 11 universities and 4 companies. Several of its grantees are also recipients of federal grants, including grantees that have formed cross-sector partnerships, bringing academia and the private sector together. This is the latest example of a well established practice.

From renewable energy, to consumer safety and medical and pharmaceutical advancements, U.S.-based research institutions and business entities have a long and successful track record of partnering for innovation. EPA's own Small Business Innovation Research (SBIR) program supports the development of new science and technology that addresses the EPA's mission to protect human health and the environment, and projects to develop and commercialize technologies to address climate change are a major focus of the program.

We are strongly in favor of doubling down on this approach, in part because it will help the United States to maintain its global leadership in advancing mCDR and other climate-related technologies. Last year's funding for mCDR research reflects this philosophy with grants going to universities, commercial enterprises large and small, and private, non-profit research institutions.

In addition to support for RD&D, it is critical that the U.S. maintain a policy and regulatory environment conducive to advancement of a domestic industry through collaboration between the public and private sectors. U.S. law regulates mCDR based on the potential for environmental impact, which is a function of scale, not the intent of the project. FTAC should ensure that both domestic and international regulatory processes and thresholds encourage public-private collaboration, not establish roadblocks to partnerships advancing these promising technologies to readiness for large-scale deployment.

From: Vivek Pathak (b) (6)
Sent: Tuesday, April 23, 2024 5:44 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: response.pdf

Dear Madam,

As an observer with insight into this area of inquiry, and as a founder of a startup investigating large scale Hydrogen harvesting from the ocean, please find the responses to the call

Kindly acknowledge receipt, and let me know if I can share any further information

Best regards,

Vivek Pathak

cell - (b) (6)

MCDR Response

Vivek Pathak

Summary

There may be suboptimal allocation of MCDR, and other climate change funding. There are enough decision makers with vested interests, resulting in unneccesarily long gestation period or supply chain limited technologies getting funding and support. Decisions may be gaming the innovation ecosystem to support the current government supported market positions of big economic players, who are otherwise publicly supporting climate change redressal. This aspect may kindly be analyzed, and if confirmed be addressed through relevant strategic actions.

1

How would a Marine CDR Plan affect you, your organization, or your community?

The Marine CDR Plan can affect us as it perturbs the CO2 concentration of the planet. It is also concerning that the same people who measure the results of these CDR experiments are the ones who stand to benefit from the research grants into the CDR plan. Thus the evaluation results would be suspect by application of conflict of interest rules. This aspect further aggravates the primary concern that over experimentation may be done, or significantly fewer than commercially viable alternatives will be tried since the selection criterion would be co-biased by other incentives of researchers: a citation productive research area, ability to solve problem in stages and get grant funding over several cycles, etc. Thus, less cool technologies which are perfectly applicable and economical, are likely to be ignored at the time of allocation of government funding, and private funding since these oligopolies are permitted to venture into the Energy markets in USA. So they can keep their thumb down and influence the speed and direction of energy transition. Wasteful federal funding may be good for the market players, but its a disadvantage for the common tax payer. Such an influence also starves out innovation by choosing winners and losers based on centralized planning.

2

What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?

As also noted previously, it is concerning that the same people who measure the results of these CDR experiments are the ones who stand to benefit from the research grants into the CDR plan. Thus the evaluation results would be suspect by a common conflict of interest test. This aspect further aggravates the concern that over experimentation may be done using public funds, or significantly fewer than commercially viable alternatives will be tried.

What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?

There should be rules regarding marine debris tracking and cleanup to avoid creating a federally subsidized trash patch once the current under-the-influence research direction is given up, and a market friendly transition to green energy is permitted. The lack of free innovation in the energy industry is caused by the close relationship between the energy industry and the government. The only way to make the green energy transition happen is the reverse: give more subsidies to the energy industry but like Glass Steagall and Banking, prohibit their participation or investment in new energy ventures.

What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research?

Comprehensive exposition and analysis of alternatives has not been done. One such instance came to light was when our startup applied to a prestigious accelerator call with focus on this area. Our method was not consistent with current orthodoxy - depending on the ocean to eventually capture the Carbon di Oxide somewhere - instead, we captured the CO2 as a high pressure liquid underwater as a result of a complex electrolytic process which also produced Hydrogen gas. So our approach was "rejected". There is no formal open competition where either through market forces, or through energy limits, any particular process has been proven as winner. That is the weakness of current knowledge.

What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale *deployment or commercial application?*

Need more open competitive alternatives. There should be greater focus on provable alternatives, and scientific repeatable measurements.

3

Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?

Priority should be to have fair and open competition and scientific comparing techniques. It appears that quite often, the decisions to fund or defund particular approaches are done with interference from biasing factors including personal relationships, provenance of technology, or other unscientific factors. Therefore, it should be a priority to collect information about approaches which are systematically rejected or systematically selected. A careful breakdown of funding and the research approach may expose that funds are being spent in narrow technical improvements instead of broad research. Private sector and University partnerships are great for creating the sense of competition and efficiency, but they also introduce group-think and insider-access bias.

While giving a level playing field to everyone is a good idea in theory, there should be some oversight over what approaches are systematically rejected, and if the rejects are somehow not gaining a level playing field from the scientific and business points of view. Such an exercise would ensure that the funding gives the desired level of results. It is not enough to check that respondents of given ethnic backgrounds have fair representation. A greater and more meaningful and result oriented metric is the distribution of such research dollars to a greater diversity of approaches.

Most specifically, this current response to your call has been motivated by the experiences of the respondent. Our approach were rejected, when we checked the winners it was clear the technology fraternal to the judges gets the funding. Such low level bias or corruption may be acceptable in general life, but to use potentially faulty competitions without over-sight of bias to spend tax payer funds at a big scale can be disastrous, both for protecting the environment, and for protecting public funds.

Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits?

Priority should be given to non-intrusive approaches which do not take away the rights of others. The rationale being that harmless approaches may find more collaboration both across interest groups, and across national boundaries.

Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Atmospheric reflection by inserting particles in the atmosphere, and ocean based CDR by adding basic chemicals to the ocean are both problematic. Since the US government does not legally own the atmosphere or the ocean water, such efforts could face costly legal challenges, making them much more costly than projected, and perhaps less effective in the end than promised. Therefore, tax payer funded, and potentially inadvertently polluting research in these areas should be highly suspect. Its aggregate impact must be carefully monitored, and legal basis more carefully addressed through iterative development based on democratic local feedback. Historically also, the greatest damage has been done under the rationale of good intentions.

4

What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

There should be bucketed breakdown of funds being spent by approach. Otherwise, there can be grounds for suspicion that specific research approaches which may be scientifically inferior are being promoted by the US government under the garb of Climate Change Research.

The impetus for this request is from the governance standpoint. If a cold headed analysis of energy technologies being ‘promoted’ by the industry is done, the outlines of a "game" become clear. With loud protestations of good intentions, the venture arms of energy and technology giants invest in and promote energy transition through technologies which often have technical poison pills. While this may be happening as a result of our collective bad luck, there is also a possibility these players tip the balance as they sit everywhere in the decision making roles - from venture investors, to advisors to US government and the military.

The PEM electrolyzers have Platinum (rare), the ceramic fuel cells and steam electrolyzers have Iridium (rare), and our now familiar EV car has Lithium (rare, expensive, flammable). It may be a coincidence that our energy transition gets a technological bad luck on every technical direction of attack, or it maybe the collective result of self interest maximizing decisions of the players involved.

The author has had the opportunity to review the technological research and developments in these areas, and there seem to be elements of crony-tech-capitalism occurring in the the energy transition industry. The information about technical approach bucketing, and diversity of provenance, if disclosed to the public can be a good insurance against such potential long term market manipulation by the big players.

5

What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of?

There efforts listed on NOAA page are quite comprehensive. There are also efforts run through venture arms of significant US oligopolies/monopolies, which can be identified through a search engine search with "ocean venture fund", "climate change vc", etc. An important Human Resources feature of these efforts is the revolving door effect, with the appointments of researchers at government funded laboratories, and venture fund employment or accelerator employment having a periodicity. It is not the intent of this observation to raise concerns about conflict of interest or of suboptimal allocation of funding. However, such closed group efforts have a historically known disadvantage of producing less than optimal results.

One specific effort which does not have recognition or funding from the US Government is the proposed Carbon negative Hydrogen pathway proposed by my company. For the record, our proposal is a planetary scale PV powered Hydrogen platform, where we have a methodology to safely transport the Hydrogen on top of ocean currents at a negligible cost. Our potential pathway to MCDR comes from a chemically viable pathway we discovered with very surprising good news: Our electrolytic solution is able to not only capture carbon from the atmosphere - but the resulting compounds can be used to construct a high melting point (5 degree C) temperature resistant artificial ice to protect the current polar ice cover (melting points of sodium carbonate solutions are elevated). Thus the same device can give us 3 wins: a) generate Hydrogen we can use as fuel, b) capture carbon di-oxide in an artificial ice which has higher melting point, and c) increase reflectivity of earth by protecting the polar ice caps (where our artificial ice is applied). Armed with the fortuitous discovery, and with the backdrop of rapidly falling solar PV prices, we were hoping that it would be a breeze to raise funding for the concept since the main technological barriers were all solved, and we had a truly scalable design, and a technically competent team.

However, our perception has been quite different. Possibly technically poison pilled and slow to gestate technologies may be getting preferential support. This may be consistent with preserving the oligopoly and monopoly positions of companies within the current energy infrastructure, as previously described.

What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government?

The presence of a small tight knit community at the helm of decision making for the entire planet, without inputs from either the markets, or from more broad open efforts is concerning when the role of the Federal Government as the vanguard of public funds and trust is considered. An inordinate amount of money can be spent on such “large” efforts, hence in the sincere opinion of the author, the funding and oversight of such efforts should be offloaded to local governments and groups at the community level.

What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Partnerships of the Federal government with the big players end up creating conditions where not only smaller firms are locked out from the market, but the technology diversity is reduced within the accelerator and venture support world. Its almost like a research-climate-fix complex exists, which has decided what to do, and we are compelled to live with sub-par solutions.

With the bigger private players pushing technology with a particular bias friendly to their current market positions, it is debatable if Federal money should be co-invested where the big players inimical to the energy transition are also investing. Regardless of the words they say, please also analyze their business operations in detail. The following is a good starting point for such an enquiry : https://www.nytimes.com/2023/08/07/opinion/oil-fossil-fuels-clean-energy.html .

Please have a look into the funding awarded by these potential "partners" in the climate change battle. You will find the same 5-6 usual suspects who keep researching and improving same or similar things for decades. That is not the way to win. You have to rethink your methodology completely. Need not even inform the oil and internet companies when making or deciding the policy. Making policy based on local decisions, and funding local innovation is a more promising approach. That way you avoid the moral hazard of asking businesses to work against their market interests.

6

What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Please check the game the big economic players are playing through you. It has been explained previously in this document. Please reach out for more details, if needed.

VIVEK PATHAK

Curriculum Vitae

Contact (b) (6) [redacted]
USA
(b) (6) [redacted]

(b) (6) [redacted]

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From: Tara Bojdak (b) (6) >
Sent: Tuesday, April 23, 2024 4:47 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Captura_Marine Carbon Dioxide Removal Research Plan RFI Response.pdf

Dear Ms. Light and Colleagues,

Thank you for the opportunity to submit comments on the National Marine Carbon Dioxide Removal Research Plan. Please find attached Captura's response to the National Science Foundation Request for Information 89 FR 13755, on behalf of the White House National Science and Technology Council Marine Carbon Dioxide Removal Fast-Track Action Committee.

If we can be of any further assistance supplying information about Captura's Direct Ocean Capture solution, please don't hesitate to reach out.

Kind regards,
Tara

—

Tara Bojdak
Director of Communication

captura

(b) (6)
CAPTURACORP.COM

Marine Carbon Dioxide Removal Research Plan

Captura Corporation Response to NSF RFI 89 FR 13755

April 23, 2024

National Science Foundation
2415 Eisenhower Ave
Alexandria, VA 22314
Submitted via email to (b) (6) [redacted]

RE: Marine Carbon Removal Research Plan

As a company developing a leading Direct Ocean Capture (DOC) technology, Captura appreciates the opportunity to comment on the development of the National Marine Carbon Dioxide Removal Research Plan as part of achieving the goals set out in the Administration's Ocean Climate Action Plan. Captura supports the creation of the Marine Carbon Dioxide Removal Fast Track Action Committee (FTAC) to coordinate marine carbon dioxide removal (mCDR) efforts across the Administration.

The science is clear that, in addition to rapid decarbonization, carbon dioxide removal will need to be deployed to avoid catastrophic climate change. Because carbon dioxide (CO_2) is ~150 times more concentrated volumetrically in the ocean than the atmosphere, and oceans cover ~70% of the Earth's surface, mCDR is a useful and important additional approach to terrestrial forms of carbon removal.

There are a range of mCDR solutions under development today that leverage the ocean's natural processes to deliver a net removal of CO_2 from the atmosphere, each with their own challenges and benefits. Captura, and others in the field, are advancing a high-potential mCDR approach known as Direct Ocean Capture or DOC that extracts CO_2 directly from the upper ocean. Due to the equilibrium of CO_2 between the ocean and atmosphere described by Henry's Law, the discharged CO_2-depleted seawater draws down additional CO_2 as it re-equilibrates with the atmosphere. The net result is the removal of CO_2 from the atmosphere via the ocean, without increasing the ocean's CO_2 content.

Just like terrestrial Direct Air Capture (DAC) approaches, DOC delivers the captured CO_2 as a measurable, physical stream of gas that subsequently can be safely and securely stored via geologic sequestration in compliance with today's regulations. Alternatively, the CO_2 can be utilized to produce low carbon intensity products such as synthetic fuels.

Captura has developed a unique electrochemical DOC process that combines standard industrial equipment with proprietary electrodialysis and gas stripping technology to remove CO_2 from seawater. Captura’s process adds nothing new to the ocean, removing only CO_2, with no by-products produced. The only inputs are seawater and renewable electricity, and the only outputs are CO_2-depleted seawater and a pure stream of CO_2 gas that can be used in products or stored in secure geologic storage.

Captura is pleased to offer the following comments in response to this RFI. Additionally, as a member of the nonprofit trade association Carbon Business Council, we support the association's independent response.

1. *How would a Marine CDR Plan affect you, your organization, or your community?*

The DOC field is still nascent but quickly growing, with an increasing number of companies developing a variety of processes for this promising mCDR approach. Captura is working to commercialize and deploy a leading DOC technology initially developed at the California Institute of Technology. However, the present set of incentives in the United States do not yet enable scale-up and commercialization. The creation of an mCDR plan that supports technologies from laboratory-scale research all the way to mature commercialization would be of immense importance to us and the wider DOC field. An mCDR plan that results in clearer permitting guidance and incorporation of DOC into existing climate incentives like 45Q, would enable Captura to deploy projects in the United States. This would in turn deliver emissions reductions and create clean-energy jobs domestically. Additionally, greater support for R&D and pre-commercial demonstrations would also benefit aspects of Captura’s work.

2. *What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*

Captura’s process is differentiated from other mCDR approaches in that it doesn’t add new material to the ocean nor increase the ocean’s CO_2 levels. It simply removes CO_2 that was previously dissolved in seawater, which results in atmospheric drawdown as the CO_2-depleted waters re-equilibrate. Our approach is fully capable of operating under existing regulatory frameworks and permitting requirements that govern the intake and discharge of wastewater or cooling water. That said, the mCDR community as a whole would benefit from both greater guidance on how to permit projects at various scales, and thus with various potential impacts, and also from a fit-for-purpose regulatory and permitting regime for mCDR. Captura would welcome such efforts and would be happy to participate in them. We also note that, as our technology operates under the take-nothing add-nothing paradigm, we would welcome a permitting scheme that scales requirements to the level of uncertainty or impact posed by each specific mCDR technology.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

For the reasons stated in other answers, Captura is pursuing a DOC mCDR technology. A key advantage of this solution is that it removes a measurable physical stream of CO_2 from the environment that can be geologically sequestered in compliance with existing regulations like EPA's Underground Injection Control.

Additionally, Captura's DOC approach poses lower environmental risks because it uses no external chemicals, adds nothing new to the ocean, and produces no by-products that may create disposal challenges at large scale. Captura has published an Ocean Health and Monitoring, Reporting & Verification (MRV) protocol that describes our practices for ensuring ocean operations are safe for the marine ecosystem. Captura is also conducting extensive studies with academic and industry partners to understand the potential impact of our technology on the marine ecosystem and will be implementing strategies to minimize any impacts in future deployments.

In addition to delivering the environmental benefit of carbon dioxide removal, the deployment of DOC facilities creates potential for a number of co-benefits. Captura's facilities can be deployed either onshore or offshore and can make use of existing ocean-based infrastructure. For example, offshore oil and gas platforms that have been retired through the energy transition can be repurposed to deploy DOC facilities, creating jobs for transitioning oil and gas workers and providing a new market for offshore renewable power. If deployed in semi-enclosed parts of the ocean such as bays and inlets, DOC has the potential to help address ocean acidification on a local level, which could have positive implications for ocean-dependent communities, such as seafood farmers.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Environmental justice and Community Benefits Plans, within the scale up and deployment of mCDR, are critical, both for maximizing the long-run societal benefits of the industry and for maintaining public trust and buy-in. The Federal Government has a vital role to play in public engagement and education, and we note that the DOE has established a constructive set of requirements and considerations for community engagement and environmental justice within programs like DAC Hubs.

mCDR proponents at earlier stages of project deployment have less resources available to navigate this important process. The Federal Government should consider providing technical assistance and resources, such as best practice guidelines when conducting Community Benefits Plans, to support project developers and ensure projects meet the needs of the communities they are partnering with.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, nongovernmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Captura has attracted over US$45M in financing from a variety of leading investors and companies since its formation in late 2021. Our technology is now fully demonstrated in our 100 ton-per-year pilot facility located at the Port of Los Angeles (Figure 1.), where we also conduct our extensive ocean health program, the results of which will made be publicly available via our Ocean Health and MRV Protocol. In partnership with Equinor, we are also deploying a larger, 1000 ton-per-year pilot in Norway in late 2024.

Figure 1. Captura's operational DOC pilot system at AltaSea at the Port of Los Angeles

Captura and our investment partners seek to deploy plants in the United States and would like to see DOC receive the same incentives and deployment support that DAC currently enjoys given the two approaches deliver identical functional outcomes – the removal of a verifiable stream of CO_2 from the environment that can be stored via secure geologic sequestration in compliance with today's regulations. The DAC Hubs program, for example, provides a great framework for partnership between a carbon removal company and the Federal Government, but the program is currently closed to DOC.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

We believe the Government's mCDR plan should cover the whole spectrum of mCDR approaches; however, the Federal Government should provide specific guidance for different approaches given they each have different impacts and co-benefits. The plan should also evaluate how the Government can support mCDR technologies across the full maturity spectrum, from basic research to pilots and field trials, to demonstrations and deployment of commercial technologies.

Again, Captura thanks you for the opportunity to comment on the National Marine Carbon Dioxide Removal Research Plan. We would be happy to discuss our answers further.

Sincerely,

Tara Bojdak
Director of Communication
Captura Corporation
(b) (6)

From: Brenna Boehman (b) (6) [redacted] >
Sent: Tuesday, April 23, 2024 4:46 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan_BBoehman comments.pdf

Hi Tricia,

I'm a PhD candidate at MIT and Woods Hole Oceanographic Institution, and an entrepreneur, submitting the following letter regarding the RFI for the Marine Carbon Dioxide Removal Research Plan.

Best,

Brenna Boehman

Brenna L. Boehman
CSO | Sinkco Labs
M.Sc. Marine Microbiology, MPI MM | LinkedIn
PhD Candidate in the MIT-WHOI Joint Program in Applied Ocean Science and Engineering

SIN

Brenna Boehman
78 Southbourne Road
Boston, MA 02130
April 23, 2024

To the National Science Foundation.
I am a PhD Candidate at MIT-WHOI Joint Porgram in Applied Ocean Science and Engineering, as well as a greenhouse gas removal entrepreneur working on ocean-based carbon removal through my company, Sinkco Labs.

I'm writing to express my strong support for the establishment and expansion of startup incubator programs specifically tailored for startups focused on ocean-based carbon removal technologies. As the global community seeks viable solutions to combat climate change, the ocean presents a vast and relatively untapped resource for carbon sequestration.

Ocean-based carbon removal technologies, including methods like algae cultivation, artificial upwelling, and electrochemical conversion, hold significant potential to reduce atmospheric CO2 levels. However, the development of these technologies faces unique challenges, such as high initial research and development costs, regulatory hurdles, and the need for specialized scientific and business expertise. Bridging the gap from academic research towards commercial development is essential to develop impactful technology and to mitigate climate change impacts.

Incubator programs dedicated to this sector could provide crucial support in the form of mentorship, funding, and strategic partnerships, thus facilitating rapid technological advancements and commercial scalability. For example, my startup participated in the AirMiners Launchpad accelerator, and it was catalytic for our success. Such initiatives would not only foster innovation but also accelerate the deployment of effective carbon removal strategies, contributing significantly to global efforts to mitigate climate change.

The leadership of the NSF in supporting these endeavors is vital. By prioritizing and investing in accelerator programs for ocean-based carbon removal, the NSF can play a pivotal role in nurturing the growth of startups that may hold the keys to our future sustainability.

Thank you for considering this vital initiative. I am eager to see how the NSF's support can transform our capabilities in fighting climate change through innovative and sustainable ocean-based solutions.

Sincerely,
Brenna Boehman
(b) (6)
PhD'24 MIT-WHOI, M.Sc.
Sinkco Labs

From: Avalon Bristow (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 4:33 PM
To: Light, Tricia M. EOP/OSTP
Cc: Janet Reimer
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Mid-A Regional Council on the Ocean_Response to 89 FR 13755.pdf

Dear Tricia Light,

Thank you for the opportunity to provide comment on a Marine Carbon Dioxide Removal Research Plan. I have attached a comment letter on behalf of the Mid-Atlantic Regional Council on the Ocean. Please contact me should you have any questions.

Best regards,

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Avalon Bristow
Executive Director
Mid-Atlantic Regional Council on the Ocean
(b) (6) [redacted]

[>www.midatlanticocean.org<](http://www.midatlanticocean.org)

MARCO
MID-ATLANTIC REGIONAL COUNCIL ON THE OCEAN

April 23, 2024

Tricia Light
Office of Science and Technology Policy

Re: Response to Request for Information on Marine Carbon Dioxide Removal [89 FR 13755]

Dear Tricia Light,

Thank you for the opportunity to provide input on the National Marine Carbon Dioxide Removal Research Plan. I am submitting this letter on behalf of the Mid-Atlantic Regional Council on the Ocean (MARCO), the Regional Ocean Partnership (ROP)[1] in the Mid-Atlantic. Since its establishment in 2009 by the Governors of New York, New Jersey, Delaware, Maryland, and Virginia, MARCO has played a unique role in the Mid-Atlantic region as the only multi-state regional partnership focused holistically on ocean issues and fosters collaboration and coordination to enhance the vitality of the region's ocean ecosystem and economy. Additionally, MARCO maintains the [Mid-Atlantic Ocean Data Portal,](https://portal.midatlanticocean.org) which provides local, state, federal, and tribal and entities and industry partners with invaluable information for coastal zone management and decision-making.

The success of a national strategy for addressing Marine Carbon Dioxide Removal (mCDR) will rely, in part, on regional coordination of local, state, federal, and tribal research and permitting needs and actions and should consider goals of the Ocean Climate Action Plan (OCAP)[2]. This approach will ensure that local priorities are identified and addressed in an efficient, coordinated way. MARCO and the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS) co-host the Mid-Atlantic Coastal Acidification Network (MACAN) which coordinates states, relevant Federal agencies, Tribes, researchers, and affected industry groups at the regional scale to address regional acidification, which is directly related to excess CO_2. In late April, MARCO will be convening another work group, the Coastal Carbon Collaborative, focusing on understanding regional mCDR by compiling relevant planned and current research activities and identifying and answering questions about regulatory frameworks and scalability.

1. How would a Marine CDR Plan affect you, your organization, or your community?

State coastal zone management highly depends on stakeholder needs and how they are impacted. There are over 34 million people that live within the coastal zone and watersheds of the Mid-Atlantic. Protecting and restoring the natural resources and ecosystem services in the Mid-Atlantic is essential for sustaining the region's blue economy. Many businesses and recreational activities that rely on coastal waters are already feeling the negative effects of acidification through impacts to species, habitats, and overall water quality. For example, through communications with MACAN stakeholders in the Chesapeake Bay region, we have learned that oyster aquaculture yields and reef habitats have decreased in the past decade due to decreased pH (increased acidification). Marine CDR can potentially enhance the ocean's natural carbon cycle and carbon storage capacity, benefit local economic development and job market, and address acidification that may be due to climate change. While mCDR is an emerging solution for addressing carbon-

[1] https://www.congress.gov/bill/117th-congress/senate-bill/1894
[2] Ocean Climate Action Plan (2023), https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf

based water quality and climate concerns in the Mid-Atlantic, it is important for decision-makers and other stakeholders to understand the benefits and potential impacts of mCDR to ensure responsible implementation.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

The MARCO states are concerned that mCDR is seen as a complete solution to carbon related climate change issues, including acidification and warming temperatures. This view should be addressed cautiously, as an overreliance on mCDR needs to be avoided. Marine CDR should be seen as a part of the overall solution, including but not limited to reductions in greenhouse gas emissions and other carbon reduction endeavors like wetland restoration/preservation efforts. Since the overall environmental impacts of mCDR are not yet known, it is also imperative that caution be taken when implementing research and mitigation plans.

Preliminary discussions about the emerging topic of mCDR within MARCO's collaborative working groups and committees have yielded questions about permitting and siting for experimental projects and field scaling. Specifically, information on which office(s) permits are issued through, the process and documentation needed, and how locations are chosen, especially within state waters or federal waters that may impact state coastal resources (e.g. fisheries). Early coordination, education, and outreach regarding the regulatory landscape and concepts for various mCDR approaches will allow challenges to be identified and resolved before implementation starts, creating a more efficient implementation process. Regional-scale collaboration is especially important in the Mid-Atlantic, where three of the nation's busiest ports and largest estuaries are located, and where bays and estuaries are all bounded by multiple states.

MARCO is also keenly interested in understanding the following questions: (1) Will carbon credits be issued for mCDR activities, especially for commercial/industrial partnerships? If so, will these be partnered with reduction incentives for generators, or just used to offset increased emissions for purchasers? (2) Will the results of technology and field-based research projects be made publicly available, apart from relatively inaccessible peer-review publications? And (3) The majority of stakeholders do not read the peer-review publications that are often generated from research. Is there a national communications strategy to report the conclusions from the research that is in line with current accessibility guidelines?

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

MARCO works to sustain the health of all coastal and ocean ecosystems in the region, and therefore encourages the study of nature-based approaches for mCDR. Nature-based solutions that restore habitats such as oyster reefs (which promote natural water filtrations), submerged aquatic vegetation (SAV) beds (which remove CO_2 from the water column), and marshes (which store carbon in their sediment) will not only contribute to the removal and storage of carbon but also increase the effectiveness of other ecosystem services. Further, habitat mitigation and restoration projects can also contribute to the need for green infrastructure to reduce the impacts of climate change related problems such as coastal erosion, flooding, increased stormwater runoff, and storm surge. Restoring natural habitat not only increases the amount of CO_2 removed from the water column and air but also positively impacts the way communities use the land and coastal zone as fishing, landscape, and protective resources.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Information can include data, data tools, and explanations of methodology and results. Ways to transmit these different types of information can be through online data repositories, graphics, schematics, posters at field sites, one-pagers, and on websites.

Data needs around monitoring, research, and validation (MRV) are still unclear. There is no clear scientific consensus yet on which ocean biological and chemical parameters need to be monitored long-term to understand the potential success of mCDR. Marine CDR monitoring should include carbonate chemistry parameters to estimate the potential impacts on species and water chemistry: pH, total dissolved inorganic carbon, total alkalinity, and the partial pressure of CO_2. Additionally, salinity, temperature, and pressure of the sample is also needed for meaningful monitoring. Addressing time scales of variability of carbonate chemistry is also important for determining long-term changes and effectiveness of mCDR. Tidal, daily, seasonal, and annual scales of variability must be considered to be able to confidently track progress.

Monitoring and field testing for mCDR should closely align with existing monitoring strategies and sites. When considering mCDR related to acidification[3] It is preferable to use sites where acidification is already known to occur when possible. Blue Carbon study sites and oyster reef restoration (for nature-based solutions) should also be considered as priority sites. Additionally, more research is needed regarding the fate of carbon moving through coastal wetlands along a salinity gradient, including soil and porewater fluxes.

The **Mid-Atlantic Ocean Data Portal**[4] is a publicly available, interactive data visualization tool that provides users access to over 6,000 spatial data layers for fishing grounds, marine life and habitat, acidification monitoring sites, a vast range of human uses, oceanographic information, and more. Decision-makers and stakeholders alike have come to rely on the Portal for the best available, multi-sectoral spatial information. Having one trusted, credible clearinghouse for these data points helps reduce user conflicts, informs siting of activities in the region, allows for fact-based facilitation of constructive dialogue among stakeholders and decision makers about regulatory and nonregulatory actions, and supports stakeholder and multi-agency vetting and confidence-building in new data as it becomes available. As new issues emerge, maintaining a modern, up-to-date, easy-to-use Portal to support sound decision making and stakeholder

[3] https://www.sciencedirect.com/science/article/pii/S0272771418308679?via%3Dihub

[4] https://portal.midatlanticocean.org/

engagement will continue to be a MARCO priority. A federal mCDR strategy could advance this work by prioritizing the availability of relevant federal information to MARCO's and other regional ocean data portals.

We highly recommend that Indigenous communities be engaged early and often. MARCO has contracted a Tribal Consultant to assist with Tribal Listening Sessions regarding all the work that we do. This could be a highly effective mechanism for engaging regional tribes and is inline with our accessibility guidelines. As part of MARCO's commitment to DEIJA[5], we produce content that is understandable, digestible, and publicly accessible to a wide range of audiences. For example, MACAN is about to publish short public outreach videos on our website, one of which is focused on technologies used to monitor acidification and how mCDR is a growing industry that will combat acidification and climate change.

Recognizing and integrating traditional knowledge and Indigenous perspectives is essential for developing equitable and culturally appropriate strategies. Implementation and field testing of mCDR should include documenting and preserving Indigenous knowledge related to ocean ecosystems, sustainable practices, and the impacts of environmental change. Incorporating this knowledge into decision-making processes can enhance the effectiveness of a successful national mCDR Strategy.

The **Mid-Atlantic Regional Ocean Forum** is an annual two-day public-facing event that serves as an information exchange between MARCO and its partner members and public stakeholders. The Forum fosters a deeper understanding and awareness of state, federal, tribal, and regional research and management programs and other activities affecting ocean and coastal waters off the Mid-Atlantic; identifies opportunities for collaboration on regional ocean issues; generates and maintain a list of contacts engaged in ocean planning to facilitate communication across the region; identifies ways to enhance federal data sharing and support for the Mid-Atlantic Ocean Data Portal to inform ocean planning and management; and engages stakeholders in learning about, identifying and responding to regional ocean issues. We encourage federal agencies to attend and participate in regional information sharing during The Forum.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Currently, there are various mCDR research projects funded by NOAA, which are expected to produce their results within the next three to five years. Additionally, there are a number of field trials that already appear to be underway by start-up companies as well as established industry partners. It is important that a national mCDR plan considers the timeline of ongoing and planned research. Some states also have ongoing or planned mCDR work. For example, the New York Department of Environmental Conservation (NYSDEC) has had a Bioextraction Coordinator on staff for several years.

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[5] MARCO statement on Diversity, Equity, Inclusion, Justice and Accessibility: https://www.midatlanticocean.org/wp-content/uploads/2022/11/DEIJA-Statement-November-2022.pdf

As of April 30th, 2024, MARCO will be convening the Coastal Carbon Collaborative (CCC), which will catalog ongoing mCDR work in the states, relevant Federal agencies, Tribes, industry, and research partners. The CCC will also specifically address many of the mCDR goals outlined in the Ocean Climate Action Plan[6]. Federal agency participation in the CCC is key to the success of advancing research and information sharing. MARCO invites the White House National Science and Technology Council (NSTC) Marine Carbon Dioxide Removal Fast Track Action Committee to participate in this group. Currently, representatives from NOAA, EPA, US Navy, US Coast Guard, BOEM, and DOE participate in our various work groups.

We encourage the federal government to leverage ROPs to advance the goals and objectives of a national mCDR strategy for research, monitoring, and implementation. The ROPs are proven and effective platforms for collaboration and coordination among states, Federal agencies, Tribes, and diverse stakeholders. Aligning efforts with ROPs allows federal agencies to tap into established networks and expertise, which will provide a more comprehensive and integrated approach to combating this, and other, climate change issues. MARCO convenes **topic-specific, inter-jurisdictional working groups**, composed of governmental and non-governmental actors, that advance regional shared priorities around a range of specific ocean topics by:

- Identifying challenges and potential solutions for decision-makers to address
- Bringing heightened focus across the region to emerging ocean and coastal issues
- Offering opportunities for stakeholder engagement and data interpretation on key regulatory and nonregulatory issues in a non-confrontational setting
- Disseminating information about ocean issues to the Mid-Atlantic public

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

mCDR could be one potential way to address acidification in coastal waters. However, careful consideration of site selection for field trials will be necessary for localized impacts. Consideration of the existing infrastructure in coastal waters for monitoring will allow for the use of pre-existing sites. MRV should include the necessary carbonate chemistry parameters and be consistent with current acidification monitoring and best practices. Existing data management systems and frameworks, such as the US Integrated Ocean Observing System[7], with internationally certified quality assessment and quality control procedures should be used to store data and make it publicly available. Untested methodologies should be piloted in federal waters, outside of enclosed embayments and sensitive habitat areas, as impacts to the coastal zone are not yet known.

Thank you, and please contact me should you have any questions regarding this response.

(b) (6) [redacted]

Avalon Bristow
Executive Director, Mid-Atlantic Regional Council on the Ocean
(b) (6) [redacted]

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[6] Ocean Climate Action Plan (2023), https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf.

[7] IOOS. 2017. National Strategy for a Sustained Network of Coastal Moorings. Available at: https://cdn.ioos.noaa.gov/media/2018/01/NationalStrategyforSustainedNetworkofCoastalMoorings_FINAL.pdf

From: Lexi Shultz
To: Light, Tricia M. EOP/OSTP
Cc: Billy M. Williams; Mark Shimamoto
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Date: Tuesday, April 23, 2024 4:32:25 PM
Attachments: image344077.png
image776805.png
image327274.png
image588474.png
image347889.png
image598356.png
image606156.png
image065060.png
image470415.png
image483921.png
image054341.png
image212831.png
image854507.png
image111578.png
Final AGU Comments - MCDR Fast Track RFI.pdf

Attached please find the American Geophysical Union's response to the MCDR-FTAC RFI.

Please let me know if there are any questions. Thank you and best wishes,

Lexi Shultz
VP, Science Policy & Government Relations
American Geophysical Union

Dear Members of the Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR-FTAC)

This letter is the American Geophysical Union's response to the RFI released on 23 February 2024 to inform development of an implementation regarding marine carbon dioxide removal (marine CDR) research. The American Geophysical Union (AGU) is a global community of Earth and space scientists and other professionals that aims to advance discovery and solution science to accelerate knowledge and advance ethical and respectful solutions.

While AGU represents many researchers who are involved directly in varying aspects of marine CDR research, AGU's own work in this area has been to create an Ethical Framework for Climate Intervention research in consultation with stakeholders and advisors including academic and private sector researchers, social scientists, ethicists, representatives from the Global South, Youth, and Indigenous communities. The comments that follow focus on what we have learned through this process rather than on direct research considerations.

Question 1: How would a Marine CDR Plan affect you, your organization, or your community?

Our community includes researchers, local officials, Indigenous Knowledge holders, and community members who have expressed a diversity of views on the issue of MCR. Overall, we would recommend that a comprehensive and appropriately funded Marine CDR plan provide an overarching framework and the resources needed for a suite of research efforts to determine the efficacy and the potential impacts of CDR removal technologies, as well as how best to ensure that such research is carried out ethically. In addition, we have heard the following from different stakeholders:

- From researchers:
    - The incredible importance and urgency of research to explore marine CDR approaches and technologies given the almost certain overshoot of global temperatures beyond 1.5 degrees Celsius.
    - The need for any guidelines and regulations on such research to be clear and followable so that research does not become impossible to undertake

- From communities, Indigenous People, and youth communities, among whom there is an enormous amount of mistrust of these technologies and approaches, as well as of the ability scientific enterprise to take their interests into account:
    - The need for full transparency of the research, the methodologies, the funding, and the data.
    - The critical importance of consultation (not just informing) potentially impacted people, and to develop methods of engagement to allow for advanced consideration of concerns of the community.
- For people of the Global South:
    - A strong desire to ensure that researchers in the Global North consider the likelihood of testing research in other nations and the need to build in capacity building into the experimentation plans.

Question 2: What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research?

AGU is concerned about the current lack of an overarching plan for MCDR research but is especially concerned about the lack of a regulatory framework for such research that could provide appropriate guidelines for transparency and engagement. The Federal Government should be prepared to establish such guidelines and to develop approaches for consultation and engagement with communities. Specifically, it would be helpful for the federal government to provide:

- A data repository for researchers to be able to readily access information about the outcomes of experiments and tests, as well as any knowledge gleaned about the efficacy and impacts of different marine CDR approaches.
- Regulations regarding transparency of research, data, and funding and advance notice and consultation with stakeholders, as well as clear guidance for how to carry out such consultation.

- Restrictions on deployment of materials into the environment without seeking advance permitting

There are some existing resources that the Federal Government could reference, including:

- A Code of Conduct for Marine CDR research developed by the Aspen Institute,
- An approach to developing federal policy for safe and responsible MCDR research developed by the Columbia Law School Sabin Center for Climate Change Law
- An upcoming Ethical Framework for Climate Intervention that will be released by AGU before the end of 2024

In terms of what additional knowledge will be needed, it would be important to develop an understanding of the climate benefits – or lack thereof – of any potential deployments, the local implications of any potential deployments – whether positive or negative, and a pathway to address the concerns of affected communities. Specifically, guidelines should be developed for:

- Clear, pre-registered hypotheses about the additionality, durability, and environmental impacts of each research effort
- Vetted and agreed upon environmental standards
- Analytical tools for identifying sites best positioned to support safe, ethical, and effective research, and
- Methods for understanding the costs and benefits of such research as compared with other options or no action.

Question 4: What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Providing information helpful to communities in assessing the benefits and risks of siting specific projects in their community, such as workforce impacts/workforce development and ecosystem impacts (potential benefits and harms), would be very useful. It would also be important for the Federal Government to provide a public database of research experiments, which should include:

- For forthcoming research, the questions to be answered, the intended use of the knowledge gleaned, the timing, location, and methodologies of the experiment, the source of the funding for the research the potential benefits and risks, and clear information out whom to contact for more information and consultation.
- Updates during the research for the public to understand what has been done, and, what, if anything, has changed with the intended plan.
- Post research, a final summary of what has been learned and what the intended next steps are.
- A set of resources for different stakeholders.
    - For communities, it would be helpful to have an outline of questions they should feel empowered to ask and have answered, which should include a place to report concerns and a process for how the federal government might respond to those.
    - For researchers, best practice documents and case studies for research and engagement would be invaluable.
- For private sector research, information about the permit provided and location to report concerns.

In addition to the public information described above, funding agencies should hold consultation meetings, workshops, and training sessions with potentially impacted communities or stakeholders. These meetings should be more than a chance for the public to testify, but instead an organized discussion where information is provided about the type of research in question, as well as its benefits and risks. The community or stakeholders' questions should be answered, but if there are concerns raised that can be addressed, the agency should address those with the researchers to modify methodologies, approaches, timing, or other factors or potentially to stop the research all together. To make the communication of such information as effective as possible, it would be valuable to consult relevant social science research and researchers.

Federal funding agencies should also engage researchers early on so that there is an expectation of consultation with communities and resulting iterative planning.

Question 6: What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

There are several critical factors in the development of a Marine CDR Plan that must be addressed.

- AGU's own position statement on Climate Intervention supports research to understand the efficacy, benefits, costs, and risks associated with climate intervention approaches and technologies, but not in a vacuum. Many sectors of the public – rightly or wrongly – have strong concerns about such research, and these must be taken seriously if we are to be able to get to a place to understand what might work and how. To that end, the transparency, engagement, consultation, and redress components of any MCDR plan must not be an afterthought but must be integrated into the very fabric of research funding and plans.
- A Marine CDR plan must be thoughtful about the questions to be answered and how that information will be used to guide further research. Given the importance and time sensitivity of understanding the efficacy and risks of MCDR, combined with the sensitivities to this type of research, it will not be enough to approve any research question that may be proposed but to instead to map out how research questions will further our overall understanding about whether or not these technologies and approaches should ever be deployed widely. As such, cost considerations, community impact, and more should be an integral part of the questions to be considered. In addition, the research should be iterative, such that knowledge and data gleaned from one set of experiments should inform the next set.
- An MCDR research plan should not assume or imply the inevitability of deployment. If the efficacy of the approaches and technologies is not proven and/or concerns raised are too serious, there should be a commitment to not proceed further.
- Finally, AGU's own Ethical Framework for Climate Intervention is still under review and development by our Advisory and Writing Committees, and we aim to release them at or before COP29. That said, we are including a draft of them here to give an indication of the types of considerations AGU will be supporting and fostering discussions about.

From: Brynn Esterly (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 4:16 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Climate Vault_Marine Carbon Dioxide Removal Research Plan_4.23.24.pdf

Dear Tricia,

I hope this email finds you well.

Climate Vault is pleased to formally submit our response to the Request for Information (RFI) for the Marine Carbon Dioxide Removal Research Plan. Please find our response document attached. Can you kindly confirm receipt?

We applaud the NSF and the MCDR-FTAC in their efforts to implement an impactful Marine CDR Plan and appreciate the opportunity to contribute our insight and feedback. We look forward to continuing the conversation as the Marine CDR Plan evolves.

Thank you for your time and consideration. If you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,
Brynn Esterly

CDR Projects Manager
Climate Vault

CLIMATE VAULT

Submitted via electronic mail on April 23, 2024

Esteemed Members of the National Science Foundation,

Climate Vault applauds the National Science Foundation (NSF) and the White House National Science and Technology Council Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR-FTAC) in their efforts to implement an impactful Marine CDR Plan ("mCDR Plan") to advance the goals of the Ocean Climate Action Plan. We appreciate the opportunity to submit a response to this RFI and look forward to continuing to engage with the NSF and MCDR-FTAC as this work evolves.

Introduction to Climate Vault

Climate Vault, Inc. ("Climate Vault") is a 501(c)(3) non-profit organization founded at the University of Chicago with the mission to simultaneously reduce carbon emissions and support innovation in carbon dioxide removal (CDR) technologies. Our founder, Dr. Michael Greenstone, is a renowned economist who co-led the development of the United States social cost of carbon under President Obama. At Climate Vault, we believe in the power of markets to solve complex challenges.

Our CDR solutions are vetted by our world-class Technology Experts Chamber ("Tech Chamber"), which includes science and policy experts from Harvard, MIT, Princeton, and UC San Diego (Scripps). The Tech Chamber is chaired by former US Energy Secretary, Ernest Moniz.

Our Tech Chamber assesses CDR technologies across three pathways: Terrestrial, Technological, and Oceanic. Given the ocean's size and natural capacity as a carbon sink, we believe mCDR solutions are imperative to helping the U.S. achieve net-zero by 2050 and collective global efforts to limit warming to 1.5°C above pre-industrial levels. However, we acknowledge that mCDR solutions are currently immature and that a dedicated, coordinated research effort to answer critical questions and overcome roadblocks to growth and expansion is needed to advance these solutions.

Climate Vault's Response to Select RFI Questions

1. How would a Marine CDR Plan affect you, your organization, or your community?

Climate Vault is a 501(c)(3) non-profit organization with the mission to simultaneously reduce carbon emissions and support innovation in carbon dioxide removal (CDR) technologies. Through our annual RFP process, we seek to identify innovative CDR technologies to receive grant funding, and thereby support the growth and development of the carbon removal ecosystem. In Climate Vault's recent RFP round, mCDR solutions comprised 15% of applications received. However, while Climate Vault and the Tech Chamber agree that these mCDR solutions show promise, most lack technical maturity and face common challenges to scaling their solutions. Some examples include: demonstrating the technical feasibility and scalability of their technologies; implementing clear monitoring, reporting and verification (MRV) processes; obtaining permits to implement pilot facilities; and identifying and addressing project impacts on local communities and ecosystems. Therefore, Climate Vault maintains that any guidelines that help to move mCDR solutions forward are worth pursuing.

There are two key ways that the mCDR Plan would support our mission to accelerate mCDR innovation:

- **Address critical barriers to adoption and scaling:** The mCDR Plan would bring clarity and certainty to the common challenges cited above. It could help to reduce the inherent and perceived risks related to these projects, ultimately encouraging greater adoption of mCDR technologies. This clarity, supporting data, and risk reduction could also lead to greater success for project developers applying for funding and investment opportunities, such as through Climate Vault's grant program.

- **Amplify the climate impact of each grant dollar awarded:** The mCDR Plan would help to alleviate costs for internal research, development and deployment efforts for mCDR project developers, thereby lowering the all-in cost to remove 1 tCO2 and enabling Climate Vault to make a bigger impact per grant dollar awarded to successful applicants.

More broadly, the mCDR Plan can have positive impacts for local communities and economies:

- **Quantification of socioeconomic benefits:** The mCDR Plan could help to identify and quantify the socioeconomic benefits of mCDR solutions in local communities. In doing so, the mCDR Plan will equip project developers, advocates and key decision-makers with the data-backed insights necessary to facilitate further adoption and implementation of these technologies.

- **Creation of new jobs and scaling of the green economy:** Following the further adoption and expansion of mCDR solutions, the mCDR Plan will help to foster and scale a new industry of green jobs with positive local economic impacts.

2. **What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?**

Engage with the International Scientific Community

There is significant work to be done to move the mCDR space forward in a manner and time frame that meets the challenge of the global climate crisis. Therefore, Climate Vault encourages the Federal Government to prioritize engagement with the organizations and institutions that are already conducting valuable mCDR research (e.g. Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, Ocean Visions), in order to accelerate the collective rate of progress. This outreach should be conducted as part of a comprehensive stakeholder engagement exercise, discussed in further detail in our response to Question 4.

Establish Standards for Research Practices

Climate Vault also encourages the Federal Government to develop standards to guide collective research practices under the mCDR Plan to support safety, effectiveness, accountability, and collaboration across all research activities, including field testing. These standards should:

- Seek to identify and mitigate potential ecological and socioeconomic risks resulting from research activities and field experiments.
- Include regular, independent assessments of program performance in order to maintain accountability, while not placing unnecessary burdens on research efforts and hampering progress.
- Promote the standardization and sharing of data across disciplines and via public forums to foster transparency and collaboration.
- Build in flexibility so that research needs and approaches can be adjusted to account for the latest scientific evidence, as it comes available.

Additionally, the Federal Government could consider developing standards that are aligned with existing international agreements, such as the United Nations (U.N.) Convention on the Law of the Sea (UNCLOS); the London Protocol; and the U.N. Convention on Biological Diversity (CBD). Doing so could help to reduce any potential future friction in research activities, should the U.S. ratify these agreements or if the mCDR Plan requires collaboration with international bodies for research and field experiments.

Prioritize Critical Needs and Common Hurdles

Based on Climate Vault's research, engagement with the CDR community, and learnings from our RFP process, we suggest that the mCDR Plan focus research efforts in the following areas to advance mCDR initiatives and scale impactful solutions:

Monitoring, Reporting and Verification (MRV)

Given the nacency of the CDR space and the complexity of the ocean, developing MRV standards and regulations is crucial to developing confidence in mCDR solutions. While a few mCDR protocols have been developed by various standards bodies to date, there is no industry-wide consensus for implementation and management. Moreover, there is little consensus at the federal level regarding what mCDR MRV approach(es) are acceptable, how carbon sequestration should be demonstrated, and where research should be allowed to take place. Therefore, Climate Vault encourages the Federal Government to host large-scale workshops with the scientific community to advance discussions and align disparate perspectives on these topics at a national, and potentially international, level.

First and foremost, the Federal Government should determine which mCDR MRV approach(es) it will require or deem acceptable under the mCDR Plan. Given the predominant schools of thought on this topic, this means clarifying whether mCDR projects and research should: demonstrate carbon sequestration potential and environmental impacts collectively (often referred to as "eMRV"); demonstrate carbon sequestration potential first, after which environmental impacts can be researched and factored into decision-making; or whether both approaches are acceptable. In each case, there is also the question of whether carbon sequestration is best demonstrated by directly measuring sequestered CO2, measuring surface ocean oxygen levels, or if both approaches are acceptable.

Additionally, community discussions must address where research can take place. While there are a few instances of projects taking place in territorial waters, the Federal Government must determine whether mCDR projects will be allowed to take place in the economic exclusion zone (EEZ) and should develop a framework for identifying optimal test sites. Moreover, if projects are permitted to take place in the EEZ, the Federal Government should clarify whether it plans to indemnify federally-funded project developers and research initiatives operating in the EEZ, should any direct or indirect negative impacts result from the tests, in order to bolster confidence in and support the scaling of thoughtful mCDR projects.

The government's requirements (or range of acceptable approaches) for mCDR MRV should be clearly outlined. Climate Vault also encourages the government to host community workshops to provide guidance on the requirements to ensure understanding and compliance among relevant stakeholders.

Environmental, Ecological and Community Impacts

Potential mCDR impacts on ocean chemistry, local ecosystems and shoreline communities is an important research area. The climate crisis calls for scaling mCDR solutions quickly, but the urgency to sequester carbon must be balanced with reasonable efforts to avoid causing undue harm. Understanding upstream and downstream impacts of mCDR projects will help address key stakeholder concerns and enable the scaling of thoughtful, well-managed mCDR projects.

Permitting

Navigating the permitting system is time-consuming and resource-intensive for mCDR project developers. The system is complex and fragmented with many local, regional, national, and international regulations and institutions that govern activities within maritime zones. These regulations were not designed specifically for CDR projects, which leaves many questions regarding how CDR project developers should comply. The mCDR Plan can provide clarity on the types of permits required for different CDR projects, the processes and requirements for obtaining the permits, and where necessary, working with regulators to resolve key information gaps and streamline compliance.

Finally, each of the above research areas can be best supported through the development of advanced oceans systems modeling tools. For example, tools that model ocean system interactions can be used to develop baselines for MRV activities and predict the range of potential outcomes or direct impacts to the ocean resulting from different mCDR approaches. Additionally, ocean modeling systems can be used to develop sophisticated planning tools, which can be used to help regulatory bodies and project developers identify optimal site locations to implement test pilots or expand existing facilities.

3. Which marine CDR techniques do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits?

Climate Vault does not believe that research efforts and field trials have progressed far enough to conclude which mCDR approach(es) are most promising. Climate Vault maintains that researching and developing a variety of mCDR solutions simultaneously is critical to identifying which solution(s) are most effective and scalable. However, Climate Vault encourages dedicated research efforts on the following solutions:

Blue Carbon

Blue carbon projects face significant challenges to scaling and permanence; however, they have significant carbon sequestration capacity and are essential to coastal resilience, supporting wildlife habitats and biodiversity, and bolstering local economies, such as fisheries. Climate Vault views blue carbon projects as a key component of the CDR landscape and suggests dedicated research on:

- Modeling and quantifying sequestration rates and capacity based on variability in environmental settings and hydrological conditions (e.g., soil and sediment depth, proximity to open water, water circulation, and wave activity).
- Identifying and quantifying climate change impacts on sequestration potential and permanence (e.g., sea level rise, rising temperatures), as well as using this data to predict and better manage future blue carbon projects.
- Opportunities to use soil additions or plant cultivars to enhance sequestration and quantify the impacts of these methods.
- Framework development for identifying preferred site locations for new or expanded blue carbon projects, including opportunities to restore degraded coastal areas, incorporate wetlands into adaptation projects, and convert hardened shorelines to natural shorelines.
- Comprehensive mapping and data sets for blue carbon stocks.
- Quantifying resilience benefits of blue carbon projects for coastline communities.

Moreover, given the impacts that climate change can have on coastal communities, such as damage caused from more frequent and intense storms and sea level rise, Climate Vault encourages the Federal Government to identify collaborative opportunities among blue carbon project developers, local governments, and federal agencies (such as FEMA) for identifying optimal sites for blue carbon projects and tracking and quantifying impacts.

Macroalgae

Macroalgae projects are unique because they do not compete with arable land or require fresh water, and some of the infrastructure and operations are already in place and could be used for future expansion. However, much remains unknown about the effectiveness and impacts of sinking significant quantities of macroalgae to the deep ocean. Therefore, Climate Vault suggests dedicated research on:

- Ecological and biological impacts resulting from the growth, collection, harvesting, and sinking of various amounts of macroalgae in different marine environments and sea depths.
- Ocean modeling systems to quantify the amount of CO2 sequestered through macroalgae growth and harvesting activities.
- Tracking systems to determine the amount of biomass that reaches the ocean floor and is effectively sequestered.
- Opportunities to use plant cultivars to increase embodied carbon and yields.
- Framework development for identifying preferred site locations for macroalgae projects.
- More efficient, cost-effective technologies for harvesting and sinking macroalgae at sea.

Ocean Alkalinity Enhancement

While the chemistry behind Ocean Alkalinity Enhancement (OAE) is well-understood, most OAE research to date has been confined to modeling and lab studies. Field trials are needed in order to better observe and quantify the upstream and downstream impacts of this mCDR approach and to develop more precise accounting for carbon sequestration capacity. Therefore, Climate Vault suggests dedicated research on:

- Quantifying the upstream environmental impacts from mining, grinding and transporting alkaline materials to application sites.
- Identifying and addressing the downstream environmental and socioeconomic impacts from alkaline material application, including effects on ocean chemistry, local ecosystems and shoreline communities.
- Establishing strict purity standards for alkaline materials, with the goal to minimize the presence of trace metals or other pollutants introduced into seawater through OAE applications.
- Framework development for identifying preferred site locations for OAE projects, including projects taking place in the open ocean, on beaches, or in on-shore facilities using coastal outfalls.
- Advancing models and tools used to monitor and verify the amount of CO2 sequestered.

Direct Ocean Capture

Direct Ocean Capture (DOC) has significant potential as a mCDR approach; however, these projects remain in earlier stages of development and implementation. Therefore, Climate Vault suggests dedicated research on:

- Identifying low-cost, energy-efficient DOC methods; in particular, the mCDR Plan should consider aligning with existing research efforts through the DOE/ARPA-E Direct Ocean CO2 Capture Program.
- Ecological and biological impacts resulting from the intake and processing of large quantities of seawater.
- Framework development for identifying preferred site locations for DOC facilities and opportunities to potentially co-locate with existing infrastructure.
- Advancing models and tools used to monitor and verify the amount of CO2 sequestered.

4. How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Stakeholder engagement is a critical component of the project planning process. For mCDR projects in particular, public acceptance is also a roadblock to advancing further research and testing. Engaging in intentional and continuous dialogue that prioritizes equity, with relevant stakeholders, and implementing feedback accordingly, is important to advancing mCDR solutions. Climate Vault encourages the NSF to incorporate the following into their process:

1. **Identify stakeholder groups**: Conduct an in-depth review of relevant stakeholder groups, including communities that may be adversely impacted by the mCDR Plan.

2. **Establish robust communication**: Engage in transparent and balanced communications with identified stakeholders groups. This includes hosting regular community education and discussion forums regarding the benefits, challenges and risks involved with mCDR technologies and related research initiatives. Additionally, a formal feedback mechanism should be created to ensure all stakeholder perspectives are represented.

3. **Implement targeted research efforts and programs**: Based on stakeholder feedback, devise targeted research efforts and programs that address the most pressing or impactful environmental,

social, and economic considerations. In particular, the NSF may consider organizing small-scale pilots where co-benefits can be demonstrated and realized in local communities. Quantifying outcomes and potential co-benefits will also provide project developers and advocates with the data they need to gain acceptance and enable the scaling of their technologies.

4. **Track and measure progress**: Implement robust data collection and monitoring systems to track progress and inform evidence-based action. Data and results should be shared transparently across stakeholder groups to build trust, accountability, and facilitate collaboration.

5. **Conduct regular reviews**: Regularly evaluate progress and community feedback to inform potential program revisions. As outlined above, program assessments should be conducted by an independent body and the results be made available to all stakeholders.

Finally, Climate Vault encourages the NSF to create a “Stakeholder Roadmap” for mCDR project developers. The Stakeholder Roadmap would help to educate project developers on the best practices for stakeholder identification and engagement, including many of the same steps outlined above, and provide them with the tools to successfully identify and engage with stakeholders at different stages of their technological maturity, including implementing test and pilot facilities or expanding their operations to new locations.

Thank you for the opportunity to provide feedback on the development of this important initiative. We appreciate your time and consideration and look forward to continuing the conversation as the mCDR Plan evolves.

Sincerely,

Brynn Esterly
CDR Projects Manager
Climate Vault

Climate Vault referenced the following sources in developing its RFI response:

Aspen Institute, Energy & Environment Program. “A Code of Conduct for Marine Carbon Dioxide Removal Research”. November 2023.

Energy Futures Initiative. “Uncharted Waters: Expanding the Options for Carbon Dioxide Removal in Coastal and Ocean Environments.” December 2020.

Energy Futures Initiative. “Clearing the Air: A Federal RD&D Initiative and Management Plan for Carbon Dioxide Removal Technologies.” September 2019.

Ocean Visions and Monterey Bay Aquarium Research Institute (2022). Answering Critical Questions About Sinking Macroalgae for Carbon Dioxide Removal: A Research Framework to Investigate Sequestration Efficacy and Environmental Impacts. Available online at: oceanvisions.org/ seaweedresearch

Romany M. Webb & Korey Silverman-Roati, *Executive Actions to Ensure Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States*, Sabin Center for Climate Change Law, Columbia Law School, November 2023. Available at: https://scholarship.law.columbia.edu/sabin_climate_change/211

From: Nikhil Neelakantan (b) (6)
Sent: Tuesday, April 23, 2024 4:14 PM
To: Light, Tricia M. EOP/OSTP
Cc: Brad Ack
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Ocean_Visions_Response_FTAC_04_23_2024.pdf

Dear Tricia,

Please find attached our response to the request for input from Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC) on the Marine CDR implementation plan.

We would be pleased to discuss these questions and our responses further with the MCDR-FTAC and other relevant Federal Government stakeholders, and connect you with Ocean Visions Network and partner organizations working to advance mCDR. We very much appreciate the important work that you and your colleagues do, and the opportunity to submit this input for your consideration.

Yours Sincerely,

Nikhil Neelakantan
Senior Program Officer, Ocean Visions

OCEAN VISIONS
Advancing Solutions for Ocean-Climate Restoration

April 23, 2024

Dear Members of the Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC),

We write our responses below on behalf of Ocean Visions and in consultation with our collaborative network made up of universities and oceanographic institutions, and a diverse set of practitioner partners -- the Ocean Visions Network. Network institutions include scientists, researchers, environmentalists, policy professionals and others who are working to better understand the potential contributions, efficacy, and environmental impacts of marine CDR (mCDR) approaches and to advance the needed research and development within effective governance mechanisms.

1. Impact of the mCDR Plan on Ocean Visions and the Ocean Visions Network

A comprehensive and appropriately funded mCDR plan would provide an overarching framework and the resources needed for a suite of research, development, and demonstration (RD&D) activities that are needed to determine the efficacy of mCDR technologies as potentially safe and effective climate solutions.

This program of RD&D would engage the resources of our broader community of science, academia, philanthropy, civil society and industry, among others, allowing us to expand current programs and create new ones to accelerate the knowledge and understanding of the efficacy, ecosystem impacts, and scalability of mCDR approaches.

2a. Questions and Concerns about the Regulation of mCDR, including mCDR research

Our concerns center on the lack of an overarching plan to advance needed mCDR RD&D and a specific enabling regulatory framework for the needed RD&D in this arena. Determining how mCDR can contribute to needed global CDR targets is in the national interest, and the US government will need to act to enable the RD&D. Currently, the processes and time needed to get permits to complete mCDR RD&D are unclear, slow, and can add years to what should be an urgent experimental process.

In particular, the federal government must speed up the permitting of well-designed field trials which answer the following questions outlined here:

- Does the mCDR activity generate a measurable reduction in seawater carbon dioxide concentration?
- Can net additional ocean uptake of atmospheric carbon dioxide be tracked in response to the mCDR activity using a combination of sensors, platforms, and models?
- What are the impacts to marine ecosystems of mCDR activities and are they acceptable when compared with the impacts of the no-action alternative or of other feasible mitigation measures?
- What are the range of impacts to human populations and are they acceptable when compared with the impacts of the no-action alternative or of other feasible mitigation measures?

In addition to streamlining authorization for research, permits should mandate transparency and rapid public access to information on the design, performance, and results of trials.

2b. Tools or resources that the federal government should provide to support mCDR research

Some of the tools the USG could provide to support the safety and effectiveness of research include:

- Creation of pre-permitted test beds in areas under federal jurisdiction (drawing on a concept already in use by the US Navy and Department of Energy for marine renewable energy).
- Technical support for permit seekers to speed up the process.
- Access to labs, ships, and other infrastructure through public-private partnerships.

- Easy access to fit-for-purpose marine spatial planning and suitability analysis tools.

The USG should also lay out the minimum acceptable standards for research design. Research designs should encourage close coordination with other sectors and stakeholders, ideally in the form of public-private partnerships (like the recently announced call by the US Department of Energy).

2c. Current Knowledge to inform the safe and effective regulation of mCDR research

- Research agendas exist for some pathways that outline the full body of evidence needed to inform safe and effective research. These include research plans with budgets for 6 pathways in the NASEM report. The Ocean Visions macroalgae research framework and the ExOIS Path Forward report outline the steps needed to move from research to deployment for macroalgae sequestration and sinking and ocean iron fertilization respectively.
- Early ocean alkalinity enhancement experiments have shown that positive environmental outcomes are possible from permitted OAE field trials done with the proper environmental safeguards. See examples here, here and here.
- Several modeling studies on the potential for mCDR, including these studies here and here, provide insights into optimal locations for mCDR research.
- A rapidly growing literature on the environmental impacts, especially for OAE, including this recent paper provides current knowledge of safe operating boundaries.
- 13 ocean iron fertilization field trials in the 1990s/2000s provide a base for further research and demonstrate that field trials did have not long-term environmental impact to the marine environment .
- Suitability analysis tools developed to identify the sites best positioned to support research on ocean iron fertilization and seaweed farming based on pre-defined criteria including safety and effectiveness.
- Studies of natural analogs including these projects, and this paper can be used to provide support for larger scale field trials utilizing the underlying mCDR approach.
- Social Science research that provides a framework for socially responsible early research including this recent paper.
- Syntheses of legal frameworks, including this one to advance safe and effective mCDR research in the United States.

Additional Knowledge Needed

Several tools and additional knowledge will help especially to make permitting of field trials faster. These include:

- Developing research designs for remaining pathways that lay out the minimum number of experiments and all design details to produce acceptable empirical evidence to make sound policy decisions for full scale deployment and commercial application. Ocean Visions and the Carbon to Sea Initiative will create such a research design for ocean alkalinity enhancement pathways in 2024.
- Guidelines on building clear, pre-registered hypotheses about additionality, durability, and environmental side effects and a publicly available repository to store these hypotheses for later referencing as field trials are completed and results become available.
- Well-vetted and agreed upon environmental thresholds that research must not surpass.
- Additional suitability analysis tools to identify the sites best positioned to support research based on pre-defined criteria including safety and effectiveness.
- Tools to do comparative risk analyses that help regulators and stakeholders understand the costs and benefits of doing the research against those of other options, including those of the no action alternative.
- Tools and guidance to perform life cycle assessments (LCA) and technoeconomic analysis (TEA) that are applicable to working in the marine environment.

3a. Aspects of mCDR that the Federal Government should prioritize for research

The Federal government should prioritize for research all solutions that can deliver gigaton-scale CDR with durable storage of CO2 of 100+ years. This information has been summarized in Strategy for NOAA Carbon Dioxide Removal Research and National Academies of Sciences, Engineering, and Medicine's A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration.

For all the techniques that pass this minimum potential viability criteria, the federal government should support field trials at appropriate scales to determine potential efficacy, environmental and social impacts, and feasibility. Once further data is available from field trials, priorities can be re-set to focus on those techniques that continue to be viable with acceptable impacts.

3b. Promising mCDR approaches with regard to mitigation, ocean acidification and other benefits

Any mCDR activities concentrated in a limited area will likely provide localized mitigation of ocean acidification. While these effects may be limited, they may provide valuable acidification mitigation if occurring during times of heightened organism sensitivity or during extreme acidification events.

3c. mCDR approaches that are more or less risky

We believe that more research is needed to assess the comparative risk of these approaches when it comes to the environment, public health, and other uses. Some lower-durability, lower-scalability approaches such as the restoration of mangroves, seagrasses, and salt marshes offer well-documented benefits to human and ecosystem health, with limited risk of side effects.

4a. Information about mCDR most helpful for the Federal Government to make available

Providing information helpful to communities in assessing the benefits and risks of siting specific projects in their community—such as workforce impacts/workforce development and ecosystem impacts (potential benefits and harms) would be useful. This could be done through access to impartial experts, community workshops and training sessions which explain mCDR, and online decision-making tools.

The research community would benefit from access to clear information on funding opportunities and to all research information in the public domain. The government can also create templates, best practices documents, and case studies for others to follow in areas such as scientific research and scientific engagement.

4b. Government engagement with mCDR stakeholders and the public

When locations are identified for potential mCDR projects, it is important to engage with communities early, both to provide information to address their questions and concerns and to consider and address their thoughts and recommendations. Governments should consider co-designing mCDR experiments incorporating local knowledge into experimental design and monitoring and verification. With Indigenous communities it is critical to ensure that their sovereignty and decision-making authority is honored.

5a. Most significant mCDR efforts

NGOs:

- Ocean Visions has a number of knowledge products and tools such as the white paper titled "A Comprehensive Program to "Prove or Disprove" Marine Carbon Dioxide Removal Technologies by 2030, the mCDR field trial database, Road Maps and the Ocean Iron Fertilization Site Suitability Tool to help a wide range of stakeholders make informed decisions.
- The World Resources Institute's report proposes an overall approach centered on informed and responsible development and deployment of ocean CDR.
- Ocean Conservancy has a number of knowledge products including the perspectives and concerns of different groups currently or imminently involved in mCDR in the US.
- The Aspen Institute has developed a code of conduct for mCDR research
- The American Geophysical Union (AGU), in partnership with scientific and policy stakeholders around the globe, is developing an Ethical Framework for Climate Intervention Research, which includes mCDR.
- [C] Worthy is building oceanographic modeling tools to ensure safe, effective mCDR.

- Hourglass Climate plans to conduct independent research into mineral-based Ocean Alkalinity Enhancement strategies to facilitate responsible scale of CDR and climate mitigation.

Academia/Research Institutions:

- Woods Hole Oceanographic Institution is developing a large-scale, high-resolution network of technologies to track carbon as it moves between the atmosphere and the ocean called the Ocean Vital Signs Network.
- The Ocean Frontier Institute is developing the North Atlantic Carbon Observatory to connect and enhance ocean observation and modelling efforts to allow for more accurate measurements of the ocean's ability to absorb and store carbon.
- Ocean Networks Canada ran a first-of-its-kind experiment in Canada testing the impact of Running Tide's wood and mycelium buoys and samples of kelp substrate on deep sea environments.
- Stanford University's Doerr School of Sustainability has launched the GHG-R Flagship program with the first step being to select 16 projects (including mCDR projects) for focused accelerator support.
- The Sabin Center for Climate Change Law at Columbia University has outlined a series of recommended actions that federal agencies could take, under existing law, to ensure safe and responsible permitting and regulation of ocean carbon dioxide removal (CDR) research in U.S. waters.
- MIT Environmental Dynamics Lab and Scripps Institution of Oceanography at UC San Diego are working with Captura to track and model the plume of CO_2-depleted seawater released from Direct Ocean Capture plants.
- The Iglesias-Rodriguez Lab at UC Santa Barbara has an active program assessing the impact of Ocean Alkalinity Enhancement methods on the functioning and health of marine ecosystems.
- The Monterey Bay Aquarium Research Institute has developed a broad suite of sensors, platforms, software and methods to measure, track, and characterize the biogeochemistry of ocean waters and the biology & biodiversity of marine communities; such technologies are essential for mCDR MRV.

Philanthropy:

- The Carbon to Sea initiative is a philanthropically funded initiative that has raised over $50M to evaluate whether ocean alkalinity enhancement can safely remove and store billions of tons of CO_2. They have already disbursed over $25M to grantees, including Ocean Visions Network organizations.
- The Ocean Resilience and Climate Alliance is a recently announced philanthropic initiative to provide more than $250 million dollars in grants over four years to catalyze work across a handful of immediate ocean-climate priorities, including in mCDR.

Industry:

- There are several initiatives led by startups. Examples of existing field trials that are led by these startups in the US and elsewhere can be found here. Ocean Visions, with the support of advisors from Ocean Visions Network organizations provides scientific and technical advice to a number of these startups through the Launchpad program.
- The Circular Carbon Network's 2023 market report identified 74 companies that have identified themselves as ocean focused CDR companies.

Other governments:

- The EU has funded two research projects that evaluate mCDR from a number of perspectives (technical, economic, legal, social etc.).
- The German government has funded a similar project that looks at mCDR from a German perspective.

Other Initiatives:

- Under the framework of the UN Decade of Ocean Science, there are Centers that address ocean-climate solutions such as the Ocean Visions – UN Decade Collaborative Center for Ocean-Climate Solutions and the Global-ONCE program, with Xiamen University in China as the lead institution.

5b. Factors to take into account when considering potential partnerships

Some of the factors that the Federal Government should consider include:

- Additionality: would a partnership enable projects to happen that otherwise wouldn't have happened as well as people to participate that would otherwise not have the opportunity.
- Mission Alignment: The objectives and goals of the partnering entities should align with those of the Federal Government.
- Differentiated strengths that the entity brings to the partnership (this could be technical skills, additional funding, place-based relationships etc.)
- Capacity to provide the necessary services.
- Opportunities to realize scale: For climate impact, these technologies will need to scale to a global level. While partnering with international entities, it is important to keep this goal in mind.
- Potential Risk: The Federal Government should assess all partners for potential risk (reputational risk, financial risk, operational risk etc.) and develop strategies for risk mitigation.
- Equity: The selection of partners should be transparent and equitable. Once partnerships are formed, it's important that the benefits and burdens are distributed equitably among all parties involved.

5c. Biggest Challenges in Collaboration and how the Federal Government should address them

- Consistency of strategy and funding over a length of time: These issues could be addressed by ensuring that the mCDR plan is funded for 10 years, which is the recommendation of the NASEM report.
- Clear understanding of strategy, transparency in decision making: This can be addressed by having a clear outline of strategy before and at the time of developing a partnership agreement and constant communication during the projects to ensure that there's visibility into decision making.

5d. Examples of partnerships most relevant to mCDR partnerships

- Access to national labs to academic, industry and other partners to run lab studies and field trials, building upon partnerships such as the one between PNNL and Ebb Carbon.
- Expanding funding for large scale multi-partner research investments such as the NOPP and ARPA-E SEA-CO2 programs which improves cross-sector collaboration.

6. Other things for the Federal Government to consider as it develops a mCDR Plan?

- It is critically important for the Federal Government to create a MCDR plan that generates all needed information about which mCDR pathways, if any, can be scaled as deployable, effective, and safe part of the national portfolio of climate solutions
- The USG can play an important role in creation of MRV frameworks and tools by developing quality standards, either as a standard setter or as a major procurer of mCDR.
- The USG should develop/fund high priority social science research efforts to address social issues and barriers to mCDR RD&D.
- Interagency coordination and coordination across levels of government will be critical to advancing a comprehensive RD&D agenda.

In conclusion, Ocean Visions appreciates the opportunity to submit this input for your consideration and looks forward to the speedy development of the Federal mCDR plan.

Yours Sincerely,

Brad Ack,
CEO, Ocean Visions

From: JP Hennessey (b) (6)
Sent: Tuesday, April 23, 2024 3:20 PM
To: Light, Tricia M. EOP/OSTP
Cc: Varendra Silva
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: mCRD RFI Response.pdf

Dear Tricia Light,

Please find an attached document with W. L. Gore & Associates's response to the RFI for mCDR.

Thank you,

JP Hennessey
Product Specialist - Innovation
(b) (6)
M (b) (6)

W. L. Gore & Associates, Inc.
Together, improving life
501 Vieves Way
Elkton, MD 21921
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Together, improving life

April 23, 2024

Comments in response to the questions posed in Request for Information from the Marine Carbon Dioxide Removal Fast-Track Action Committee.

Question 1: How would a Marine CDR Plan affect you, your organization, or your community?

> A Marine CDR Research Plan will enable corporations and startups to focus on development, scale up, and deployment of their core technology to climate relevant levels. Resolving critical uncertainties related to Measurement, Reporting, and Verification (MRV) and environmental impact of the most promising mCDR technologies will allow these key industry players to focus their limited investment dollars on their core technology development and deployment. MRV and environmental impact assessments are cross-cutting activities and centralized, government sponsored initiatives will benefits all interested parties.

Question 3: Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

> Electrochemical marine CDR should be a prioritized method of carbon dioxide removal for its potential to scale and the long-term duration of carbon storage it provides. Because of these benefits, it shows promise to make a significant impact on climate change and ocean acidification. More research is necessary to establish MRV protocols for these methods of CDR. Additionally the environmental impact of shifting localized ocean chemistry needs to be better understood for both its potential negative and positive impacts.

> Ocean Alkalinity Enhancement (geochemical and electrochemical) and CO2 Stripping have the potential to alleviate localized ocean acidification. The potential benefit to marine ecosystems, specifically corals and mollusks, due to a localized increase in pH is an area worthy of further investigation that may help to support site selection for the implementation of electrochemical mCDR technology. The co-benefit of increasing localized ocean health will likely support social license to deploy these mCDR systems at scale.

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Together, improving life

Question 6: What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

> 45Q tax credits have spurred the innovation and deployment of direct air capture (DAC) technology within the United States providing a reliable funding mechanism to reduce the capital risk in the deployment of such large and expensive assets. The inclusion of mCDR technological approaches for 45Q credits, at the same credit level as DAC, is necessary to spur further development in mCDR technology as well as enable rapid deployment of sizable systems.
>
> Many mCDR approaches will be optimally sited off the coast and potentially in the open ocean. 45Q modifications should allow companies to qualify for credits if their mCDR technology is implemented anywhere within the Exclusive Economic Zone of the United States.

Sincerely,

John P Hennessey

John P. Hennessey
Product Specialist
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From: Daniel Goodman (b) (6)
Sent: Tuesday, April 23, 2024 3:32 PM
To: Light, Tricia M. EOP/OSTP
Cc: Christopher Carstens; Daniel Carstens
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Carbo Culture - RFI Response.pdf

Hello Tricia,

Attached is Carbo Culture's submission to the RFI. Thank you for your consideration. If there are any other opportunities for industry stakeholder comment, please let us know. We'd be happy to share more of our thoughts.

Thank you,

Daniel

--

Daniel Goodman
Special Project Lead
–
(b) (6)
–
carboculture.com
Twitter LinkedIn Instagram

Marine Carbon Dioxide Removal Research Plan - Request For Information

[Federal Register Link]

Prepared by:
Christopher Carstens, CTO, Carbo Culture, Inc.
Daniel Goodman, Special Projects Lead, Carbo Culture, Inc.
Daniel Carstens, Ocean Engineering Advisor, Carbo Culture, Inc.

Carbo Culture, Inc.
440 N Barranca Ave
Covina CA 91723-1722

1. How would a Marine CDR Plan affect you, your organization, or your community?
Carbo Culture is a carbon sequestration company specializing in the construction and operation of biochar generating pyrolysis reactors. Since 2022 we have been exploring the idea of ocean carbon sequestration. In November of 2023, Carbo Culture submitted a research permit application with the EPA proposing a terrestrial biomass sinking project off the coast of San Francisco, California. We are currently in active discussion with the EPA and we appreciate the time the EPA has spent and continues to spend to review and comment on our application. The process has at times been confusing, though, and we hope that our responses, from the perspective of a commercially active carbon sequestration company, will contribute to the drafting of guidelines that will help streamline current and future mCDR investigations. Our focus for this RFI will be on the permitting aspect of mCDR projects and our experience working with the EPA as the primary regulatory authority for our project.

From our earliest discussions with the EPA, we felt that the process could benefit from more specific guidance around what information was expected. By specific guidance, we mean the exact pieces of data that, if submitted, would satisfy the respective permit application section. The mCDR research permit application template the EPA has available does give helpful higher level guidance and information requests, for example "Biological characterization of the proposed [research] location" but further guidance such as age of the data acceptable, resolution, proximity to the site (in the case that nearby data was available from a different study), how it should be presented, was not provided. The EPA seemed hesitant to give specific answers to those questions, leading us to submit information we weren't sure would satisfy the requirements. We would have much preferred to have an extensive, detailed list of information and parameters we'd need to collect upfront - with the understanding that once we've collected these pieces of information, the EPA would be satisfied.

Another area where we feel the permitting process could be improved is the discussion of individual permit sections in isolation. Early in our research permit exploration, we wanted to get more clarity on certain sections before preparing and submitting the entire application. The EPA did give some detail on individual sections but ultimately requested that we submit the entire application - once received, they'd be able to give more comments specific to our project. This meant that as an organization, we had to devote the resources necessary to prepare an entire permit application knowing that some sections would likely be missing information because the expectations were not as clearly defined and we were unable to clarify them ahead of submission.

The lack of explicit deliverables (vs. general deliverables) and lack of specificity around the types of information expected means that the sufficiency of any information is dependent more on the opinions of the regulators and only achieved through multiple rounds of submission and comment. Having a standardized, detailed checklist of specific requirements that must be met in order for a project to proceed would be helpful. In our opinion, the current EPA checklist should be expanded so that there is less ambiguity around what needs to be provided given a certain project scale (see Question 2).

Having a mCDR plan in place will allow organizations like ours to have more meaningful discussions with regulators earlier because both the organization and regulators know what boxes need to be checked in order for a project to proceed. The criteria are less opinion based but rather clearly defined deliverables drafted by the Government in collaboration with private and public organizations. We just want to know what is acceptable or not in non-ambiguous terms. What would be nice is for the regulators to give us clear changes that need to be made in order for them to approve something. To the EPA's credit, recent feedback has included concrete deliverables, which was very much appreciated, because we know what information we need to collect.

A Marine CDR plan will also create an incentive to get more projects to an approvable state. Though the EPA lists mCDR as a type of research project that *can* be approved, within the last 3 years, only one mCDR project appears to have been approved via the EPA.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

The Federal Government should assist organizations by providing clearer definitions for background data and site acceptability.

Background data:
A variety of oceanographic data are available from various public and private sources, hosted in mapping tools such as ArcGIS. We believe standards around ***usable*** data need to be put in place so that organizations know what data they can use from existing sources and what data might need to be collected - or for missing data, the standards that must be met for that data to be usable for application purposes. For example, how old is too old for data with respect to mCDR? If data was collected near the activity site, but not at the activity site, can that data be used? Organizations would need to pay potentially hundreds of thousands of dollars to collect new oceanographic data, so understanding when this is a necessity would be helpful. For a general MPRSA permit, an EIS is needed. This includes collecting extensive data on a potential site. The EPA has stated that the data requirements for a research permit are less extensive than a special or general permit, however they weren't able to articulate those differences, meaning that as an organization, we don't know what data is needed for the research permit vs. what data is only needed for a general permit. Presumably Federal mCDR research opportunities would provide a lower hurdle for organizations trying to conduct research, but if the data requirements

are no different than a general permit, then organizations could be excluded due to the extreme financial burden of collecting all that new data.

If data age, quality, or applicability is a concern, can the Federal Government sponsor regional surveys designed to collect data that can be applied across different mCDR applications? If a company was able to leverage data that was collected and vetted already, then they can better focus on executing their specific project.

Can requirements be standardized based on project scale or other metrics? Right now, every project is unique which means that applications must be reviewed on an individual basis - requirements for one project may not apply to another. Can the government establish project scales that have less extensive background data collection requirements because the possible impacts to the ocean are limited by the scale of the project? The EPA appears to have the same requirements for background information regardless of project scale so a small project would need to collect and prepare the same information as a project 10x as large. Categories of projects can be created with their own list of requirements so that companies know what is expected of them ahead of time based on their project scope.

Site Acceptability:

In determining a site for mCDR activities, the MPRSA provides a good amount of guidance on the criteria that a site must meet in order to be acceptable. The research permit application requires a variety of site specific information, including organism habitat information, oceanographic information, results of simulations at the site (incorporating site specific current, density, temperature etc. data), and field survey design must be included. Ahead of submission, we attempted to get more guidance from the EPA on types of sites that would be acceptable. The EPA said that it would be hard to determine a site's acceptability without having all the other permit information as well. We've gone through multiple rounds of discussion, providing information on possible sites, and are still at a point where we don't know where we can conduct our research project. Because so many parts of the permit depend on the specific location of the activities, can identifying and locking in a location be completed earlier in the process so that other parts of the permit can be built around it?

Alternatively, perhaps the Federal Government can designate ocean areas that are only for mCDR research. These areas can be large enough such that several projects can occur within the boundaries and their location can be selected to minimize ocean impacts per the MPRSA. The background data collection and site characterization will have already been completed so entities interested in proposing a project know where they'd be allowed to conduct the research.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

The Government should be concentrating on projects that have rapid and certain implementation, capable of large-scale use within months or years, not decades. Methods demanding lengthy development, or whose success is uncertain, are less desirable than those that are sure and practical.

Carbo Culture believes that terrestrial biomass sinking is ready for full scale deployment and larger scale testing is necessary to reach commercial scales Terrestrial biomass sinking should be prioritized because it is rapidly scalable, requires minimal infrastructure, and can provide benefits to both the ocean as well as communities on land. The impacts of terrestrial biomass in the deep ocean have been studied extensively at small scales and there are natural processes that carry millions of tons of terrestrial biomass into the ocean annually. Larger-scale controlled pilots are the logical next step in researching this method.

To sequester 1Mt CO2e/year, 2.52M cubic yards (yd3) of terrestrial biomass (with 43% carbon and 0.33 metric tons/m3 density) must be placed on the seafloor. The San Francisco Deep Ocean Disposal Site (SF-DODS) used for the disposal of dredged material has an annual volume limit of 4.8 million yd3 and has received an average of 1M yd3 of material per year over a 16 year time period. Also worth noting, a review of historical environmental monitoring data collected at SF-DODS indicated that disposal activities have not negatively impacted the flora or fauna associated with the environment (Germano et al. 2009). So a similarly scoped site, designated for carbon sequestration, could easily accommodate 1Mt of CO2e sequestration per year. Agricultural and forestry residues, already transported in these quantities around California or elsewhere in the US can be used to move biomass to ports. Barges used in the disposal of dredged material can be used to transport bulk biomass to an ocean placement site. If the material is negatively buoyant, it only needs to be released from the barges (without baling or containerization) to sink to the seafloor below.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the Government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

The Government should provide information explaining the benefits of mCDR as a tool to fight climate change as well as the safeguards that are put in place to ensure safe research in the ocean. A knowledge gap might exist between the entities and the Federal Government wanting to conduct more mCDR research, and community members who may not understand why or how ocean research is necessary to address climate change. In order to obtain more widespread approval for mCDR projects, the communities should be aware of the benefits - in the same way that conventional carbon dioxide removal is becoming more recognized.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, nonGovernmental organizations, and other Governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

The Federal Government needs to create a pathway to approve projects within a reasonable amount of time and at scales necessary to understand climate level CDR activities. Companies are already setting up pilot projects outside the US, likely because existing regulatory approval is slow and there isn't a Federal objective to get more projects approved within the US yet. As a result, the United States is missing out on the potential technological and economic benefits of these projects. While having adequate protections for marine resources is extremely important, if the Government wants more studies on mCDR, they should focus on getting projects vetted and approved and making that an objective for the relevant reviewing regulatory agencies.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Create standards around MRV so all companies know what data they should collect and how it needs to be presented/organized. Right now MRV in the ocean space isn't well established and organizations are working on creating their own standards. Additionally, the EPA is requesting that research activities and data collection demonstrate that carbon is being sequestered. The Government should work with ocean CDR companies or certifiers to create MRV guidelines that are actionable for organizations conducting research. These MRV guidelines will dictate what data needs to be collected and how it should be used to demonstrate permanence to the EPA or other relevant agency.

Related to the MRV standards, the Government should establish a list of tools, such as oceanographic modeling tools, that are acceptable for organizations to use in preparing their projects. Our project proposal utilizes simulation tools, but we also need to demonstrate the validation of the tool in order for the output to be considered. Having a list of approved simulation, mapping, data analysis etc. tools would allow organizations to present analyses using methods that the Government is already comfortable with. The focus can then be on the results of the analysis vs. the validity of the underlying method.

From: Patricia Estridge (b) (6)
Sent: Tuesday, April 23, 2024 3:08 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan.pdf

Hi Tricia,

I am an entrepreneur submitting the following letter regarding the RFI for the Marine Carbon Dioxide Removal Research Plan.

--
Paddy Estridge
seaweedgeneration.com
Seaweed Generation Ltd

Seaweed Generation Limited
April Cottage
King Charles Quay
Falmouth
TR1 3HQ
email: [redacted] (b) (6)
tel: [redacted] (b) (6)
www.seaweedgeneration.com

April 22, 2024

To the National Science Foundation.
I am a greenhouse gas removal entrepreneur working on ocean-based carbon removal through my company Seaweed Generation Ltd.

I'm writing to express my strong support for the establishment and expansion of startup incubator programs specifically tailored for startups focused on ocean-based carbon removal technologies. As the global community seeks viable solutions to combat climate change, the ocean presents a vast and relatively untapped resource for carbon sequestration.

Ocean-based carbon removal technologies, including methods like algae cultivation, artificial upwelling, and electrochemical conversion, hold significant potential to reduce atmospheric CO_2 levels. However, the development of these technologies faces unique challenges, such as high initial research and development costs, regulatory hurdles, and the need for specialized scientific and business expertise.

Incubator programs dedicated to this sector could provide crucial support in the form of mentorship, funding, and strategic partnerships, thus facilitating rapid technological advancements and commercial scalability. For example, my startup participated in the AirMiners Launchpad accelerator, and it was catalytic for our success. Such initiatives would not only foster innovation but also accelerate the deployment of effective carbon removal strategies, contributing significantly to global efforts to mitigate climate change.

The leadership of the NSF in supporting these endeavors is vital. By prioritizing and investing in accelerator programs for ocean-based carbon removal, the NSF can play a pivotal role in nurturing the growth of startups that may hold the keys to our future sustainability.

Thank you for considering this vital initiative. I am eager to see how the NSF's support can transform our capabilities in fighting climate change through innovative and sustainable ocean-based solutions.

Sincerely,
Patricia Estridge

CEO
(b) (6)

From: Pete Chargin [redacted] >
Sent: Tuesday, April 23, 2024 2:44 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Planetary Response for FTAC RFI 89 FR 13755.pdf

Thank you for the opportunity to respond to the FTAC RFI 89 FR 13755

Please see our comments attached.

If you have any questions, please don't hesitate to call or email me.

Thank you again.

Pete Chargin

--

Peter Chargin

Vice President, Commercialization and Community Relations

[redacted]

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April 23, 2024

Tricia Light
White House Office of Science and Technology Policy (OSTP)
Submitted via email to (b) (6) [redacted]
Document Citation: 89 FR 13755

RE: Marine Carbon Dioxide Removal Research Plan

Dear Ms. Light and Colleagues:

Planetary Technologies is developing the world's first carbon removal system that turns coastal outfalls into carbon dioxide (CO_2) removal machines. Through a process known as Ocean Alkalinity Enhancement (OAE), we add a pure and mild form of antacid or "alkalinity", such as magnesium hydroxide or lime to the ocean, respecting all existing water quality permits. Once added, this alkalinity neutralizes acidic CO_2 that is present in seawater by converting it into carbonate and bicarbonate. As ocean CO_2 is converted, the ocean absorbs CO_2 from the atmosphere to bring the air and ocean back into equilibrium - lowering of atmospheric CO_2 levels. As an added benefit, OAE reverses ocean acidification in the local area, potentially providing ecosystem restoration benefits.

This process is aimed at protecting the climate and healing the ocean, ultimately achieving carbon dioxide removal and storage at gigatonne scale.

We are actively developing projects in the United States and around the world and would like to expand our US presence.

We would like to thank you for seeking input from innovators in the mCDR space, and we submit the following comments related to the Marine Carbon Dioxide Removal Research Plan.

Although in this response we specifically discuss high quality carbon removal, Planetary also strongly endorses initiatives that support the IPCC's urging to dramatically cut emissions.

Question 1. How would a Marine CDR Plan affect you, your organization, or your community?

- Marine Carbon Dioxide Removal (mCDR) has the potential to be the lowest cost and highest scale carbon removal pathway (see State of Carbon

Removal). It should be a critical piece of the national climate strategy.

- An effective mCDR plan would speed research, development and deployment and thus provide critical knowledge for maximizing mCDR's contribution to US CO_2 management efforts.
- We hope that any mCDR plan would help clarify the roles of the different agencies, at both the federal and state level, that are involved in the regulatory process. This could streamline our efforts to develop pilots and later deployments, which would speed our ability to develop and responsibly deploy mCDR solutions.
- A strong mCDR plan could drive additional private funding. For example, DOE announced $50M in funding towards a direct air capture project in Louisiana earlier this year called Project Cypress. This allowed the partnership behind Project Cypress to mobilize an additional $51M in private investment.[1] The same dynamic has occurred in other locations where mCDR has received government funding.
- Similarly, by helping to clarify a pathway to accepted mCDR carbon credits, an mCDR plan could encourage private carbon credit purchasers to consider marine carbon removal voluntary credits, which would also bring additional private funding to the space.
- Because mCDR is not well established as an accepted pathway to high durability carbon removal, an effective plan would provide much-needed awareness of the potential benefits that the ocean can provide. This would enable open and fact-based inquiry and public discussion into the circumstances under which mCDR pathways can be safely, effectively, and responsibly deployed.
- While the focus may be on a US mCDR, a well thought-out national plan here could influence and facilitate international efforts in this field. The US plan should take into consideration successful policy and planning efforts being conducted internationally so as to build on existing knowledge and avoid redundancy in effort.

Question 2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?

- Effective regulation of mCDR is critically important to protect our waterways and to develop the trust of local communities, which will be required for long term successful mCDR deployment.
- Regulation of mCDR, especially in the near term, should help determine which pathways are safe and effective. mCDR regulation must be in proportion to the degree that a given project creates long-term or especially serious risk. Small and short field trials which help create knowledge and which have little chance of long-term impact should be encouraged.
- Iterative expansion of well designed projects, with each phase subject to proper review, can increase understanding, community support, and safety.

[1] https://climeworks.com/news/project-cypress-team-awarded-funding-from-us-doe

- Regulation must be preceded by the creation of agency expertise in each of the regulated pathways.
- In many cases, for example with some ocean alkalinity enhancement projects, existing regulations such as NPDES can be used in the short term to help prevent water quality degradation. Undue burden should not be placed on projects that can be deployed within existing permit limits.
- Information gathered in initial trials can help inform the creation of more general permits that are fit for purpose to regulate larger scale mCDR projects. At the same time, there is no clear line between "research" and "deployment" - most mCDR projects combine private investment and research into safety and efficacy. This is likely the only approach that will enable a timely determination of the strengths and weaknesses of all potential pathways.
- The addition of federal funding to early stage RD&D can enable sufficient visibility and control over initial projects, and can be done much more quickly than the typical full process of creating a fit-for-purpose regulatory mCDR framework. The NASEM report (Research Strategy for Ocean Carbon Dioxide Removal and SequestrationNASEM, 2022) recognizes the need for governmental support and calls for specific research funding for each appropriate pathway. Investment in this important pathway has lagged federal funding for other approaches.
- Supporting the collaboration between academic, industrial, and government sectors can be extremely helpful and should be encouraged to inform the creation of effective regulation.

Question 3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?

- The federal government should seek and promote the best mCDR approaches based on their potential quality, cost-effectiveness and potential co-benefits. Quality includes durability, additionality, leakage, verifiability, risk of reversal, uncertainty, risk to the environment, and potential scale. The role of the federal government is to provide an inclusive and level playing field so that evaluation of various methods can be conducted, and those deemed promising receive support for further research at larger scales.
- New, emerging approaches should be continuously encouraged and supported when justified. It is likely that a portfolio approach will be "best" in the long run - it is likely impossible to a priori determine the optimal portfolio.
- Of the mCDR approaches currently being considered, Planetary believes Ocean Alkalinity Enhancement (OAE) is especially promising because:
    - OAE is a CDR method that is already proven at global scales, as it mimics the natural carbon cycle wherein alkaline rocks and water react with excess CO_2 over tens of thousands of years to globally moderate atmospheric CO_2. This speaks to the inherent safety of the process.
    - OAE helps counter ocean acidification and rebalance ocean chemistry, de-stressing ocean biology.

    - OAE quality is one of the highest available. Durability is up to 100,000 years, risk of reversal is essentially zero, additionality is typically 100% and leakage 0%, uncertainty is low and rapidly declining, and the potential scale is perhaps the largest of any pathway (The State of CDR indicates a potential annual scale of 100Gt).
    - Cost estimates for OAE are consistently one of the lowest per tonne for sequestered CO_2.

Question 4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders?

One of the key roles the federal government can take is to lead the national discussion on CDR generally and specifically on mCDR. This includes the following

- mCDR can become a very large economic opportunity. The US can play a worldwide leadership role and secure the economic gains of that leadership.
- The importance of a wide portfolio approach to CDR, avoiding a large reliance on any specific pathway or set of pathways, such as land-based CDR which is limited by the demands already in place on land in supplying food, fuel, water, housing and transportation.
- All CDR activities will require testing, and mCDR is no exception. There should be federal assurances that mCDR will be deployed at large scale only in circumstances where it is safe and effective.

Question 5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of?

- A nice overview of current US/International mCDR efforts, including entities, projects and funding, and recommendations for the US government moving forward was recently published by the Carbon to Sea Initiative (here). However, we view the proposed federal investment in mCDR in that report of "at least $100M" in the preceding report as woefully inadequate given:
    - the nation's urgent need to expand CDR potential, and
    - the larger mCDR funding recommendations given by the National Academy of Science and Medicine (here) and the Energy Futures Initiative (here).
- The Carbon to Sea Initiative and Ocean Visions are both actively advancing mCDR pathways. The Ocean Frontier Institute through Transforming Climate Action is advancing the science of mCDR through the application of more than $400m in funding from a combination of the Canadian federal government and commercial entities. The Carbon Business Council and the Carbon Removal Alliance each represent the carbon removal industry generally and have subgroups dedicated to advancing marine carbon removal.

- Examples of private, academic, and commercial partnerships that can be used as models include: NOAA, University of Maryland (UCMCES), Planetary, University of Delaware, and the Hampton Roads Sanitation District are working together to test alkalinity addition in Virginia. Carbon to Sea, Dalhousie University, and Planetary are working to test alkalinity addition in Halifax, Nova Scotia. Each partnership has already developed substantial knowledge and will continue to advance the mCDR field.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?"

- The federal government, in addition to regulation and funding, has an opportunity to encourage a fuller understanding of mCDR and the inclusion of mCDR into the suite of pathways to address climate change. Currently, "ocean dumping" or "geoengineering" are frequently the context of discussions regarding mCDR. The reality is that these pathways all seek to restore and heal the ocean, which is continually under attack from the same forces that are causing climate change.
- Speed is of the essence. We ask the Federal Government to consider the UNFCCC statement regarding the precautionary principle: "The Parties should take precautionary measures to anticipate, prevent, or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures..."
- A national plan to quickly, comprehensively, and fairly encourage, evaluate and advance mCDR RD&D is required to preserve and advance the wellbeing and national security of the country via effective CO_2 management.

We appreciate the efforts that you are taking, and we applaud the National Science Foundation (NSF), the White House National Science and Technology Council (NSTC) and the Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC) for leading. This request for information serves as an excellent start, and with rapid next steps can catalyze hopeful, effective, and responsible action.

Planetary stands ready to share our knowledge and expertise to advance mCDR.

Thank you,

Pete Chargin

Pete Chargin
VP Commercialization and Community Engagement
Planetary Technologies Inc.

From: Daniel Carstens (b) (6) [redacted] >
Sent: Tuesday, April 23, 2024 2:43 PM
To: Light, Tricia M. EOP/OSTP
Cc: Daniel Carstens
Subject: [EXTERNAL] MARINE CARBON DIOXIDE REMOVAL RESEARCH PLAN
Attachments: Dcarbo culture Nation Science Foundationocument1.docx

I am submitting this as an individual who has been working on this subject. Not as a company.

MARINE CARBON DIOXIDE REMOVAL RESEARCH PLAN QUESTIONS

DANIEL KAI CARSTENS
(b) (6)
(b) (6)

4/21/2024

Introduction. My background is in Ocean Engineering with a degree from Florida Atlantic University in 1969. I have spent my career since then working on ocean construction projects such as deep-sea oil pipelines and designing the construction equipment to install these pipelines as well as designing the trenching equipment to lower the pipelines, power cables and fiber optic cables into the seabed. I have worked all over the world including the major rivers of Indonesia and New Guinea and work in Prudhoe Bay Alaska. Even one year in Iraq getting their oil and water pipeline system working.

From my time in University, I have been interested in the Idea of log falls and what happens when large volumes of woody material sink to the deep ocean floor. We did not know this 55 years ago and have not advanced since then. There just was no way to make a living doing anything like this. Times seem to have changed and I am trying to make my mark on saving the world for my family and have been working on several carbon sequestering plans with the goal of one million tons of CO_2 sequestered. I have spent a couple of years developing ways to get materials negatively buoyant before putting them in the ocean. The biggest problem with working in the ocean is it is very expensive and will beat you down. I had a professor in mechanical design in the ocean who had the rule that any machine designed to work in the ocean should have no moving parts to break or seize. Every moving part is a severe compromise to a good design and how true this is.

I have spent a lot of time over the past few years trying to find the best way to sequester Carbon (CO_2) into the deep ocean as I thought I could best use my knowledge and experience. In that time, I have developed several plans that I am confident could sequester a million tons of CO_2 over several years and the supply of materials now and into the future are there. There is nothing to be developed that does not exist near my material supply.

I had read up on deep sea dumping and believe I have all the problems and costs covered.

Then I looked what I needed to get to deposit any material in the deep ocean seabed. To be safe I assumed I would need to go down 3,000 meters to know that the material would just sit there for 1000 years or if it broke down, any CO_2 given off would not rise to the surface in 1000 years. The Science literature seems to confirm this. I even thought I could put a couple of hundred thousand dollars in this and check out my method and make money or break even, while saving the world. Amazing how naïve I could be.

Question #1

This is the thimg that must be streamlined in the permit process.

Then came the realization of what it takes to get a permit from the EPA. I found it will probably cost several million dollars to do surveys to pick an offshore dump site and then a second seabed survey to find out where the first load of material I dropped has landed. EPA requirement. This is just for one drop of material, and they want that to be as small as possible. Then assuming I get a permit to continue, I must make another seabed and water column survey to see what has happened in one year time. I would expect nothing but if critters like this woody material, then

great. Nothing is going to rise from this depth. With all this money spent, I have no idea if I'll be shut down if I can't find the dime size pieces on the seabed or under what conditions that they would say I am doing damage to the environment, and I have no power at all. The background of the EPA and Ocean dumping has been to try to refuse any material proposed, as up until this carbon sequestering concept, any company that wants to dump something in the ocean is trying to get rid of some awful material such as toxic chemicals. I understand this.
They have no idea that anyone wants to help the earth. It takes a lot to make this mind change.

To sum it up this made it impossible to go further. I also note that nowhere in your set of questions is it suggested that the only real challenge or route to mCDR dumping material in the sea is an EPA permit.

What I would like to see in any government sponsored mCDR is for there to be a clear definition of what would be necessary to get a ocean dump site and how you could choose one and what the expected costs would be for all the oceanography data and bottom seabed survey at the depth of the Titanic over a area of about 20 to 25 square miles as that is the probable size of site needed at this depth for the material to be dropped in the middle and still be on the site.
Then what are the chances there is something on the site you pick that negates that site and you start all over. This can take years with no clear Idea you can do it before going broke or if you are fortunate to have investors, they just say give it up.

On the positive side there should be some science group to evaluate what type of mCDR plan a company has, does it make sense and should the government be interested in making it work. This should happen before an EPA permit is applied for and could save a lot of grief. There should also be a request for ideas from the public on what could be done. I can't think of a better school science project for the whole country at this time. Get the public involved through their children. 500,000,000 minds should come up with many unique solutions and some funny ones,

I would like the mCDR plan to have some way for someone like me that could put together different carbon sequester plans that can operate at a large scale now and into the future , has an efficiency of over 98%, Requires no research into new technology and can be started working at five thousand tons of CO_2/month and the material is as inert as you could possibly find. I am afraid that I am looking at the script for another great film that would be even scarier and real than Don't Look Up. It would be DON'T LOOK DOWN.
I recently read a paper on how to sequester corn stoves in the deep ocean in the Gulf of Mexico that was written in 2009. Here we are fifteen years later and not one single CO_2 sequestering project is in operation or even close to it. I have found out why.

The ideal mCDR system would have the EPA find sites for possible material sequestering and do the surveys and data collection. They have the most data on the oceans I would expect. Then the companies come to the EPA to give them a site to fit their needs. The sequestering companies are not oceanographers and are working on how to dispose of CO_2 in the ocean. They should not have to spend millions of dollars to do seabed surveys to just find where the material has landed without getting anything else from the amount of money spent. This work requires a full-scale test of a sequestering system for at least a year and then go find the material after there is enough on the ocean floor and find and sample bags of material that were dropped with each dump could be recovered for any testing the EPA believes would tell them if some damage to the seabed was

being done and what benefits. Then we would have some real data on how cellulose and lignum materials react on the deep ocean floor and this would advance other sequestering systems.
The EPA should do the surveys with ocean research firms to get the most knowledge out of the surveys. The company can then continue getting carbon dioxide out of the atmosphere which is what they were set up to do. A million tons of CO_2 removed from the Central Valley of California would have an impact on the air pollution there, which is severe, and much of it caused by the burning of crop residues to just get rid of them. This is a perfect combination of available material, deep ocean availability nearby and an area that needs air pollution cleanup. The problems of CO_2 are not going to be solved with small scale tests of materials in aquariums or test tubes. If there could be any side effects. We need to find out now and not later. Why should many companies be looking at deep ocean carbon sequestering if there is a flaw in the outcome. Make a full-scale test for 6 months to a year and get the issue settled or fix it. I hear the word fire but I don't see the fire truck. Just the words fire, fire, fire!!! The American needs to know this is going to be solved with **low** as well as high technology. It would make them feel better and have more confidence in the country. A little human Psychology will go a long way. Get the country involved.

Question #2

My concerns of the present method of getting permits for deep ocean sequestering is that a fortune could be spent and still not have a site to work in, I believe the Federal Government should fully fund the EPA to find sites where this full-scale testing could take place including any oceanographic studies. That's what large research groups such as Woods hole or Monterey Bay could be involved in and if there surveying for sites, do things they feel are important for this work. This will take one to several years out of the time to get started or just go broke trying to do some good. The Federal government should also fund the surveys after one year or whatever into the future if the EPA requires it.
There is limited knowledge on how to get many materials to the seabed. If there is doubt, try it in a dumpster of water. Or give me an email. That's all it takes. Then any organic material will also get heavier as it sinks in the ocean as all pockets of air are compressed by 99 percent on the way to the bottom and the material may also shrink in size from the extreme pressure of 5000 psi at the seabed.
Once a company gets a plan working and making a profit, then the government should start charging a rent on the dump site if necessary to offset survey costs, I see no problem with this once the learning period is done and that is up to the government to decide. This could also be paid as a monthly rate per dump or for a thousand tons of CO_2 or material dumped.

Question 3

The methods to prioritize are the ones that can be done now without a great deal of ongoing research. Go for the low hanging fruit first or in my case, the fallen fruit bits, and pieces. Go for plans that can get rid of 5 to 10 thousand tons per month for the foreseeable future. Not 100 tons in a year. The process should be efficient. I have several that would be over 98% efficient. The system should be repeatable for centuries, and crop residue will always be there. It should sequester the material for 1000 years and putting it in 11,500 ft of water takes care of that. The most important thing is that it should be economical. I have worked it out and should do better than break even. But that is part of testing and research at full scale will provide me. A real-world economical study. I have assumed there will be other costs and that is in the budget. Anything in the ocean will have extra costs. If it is not economical, then I stop or reach out to the government to see if sequestering hundreds of thousands of tons of CO_2 gas is worth a small loss of money is worth helping. I am perfectly confident this will not be my problem, but others plans may. A 6 month to a year full scale operation will answer the economic questions clearly and that is part of the research to be answered and what others could learn from.

Question# 4

I would like to see TV programs on what people and companies are doing to solve the problem. The more people hear, the more they get used to it. Public Broadcasting would be a good start. Aim it at children in school and have schools make them watch them. Make them think how they can do it better or differently. Junior high school through college kids can come up with ideas they can discuss that they can save the earth. For children in grammar school, they can think of ideas, but this is where parents will help them, and they get sucked in on the problem and the learning.

Question #5

The things I am working on are of course what the government should be looking into creating partnerships with. What is a partnership with the Government? Depositing high carbon content materials in large quantities should be a high priority. I would like to find anyone in the government or Science Foundation that would like to talk about this. I did not give details as this is a public document. I have noticed in recent months that deep sea sequestering is even falling out of the methods talked about. Now its soil and chemicals. Good luck getting that done. I Keep it simple. If we could agree on a material, I want to use is OK at least for testing and I had a site to dump it, I could have 5000 tons of CO_2 sequestered in three months with one drop assuming a little time to get it all together and finalize contracts. (Included in three months} Then one load of approximately 5,000 metric tons of C02 per month until it is decided to work this at full scale, and this could go to 10,000 tons or much more, crops permitting! It may take three months to put all material contracts together so it would be great right now in the spring to get started. There is also the rest of the world that grows food. Don't just say well it could be next year.

Question #6

This may be a repeat of things above, but the Government must make it easier for companies to get a permit to deposit carbon material and reduce the cost and time. Companies are being driven to go overseas to get a friendlier reception and something done and this should not happen. The acceptance that something must be done now has been accepted from your paper. The government should now fund the EPA to survey sites near all large harbors of the USA where dredging occurs as this will provide the barges necessary to do the work. San Francisco is probably the most important as it is very close to the central valley farmland and to very deep water. Please investigate this. Dowa the Government have any large bottom opening barges in San Francisco. (Just asking) I would suggest the NSF have a few people investigate how to get a dump permit from the EPA and prepare a financial spread sheet on the costs and expected time to get it done. Don't get the data but the costs to get it. That should answer one big question on what is needed in a CDR plan. It would also be great if there were people interested in getting this going to talk to us that want to do it.   I have found it very hard to talk to anyone as they want everything in writing. First some general talk and then the sworn testimony. Please make it all simpler to just discuss issues. Are there interested entities to talk to? Is the anyone at the NSF that would want to discuss a potential ready to operate mCDR.

I am submitting these comments as a private individual interested in doing something good and I would like to see somebody else than oil companies or big corporations moving on this subject. They have the money but no guaranty that it will work better or just look like it. Give the public a chance to get this done right. I would bet a thousand dollars there is nothing that is even close to my proposal. Of course, it is to the winner's favorite charity, and you pick the judges. I have worked and experimented on this a long time, and I would like to just see a mCDR proposal that seems viable. Thank you for an opportunity to contribute and I hope to hear back from somebody. You can email me for the phone number of my Deep Ocean Lab. That's where I sink stuff.

Regards and good luck with your endeavors.

Daniel Kai Carstens

From: (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 2:09 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: mCDR Research Plan_Comment_BigelowLaboratory.pdf

To Whom It May Concern,

On behalf of the Bigelow Laboratory for Ocean Sciences in Maine, I write to provide comments on the Marine Carbon Dioxide Removal Research Plan, as requested in Document 89 FR 13755. Thank you for inviting public input on this important topic. If our organization can be of further assistance, please let us know.

Kind regards,
Beth

Dr. Beth N. Orcutt she/her
Vice President for Research
Senior Research Scientist
Bigelow Laboratory for Ocean Sciences

Also:
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Dr. Beth N. Orcutt (she/her)

Vice President for Research

(b) (6)

23 April 2024

RE: Input on Marine Carbon Dioxide Removal Research Plan citation 89 FR 13755 document number 2024-03758

To Whom It May Concern,

Thank you for inviting input – on behalf of the Marine Carbon Dioxide Removal Fast-Track Action Committee – on the development of an implementation plan to advance marine carbon dioxide removal (mCDR) research as part of the Ocean Climate Action Plan (OCAP). We understand that the intent is to establish a comprehensive Federal mCDR research program; to clarify permitting, regulatory, standards and policies, and guidelines for mCDR research; and to establish a mCDR initiative to enable public-private partnerships and mechanisms to strengthen interagency coordination, public awareness, and engagement.

As a Maine-based non-profit research organization focused on studying the foundation of global ocean health and unlocking its potential to improve the future for all life on the planet, implementation of mCDR research is a topic that the Bigelow Laboratory for Ocean Sciences cares deeply about. Below, we offer our perspective on the specific questions asked in the request for information. For awareness, we also previously provided input to OSTP on development of the OCAP about how our research aligns with critically important ocean climate action.

1. How would a Marine CDR Plan affect you, your organization, or your community?

Researchers at Bigelow Laboratory have been studying the marine carbon cycle for decades, primarily through basic research funded by National Science Foundation's Division of Ocean Sciences and NASA's Ocean Carbon and Biogeochemistry programs. Despite this history of research at Bigelow and other organizations, understanding of the carbon cycle still has key knowledge gaps which are essential to close to enable a new industry of mCDR strategies, to ensure verification of carbon flows. For example, the role of non-photosynthetic light harvesters, viruses and other key members of marine ecosystems in controlling carbon cycling in the upper ocean is still poorly known. There are also key technological obstacles in being able to effectively monitor the carbon cycle at baseline, as well as for detecting changes in marine ecosystems that might indicate that harm to ecosystem services is occuring. A federal mCDR research plan would allow interagency coordination and collaboration to address these knowledge and technology gaps. Our researchers stand ready to assist in these efforts.

2. What questions or concerns do you have about the ***regulation*** *of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to* *support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*

Concerns:

First, we believe the federal government needs to play a central role in supporting and guiding mCDR research. In the absence of such a role, the vacuum will be filled by a mixture of for-profit and philanthropic funders and researchers. We expect such actors will be less likely to adhere to federal data availability and transparency practices that are critical to ensuring trust in, and therefore value of, the resulting data. Furthermore, the federal government needs to play an active role in defining monitoring, reporting and verification requirements as well as environmental impact assessments requirements, and how such data are made transparent to allow for independent assessment and public understanding. Society needs to have proof that mCDR strategies are actually working to remove CO_2 from the atmosphere – and what the side effects are – which requires robust monitoring, reporting, and verification and EIAs.

Second, we believe that each mCDR strategy needs its own research and permitting framework (and interagency points of contact) – instead of a one-size-fits-all approach for all mCDR strategies – as each would have unique impacts on ecosystem dynamics and overlap with existing regulatory frameworks. For example, farmed seaweed growth may impact the coastal zone and is heavily regulated by state and federal agencies, with strict guidance for any deposition nearshore. But its purposeful deposition of biomass en masse offshore will impact the deep sea, with less transparent sets of laws pertaining to theselocations beyond the EEZ, and with a very different ecosystem. By contrast, ocean iron fertilization will impact upper offshore ocean and mid-water marine food webs, and will be subject to laws pertaining to the offshore environment and/or areas beyond national jurisdiction. Given the complexity and depth of knowledge needed to understand and regulate each of the different mCDR strategies, they should be treated separately.

Third, this is a rapidly evolving field, so it is important that federally mandated regulatory tools (for example, geopolitical and offset-based carbon accounting protocols and assessments) keep apace with development, changing as our knowledge base grows and new tools are available.

Finally, regulation of this industry should take an adaptive management approach, where actions are guided and adapted as new information becomes available.

Additional knowledge needed to inform readiness:

First, we believe that efficacy and safety assurance will require comprehensive baseline knowledge on marine biogeochemistry, the food web, biodiversity and connectivity, and ecosystem services throughout the water column and to the seabed, not just in the ocean surface. We highlight that understanding biodiversity and connectivity is not trivial as there are still major knowledge gaps about biotic interactions in the ocean, such as the role of non-photosynthetic light harvesting, viral infections, and other microbial processes that dominate the marine carbon cycle. Baselines will require assessments of seasonal and annual variability of marine biogeochemistry, the food web, biodiversity, and ecosystem services to have sufficient knowledge prior to pilot testing of impacts. We would like to emphasize that mCDR strategies to increase CO2 uptake from the atmosphere by the oceans will also likely impact other climate-relevant gasses, yet this aspect has not received much attention.

Second, we believe that additional knowledge is needed from pilot studies of mCDR strategies, including monitoring the impacts of pilot tests. We note that the spatial scale required for pilot studies is highly variable between CDR strategies: ocean iron fertilization studies will require thousands to tens of thousands of square kilometers, whereas seaweed blue carbon pilot studies could be done on the order of hectares to hundreds of square kilometers, and ocean alkalinity enhancement pilot test spatial scale is probably somewhere in between. Such pilot data is urgently needed to inform models and decision-making as well as to test monitoring, reporting, and verification methods. Models need to be scaled to examine impacts to geologically relevant timescales of carbon removal (1000+ years), not just 100 year removal horizons. Importantly, there also needs to be an open and transparent process for expert and other stakeholder input into defining environmental goals and objectives for setting permissible levels of harm from impacts, and for determining the indicators required to assess for harm in environmental impact assessments.

Developing such baselines and analyzing impacts will require amplification of the federal oceanographic research portfolio to a scale not witnessed before, requiring more ships and observatories at a time when the federal oceanographic fleet is diminishing, and more research funding at a time when oceanographic funding has flat-lined. Moreover, there is an urgent need for more easily deployable autonomous sensors for measuring key variables to monitor not only baselines but also the monitoring required for mCDR verification.

Finally, we believe that social science research is needed about societal understanding and perceptions of mCDR potential and risks. In particular, research in this aspect is needed also in an international context and in co-production with international partners, especially from developing countries, since most CDR strategies will impact the global ocean and economic development for developing countries.

Tools needed from the federal government:

Co-production of knowledge with communities who will be directly or indirectly impacted by environmental manipulations is necessary to ensure environmental justice in decision making. It will require more targeted federal funding for outreach efforts and engagement with stakeholder groups, to provide education on the opportunities and limitations of various MRV tools and how to evaluate the validity of varied carbon accounting approaches. The federal government could provide toolkits to help researchers and mCDR proponents to connect with communities for this purpose, to ensure that researchers take into account ethical implications of the studies. For example, if a mCDR strategy is found to be effective at carbon removal but has a negative impact on a community that has historically not contributed to carbon emissions, should this carbon removal solution be advanced, and/or should the community be compensated for the impact?

The federal government also has a key role to play in defining how much baseline information is necessary for decision making, and also in defining how uncertainty is addressed in decision making.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Our primary recommendation is that federal funding for major mCDR infrastructure projects – and federal regulation of an emerging mCDR industry – needs to be guided by field-based scientific data about both scalability balanced against relatively low capital requirements and impacts of the various proposed technologies, with proven monitoring, reporting and verification methods to confirm CDR efficacy.

For comparison, looking at the land-based CDR strategy of direct air capture combined with subsurface sequestration as carbonates in basalt aquifers reveals that it costs \$10-15MM to build a plant that can sequester 4,000 tonnes of CO_2[1]. Scaling this current tech to achieve 1 gigatonne of CO_2 removal would require 250,000 plants and \$2.5 trillion dollars. While costs will inevitably drop, is it right to invest such a scale of public funds into such capital-intensive infrastructure?

Based on currently available science, we believe the mCDR strategy with the best chance of high-efficacy, low-capital, low-impact scalability is ocean alkalinity enhancement through mineral supplement (OAE), although we caution that much more research is needed to have certainty about this. Research from small scale, short term studies suggests that impacts of OAE on ecosystems may be limited[2], although there are key knowledge gaps at longer timescales, larger spatial scales, and at a diversity of latitudes. While ocean iron fertilization (OIF) may be

[1] https://www.theguardian.com/environment/2021/sep/09/worlds-biggest-plant-to-turn-carbon-dioxide-into-rock-opens-in-iceland-orca

[2] Peer-reviewed publications demonstrating resilience of phytoplankton communities to OAE: https://www.science.org/doi/10.1126/sciadv.adg6066; https://egusphere.copernicus.org/preprints/2024/egusphere-2024-847/;

low-capital to implement at scale[3], modeling information suggests impacts from OIF may be higher and efficacy may be low[4]. More field research and pilot scale studies are needed to calibrate the costs, impacts, and efficacy for OAE and OIF, as well as for large-scale coastal blue carbon initiatives and OAE through electrochemical approaches, though these latter approaches will likely be modest and regional.

While the scale of current practices of seaweed-farming and associated passive sequestration from naturally deposited detritus is quite small[5], the practice generates jobs and revenue and offers a diversification strategy for working waterfront communities that are experiencing lower and lower yields from wild-capture fisheries and requires relatively little initial investment. This is the only proposed mCDR strategy to do so. It also offers current avenues (i.e., the lease permit application process) for local stakeholders to engage with the review of the intent to employ an mCDR strategy, and to learn, first hand how MRV tools are applied. Because pilot studies can be applied at a small scale (for example, the average size of a seaweed farm in Maine is only 4 acres) where environmental impact assessments are often already in place, it is the easiest among the mCDR strategies to establish testing protocols and procedures.

In parallel to prioritizing field studies to generate data suitable for testing efficacy, impact, and scalability, the federal government should also prioritize research into detailed, data-driven life cycle assessment (LCA) research on these leading, scalable approaches. Research prioritization into scalable observatory methods for monitoring, reporting, and verification are also needed.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Information on efficacy and risks and side-effects are most important at this time for the public, as well as education on the current standards for carbon accounting and how they differ across geopolitical systems and off-set markets, since not all carbon credits are equal. Costs will shift if/as adoption is pursued, so information about costs is of less concern at this time, but data quality should impact carbon value - both socially and economically.

The public will also be looking to the Federal government to explain what kinds of mCDR technologies are already being deployed, even experimentally, and how those technologies are being monitored, reported, and verified. In essence, maps and tracking of what mCDR is already happening in "our backyards" and how it is being held to account.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal

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[3] https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2023EF003732
[4] https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.16854
[5] https://doi.org/10.1101/2023.01.02.522332

Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

The ExOIS group (oceaniron.org) is pursuing large-scale OIF research in the North Pacific Ocean. The group has adopted a responsible research statement and commits to transparency and data best-practices.

We believe that for-profit entities pursuing mCDR should be required to at least partner with non-profit/academic NGO's to reduce concerns about objectivity, and be held to data transparency standards regarding monitoring, reporting, and verification.

There are several small-scale privately funded mCDR research programs and start-up companies scattered across the US set to explore the utility of seaweed farming as a carbon removal strategy. The opportunity for more cohesive public-private partnerships that collate, at a minimum, the metadata information gathered at each of these efforts into a publicly accessible database, may illustrate the extent to which these efforts are underway. At best, it may illustrate where there are consistencies and disparities in approach and results. Further, offsetting and insetting "projects" using mCDR strategies (namely blue carbon from submerged aquatic vegetation) are beginning to emerge at entities like Gold Standard and Verra, often located outside of the US. These may also provide critical insight to approved methodologies elsewhere that US-based projects may decide to adopt or adapt.

Thank you for requesting information on the mCDR research plan. If our scientists can be of assistance, please do not hesitate to call upon us.

Sincerely,

Beth N. Orcutt

Beth N. Orcutt, PhD

Vice President for Research

From: Kristen Yarincik (b) (6)
Sent: Tuesday, April 23, 2024 12:36 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: IA_Response to mCDR Research Plan RFI_23Apr2024.docx

Thank you for the opportunity to provide input to the mCDR Research Plan. Attached please find a response from the IOOS Association.

Best,
Kristen

Kristen Yarincik (she/her)
Executive Director
IOOS Association
(b) (6)
(b) (6)

Request for Information: Marine Carbon Dioxide Removal Research Plan
Document Number: 2024-03758
Submitted by the IOOS Association
Contact: Kristen Yarincik, Executive Director, (b) (6) [redacted]

Thank you for the opportunity to provide information to inform the development of a national marine carbon dioxide removal (CDR) research plan. The IOOS Association is a nonprofit organization that supports and advances the U.S. Integrated Ocean Observing System (U.S. IOOS) and its mission to deliver sustained quality and timely information about our ocean, coasts, and Great Lakes that supports decision making related to climate and coastal resilience, ecosystem health, resource management, and more. The IOOS Association works with the 11 regional coastal observing systems (Regional Associations) of IOOS to support a national network of ocean and coastal observations through cross-program communication and collaboration. IOOS is a program that supports the missions of 17 federal agencies, making it an ideal system for coordinating coastal and Great Lakes data needs across the government. Additionally, the Regional Associations, positioned around the nation's coasts and Great Lakes, engage with local and regional stakeholders and communities, including Indigenous communities, Tribes, and other underserved groups, to understand their needs and to co-develop regional observing activities, data products, and services.

Our response addresses the following questions in an integrated way:

- *What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*
- *What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?*
- *What factors should the Federal Government take into account when considering potential partnerships between…entities and the Federal Government?*

Observing data and ocean models are critical, cross-cutting components of the Ocean Climate Action Plan and should be central to an mCDR research plan, regardless of the CDR approaches being advanced through the research. The National Academies' research strategy[1] for ocean-based CDR called for developing needed observing data and infrastructure capacity based on existing regional, national, and global observing systems. The IOOS system has the benefit of supporting both long time-series and real-time data at nested scales from regional to national. The mCDR research plan should outline the real-time and long-term observing data needed for modeling and understanding the efficacy and environmental impacts of a given mCDR approach and should consider how IOOS can be leveraged to meet these needs. For example, the IOOS Regional Associations can provide the following observational capabilities, considered necessary for mCDR research, development, and scaling[2]:

- Infrastructure (physical platforms and data management infrastructure) that can be leveraged for new data collection, integration, and accessibility;
- Long-term data for evaluating potential mCDR sites; and
- Environmental baseline data against which to measure change and for monitoring environmental conditions as field research and experimentation advances.

The IOOS regions currently collect and serve physical, biogeochemical, and biological data, including observation of marine life, pH (ocean acidification), and harmful algal blooms. This means that IOOS has existing infrastructure to compare data within and outside of experiment areas and to monitor for positive impacts of mCDR approaches (e.g., reduction of carbon dioxide and ocean acidification) and unanticipated outcomes such as the triggering of harmful algal blooms, displacement of marine organisms, and an alteration of food web structure and trophic interactions[3]. This infrastructure is flexible and can be scaled as needed to specifically support mCDR research. As an example, ecosystem moorings co-locate multiple sensors that collect multidisciplinary measurements from the atmosphere, surface waters, down through the water column that are needed to monitor ecosystem health. Sustaining and expanding the coverage of the network of ecosystem moorings maintained by the IOOS Regional Associations and other organizations would meet many observational needs to monitor the impacts and effectiveness of mCDR approaches. The network of existing moorings can be increased as needed and maximized so that all these assets collect the full suite of possible measurements[4].

Additionally, IOOS is a federally certified, public-private system for integrating data from multiple partners. The IOOS Regional Associations bring established regional partnerships with local experts, users, and stakeholders across sectors that position IOOS well to support observing needs related to mCDR research, development, and implementation. The Regional Associations support Principal Investigators at universities and other types of organizations to implement work that is core to the IOOS mission, as well as related efforts on behalf of NOAA and other

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[1] National Academies of Sciences, Engineering, and Medicine. 2022. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

[2] National Academies. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration.

[3] Cooley, S.R., S. Klinsky, D.R. Morrow, and T. Satterfield. 2023. Sociotechnical Considerations About Ocean Carbon Dioxide Removal. *Annual Review of Marine Science*, 15:41-66. https://doi.org/10.1146/annurev-marine-032122-113850.

[4] IOOS. 2017. National Strategy for a Sustained Network of Coastal Moorings. Available at: https://cdn.ioos.noaa.gov/media/2018/01/NationalStrategyforSustainedNetworkofCoastalMoorings_FINAL.pdf

agencies. The IOOS Regional Associations represent a potential solution to challenges associated with research and observation related collaborations involving multiple agencies and nonfederal partners. A research plan should call for data from mCDR research and experiments to be made accessible through IOOS; the open data policy of IOOS enables transparency and replicability of the science.

As mCDR projects and monitoring, reporting, and verification (MRV) strategies are developed, it is essential to preserve certain climate-quality observing systems to ensure critical climate change time-series remain unaltered and to provide control sites for MRV and related models. We encourage authors of the Plan to consult observing system leads to identify those climate stations intended to serve as control sites to remain unaltered. This aspect needs wider communication to involved parties.

In addition, biogeochemical models capable of predicting local-to-basin scale changes to the carbonate systems over days-to-decades (and longer) are critical to designing effective mCDR experiments and to conduct MRV. The IOOS Regional Associations and their partners lead the development, assessment, and delivery of biogeochemical models capable of scaling for evaluation of mCDR efficacy and strategies. These regional models include but are not limited to:

- the NANOOS LiveOcean model;
- the CeNCOOS North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO) and developing ocean acidification observing system optimization assessment;
- the MARACOOS-supported Chesapeake Bay Environmental Forecast System (CBEFS), developed by the Virginia Institute of Marine Science and located on the MARACOOS OceansMap Chesapeake Bay Portal;
- SCCOOS investment in ROMS nearshore physics realizations and coupling to the Biogeochemical Elemental Cycling (BEC) ecosystem model;
- the SECOORA-supported Coupled Northwest Atlantic Prediction System (CNAPS) developed by North Carolina State University, which provides near real-time nowcast / forecast for regional-scale marine environmental conditions including marine biogeochemistry and daily output of key state variables (e.g., NO_3, chl a, DIC, pCO_2, DO).

A suite of operational, ecological forecasting models are supported by these model frameworks and offer a unique opportunity to evaluate observational impacts with respect to ocean acidification (J-SCOPE and NEMURO), harmful algal blooms (C-HARM), and populations of sensitive fish, reptile, and marine mammal species (EcoCast). These existing models provide a range of possible platforms for experimentation concerning mCDR MRV as well as inform optimal location, timing, and duration of mCDR activities to limit risks and unintended consequences.

For over a decade, IOOS Regional Associations and the NOAA Ocean Acidification Program have supported a national network of regional Coastal Acidification Networks (CANs) to build public knowledge of the regional drivers and impacts of coastal and ocean acidification, coordinate stakeholder needs, and facilitate action through connections to scientists and policymakers[5,6]. The national network is composed of six operational CANs, all executed by IOOS RAs, with membership from academia, industry, and both governmental and non-governmental organizations. The CANs provide a communication infrastructure to coordinate these diverse partners and equip regions with the tools needed to prepare for and adapt to ocean climate change. CANs offer a unique and valuable tool to communicate climate solutions, risks, and opportunities to often excluded and frontline groups, including industry.

Finally, the IOOS Regional Associations regularly engage and have trusted relationships with local stakeholders and rights holders, including Tribes, Indigenous Communities, and others who rely on ocean resources and ecosystem services. These audiences will have questions and concerns regarding mCDR and its impacts on ecosystems that can be addressed with transparent data that is publicly accessible within systems they are accustomed to working within.

In summary, IOOS is an existing system that can support observational data for research and development of mCDR techniques, both in terms of data for efficacy and impact studies, in a nested local-to-national scale infrastructure. The existing capacity of IOOS can be leveraged to meet the specific needs of mCDR research for observation, data management, stakeholder engagement, and partnership building and collaboration.

Thank you for considering our input to the development of a national mCDR research plan.

Sincerely,

Kristen Yarincik, Executive Director

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[5] Cross J.N., J.A. Turner, S.R. Cooley, J.A. Newton, K. Azetsu-Scott, R.C. Chambers, D. Dugan, K. Goldsmith, H. Gurney-Smith, A.R. Harper, E.B. Jewett, D. Joy, T. King, T. Klinger, M. Kurz, J. Morrison, J. Motyka, E.H. Ombres, G. Saba, E.L. Silva, E. Smits, J. Vreeland-Dawson, and L. Wickes. 2019. Building the Knowledge-to-Action Pipeline in North America: Connecting Ocean Acidification Research and Actionable Decision Support. *Frontiers in Marine Science* 6:356. https://doi.org/10.3389/fmars.2019.00356

[6] Alin, S.R., R.E. Brainard, N.N. Price, J.A. Newton, A. Cohen, W.T. Peterson, E.H. DeCarlo, E.H. Shadwick, S. Noakes, and N. Bednaršek. 2015. Characterizing the natural system: Toward sustained, integrated coastal ocean acidification observing networks to facilitate resource management and decision support. *Oceanography* 28(2):92-107, http://dx.doi.org/10.5670/oceanog.2015.34

From: Sophie Gill (b) (6)
Sent: Tuesday, April 23, 2024 12:21 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: mCDR RFI - Isometric.pdf

Hi Tricia,

Please find attached our response to the mCDR FRI for the FTAC. Please let me know if we can answer any clarifying questions or anything else you need from us.

All the best,
Sophie

Dr Sophie Gill
Marine Carbon Removal Lead at Isometric

London, United Kingdom

mCDR RFI

1. How would a Marine CDR Plan affect you, your organization, or your community?
Isometric is a carbon removal registry developing scientifically rigorous MRV protocols underlying the quantification of carbon removal credits. The Marine CDR Plan can:

- Set a roadmap and fund research targeting key uncertainties underlying the quantification of a carbon credit
- Provide guidance on social and environmental safeguards around project development reducing the due diligence required by private actors in deciding which projects to participate in

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Making sure that the London Protocol allows mCDR deployments to go ahead and enables innovation in the space.

(For abiotic mCDR projects)
Guardrails around safe deployments:

- Siting and permitting:
    - Process for stakeholder input
    - Policy tools to ensure environmental justice and protection of marginalized and/or tribal communities
    - Safety thresholds around intervention capacity, such as pH or tonnage thresholds
    - Permitted activity duration
    - Monitoring and data sharing requirements
    - Case studies for permitting, siting and community engagement
- Framework for compliance
    - Violations reporting and public accountability

Project-level/ field testing:

- Sufficient understanding of ecosystem impacts
    - Long term ecological monitoring cannot feasibly lie within a single CDR project's scope of work
    - Resources required: Ship and monitoring assets for time series data collection, biological sampling and ecological surveys to investigate long ecosystem impacts of mCDR interventions.

- Model validation of mCDR interventions to quantify integrated CO_2 uptake
  - Evidence of carbon removal needs to be demonstrated through validated models which gain public trust. There is significant debate within the community on the role of biogeochemical ocean models and measurements for quantifying CO_2 uptake. There has yet to be a demonstration of a biogeochemical model accurately simulating an ocean alkalinity enhancement event.
  - Resources required: design of a field experiment with a large enough perturbation that yields a signal which can be detected by existing sensors, significant assets deployed to measure carbonate chemistry and a dual tracer release study

Additional knowledge requirements:

- Process-based studies on measuring carbon fluxes
  - Air-sea carbon flux in coastal areas
  - Benthic carbon and alkalinity fluxes due to alkalinity enrichment in sediments
- Cross-comparison of mCDR approaches to develop accurate metrics to evaluate efficacy

Additional data requirements:

- Access to field testing sites with significant baseline site characterization
- Regional monitoring (ie. deployment of moorings and buoys) and collocation of monitoring assets in strategic basins where mCDR activities are likely to occur and have higher efficiencies

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

- Abiotic mCDR in coastal areas (e.g. ocean alkalinity enhancement, direct removal of CO_2 from seawater) has the following benefits:
  - Can mitigate pre-existing locally acidic coastal waters
  - Collocation with existing coastal infrastructure
  - Proximity to monitoring assets

- Open ocean, biotic CDR (e.g. iron fertilization, macroalgae growing and sinking, sinking of terrestrial biomass in the ocean) does not fit in the same bracket of benefits as these approaches above, due to the fact it can be:
  - Difficult to monitor
  - Difficult to verify

- Accompanied by more ecological risk e.g. potential for creation of oxygen minimum zones

There is a huge amount we can learn from active deployments going on right now; it is in some ways too early to categorically say which approaches should be pursued and which should not; ramping up of trials and commercial deployments coupled with high bars for environmental and social safeguarding are the best way for us to learn more to be able to make these judgements.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

- Biggest challenge we foresee for governments will be moving quickly enough to keep up with the best available science, compared to for example existing registries able to stay agile - leveraging partnerships with existing registries could be a productive avenue here. The ability of the Federal Government to contribute to funding and research on filling knowledge gaps for marine carbon removal, plus perhaps providing high-level standard setting and permitting (i.e. at abiotic/biotic mCDR grouping level) could accelerate the scaling of this sector.
- Most significant marine CDR efforts to be aware of:
    - National labs e.g. LLNL, PNNL
    - Standards efforts underway at NIST
    - Department of Energy mCDR workstreams
    - Isometric (registry) - world's first OAE from coastal outfalls protocol
    - [C]worthy - Focussed Research Organization developing open source modeling tools for MRV
    - Suppliers of marine carbon removal e.g. Planetary Technologies, Ebb Carbon, Equatic, Captura, SeaO2, CarbonBlue, Ephemeral Carbon, Running Tide, PRONOE, Carboniferous, Rewind
    - NOAA mCDR program

- Ensuring that the mCDR industry is decoupled from facilitating an increase in the lifetime of fossil fuel emitting industries, and that a negative emissions technology does not build a dependency on an emitting industry, leading to net positive emissions when considering the full systems boundary

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

- Federal Government plans for procurement of mCDR
- Strategic synergy and partnerships with coastal communities and industries
- Equitable sharing of benefits with local communities

From: David Lawlor (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 12:01 PM
To: Light, Tricia M. EOP/OSTP
Cc: Kevin Travis; Lauren Linsmayer; Anthony Rogers; Liz Whiteman
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan - RFI Response.pdf

Dear Tricia,

Please find attached to this email a PDF constituting the California Ocean Science Trust's response to the RFI issued by the National Science Foundation, on behalf of the White House National Science and Technology Council Marine Carbon Dioxide Removal Fast-Track Action Committee regarding the Marine Carbon Dioxide Removal Research Plan.

If you have any questions about our response or any trouble accessing the attached file, please contact me. Thank you.

Regards,
David
-

David Lawlor (he/him)
Director of Philanthropy
California Ocean Science Trust
(b) (6)
(b) (6) [redacted]

CALIFORNIA
OCEAN SCIENCE TRUST

RFI Response
Marine Carbon Dioxide Removal Research Plan
White House mCDR Fast Track Action Committee (mCDR-FTAC)

Name of Organization Filing Response
California Ocean Science Trust
1017 L Street, #293
Sacramento, CA 95814
(b) (6)
www.oceansciencetrust.org

Questions Being Responded To
1. How would a Marine CDR Plan affect you, your organization, or your community?
2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?
5. What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges?
6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Response
Established by state law, California Ocean Science Trust (OST) has over 20 years of dedicated experience in bringing solution-oriented science to accelerate progress towards a healthy and productive ocean future in California. We bridge the gap between cutting-edge scientific research and sound ocean management by leveraging public and private funding to forge interdisciplinary science partnerships, encouraging science co-production with communities, and building research capacity focused on California's priorities and climate goals.

California is a global leader on climate action and a hub for scientific advancement and technological innovation. The recent increase in public and private investment into marine carbon dioxide removal (mCDR) research has accelerated this burgeoning climate industry in California, which includes some of the first field testing of mCDR technologies in state waters. In response to this accelerated growth, OST has leveraged our independent role to deliver science information to decision-makers and facilitate coordination between industry, academic, and policy communities at state and regional levels to support the science-policy interface.

At the state level in California, we are seeing the need for:

- Strengthened science diplomacy across sectors to identify knowledge gaps, deliver trusted scientific information, and guide decision-making processes.
- Increased academic engagement and support to bolster independent research and encourage multidisciplinary collaborations.
- Informed decision-making to develop a holistic research agenda and explore science-guided policy pathways.

Given the rapid pace of mCDR development and the need for transparent and responsible research to inform decision-making processes at state, regional, and federal scales, OST recommends that the Marine CDR Plan lead to identified opportunities and mechanisms for increased state and federal coordination. As a state-mandated science entity, we encourage state-federal alignment on the development of a mCDR research plan, including science-based guidance necessary to inform decisions on policy, permitting, regulation, and standards.

Responsible advancement of ocean-based climate mitigation, such as mCDR, will require sustained coordination between scientific and management communities to safeguard environments and coastal communities, while supporting the development of effective and durable strategies. California Ocean Science Trust is positioned to leverage our role as a trusted and effective translator, convener, and leader to responsibly advance mCDR research, align state-federal action, and inform science-based decision-making in California.

From:	Lindsay Gardner (b) (6) [redacted]
Sent:	Tuesday, April 23, 2024 9:27 AM
To:	Light, Tricia M. EOP/OSTP
Cc:	Jessie Ritter
Subject:	[EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments:	MCDR FTAC RFI_NWF Comments Ultimate April 23 2024.pdf

Dear Ms. Light,

The National Wildlife Federation greatly appreciates an opportunity to submit the attached comments in response to the MCDR-FTAC RFI on the Marine Carbon Dioxide Removal Research Plan.

Please let me know if you have any questions or concerns. Thank you.

Sincerely,
Lindsay Gardner

NATIONAL WILDLIFE FEDERATION™

Lindsay Gardner
Director, Marine Conservation
National Wildlife Federation
(b) (6) [redacted]
www.nwf.org
Uniting all Americans to ensure wildlife thrive in a rapidly changing world

NWF.ORG

April 23, 2024

Re: Marine Carbon Dioxide Removal Research Plan RFI, National Wildlife Federation Comments

Submitted via email to: (b) (6)

Dear Ms. Light:

The National Wildlife Federation (NWF) strongly supports the effort to develop a marine carbon dioxide removal (mCDR) research and implementation plan to advance a key recommendation of the Ocean Climate Action Plan (OCAP). We are pleased to submit the following comments in response to the recently-issued Request for Information (RFI) led by National Science Foundation on behalf of the White House and Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC). The Intergovernmental Panel on Climate Change (IPCC) attested that there needs to be deep, rapid escalation in carbon dioxide removal to limit warming to 1.5 degree Celsius above pre-industrial levels.[1] In the United States, the need to address climate change and carbon dioxide reduction is undeniably critical, but must be executed in ways that minimizes costs to communities and the ecosystem. As industry, NGOs, philanthropists, and frontline coastal communities evaluate and plan for ocean-based carbon dioxide removal, there is a need for a comprehensive, coordinated approach to ensure safeguards and address knowledge gaps, including incorporation of Tribal and Indigenous knowledge, while advancing understanding and the needed science. This should include development of monitoring, reporting, and verification (MRV) standards to inform field trials, prior to any potential upscaling/full-scale deployment. Responsible research and development that is guided by a federal research plan and permitting framework should be a top priority and the FTAC is well-positioned to accomplish this.

The National Wildlife Federation's Perspective on mCDR Research

Today, with over 7 million members and supporters, the National Wildlife Federation is the nation's largest conservation organization. Under our unique Federation model, we have affiliate partners in 52 states and territories. We cannot complete our mission of uniting all Americans to ensure wildlife thrive in a rapidly changing world without addressing threats facing ocean health and marine biodiversity, with climate change supreme among them. Investigating the power of the ocean to address and mitigate climate change is an area that builds on our work and experience in terrestrial carbon removal technologies. While the mCDR technology and pathways are still in the early stages of research and development, NWF has been working to gain an understanding of the efficacy and effects of these technologies, including potential impacts – both positive and negative – of mCDR on ocean and coastal communities, ecosystems, and Tribal and Indigenous people.

We believe that this research must be transparent, informed by best practices and aligned with a shared code of conduct for industry and others working with communities that is inclusive of their interests, science, and perspectives, and acknowledges Free, Prior, and Informed Consent, as field trials move forward. This research must proceed with care and caution, as well as with respect and deference to Tribal and Indigenous knowledge holders, so as to ensure that these approaches are pursued in a way that is protective of and beneficial to the marine environment, its inhabitants, and coastal communities. As the Aspen Institute aptly states in their recently released Code of Conduct, "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

[1] IPCC FAQ Chapter 4 https://www.ipcc.ch/sr15/faq/faq-chapter-4/

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."[2]

<u>The Need for a Comprehensive Marine Carbon Dioxide Research Plan (Questions #1 and #2)</u>
To date, the knowledge base underpinning the full range of mCDR pathways is still quite limited. The development of a comprehensive and coordinated federal research plan is imperative, as the United States works to develop methods and solutions to increase the amount of carbon dioxide that can be safely and responsibly taken up by the ocean and projects are being tested and deployed for field trials.

While NWF does not endorse particular mCDR pathways or approaches at this early stage in the research phase, our initial assessment suggests that both seaweed cultivation and ocean alkalinity enhancement approaches merit further investigation. Currently, gaps surrounding the ecosystem and wildlife impacts of these approaches prevent responsible upscaling and deployment. Federally led research efforts that incorporate Traditional Ecological Knowledge (TEK) where applicable as an integral part of enhanced understanding, will help address existing knowledge gaps about whether and how mCDR approaches such as these and others will work in situ in the ocean, and their associated consequences.

Recommendation:

- To maximize safeguards and benefits to communities and the environment as the FTAC develops its research plan, it should seek to address gaps in understanding regarding ecosystem response, impacts and efficacy, not only through the evaluation of specific individual pilot projects, but also at the cumulative projected impacts of multiple projects to the broader ocean system (at local and regional scales).
- To better understand how mCDR projects might impact ecosystem processes, research plans should examine ocean locations that have naturally occurring fluxes of alkaline material to serve as analogs to mCDR approaches, the resilience of different types of marine ecosystems to alkalinization, the effects on deep sea species of increasing organic matter delivery to the deep ocean, and changes in community composition with various mCDR approaches in different ecosystems, along with potential co-benefits of mCDR, such as increasing local shellfish yields and improving local coral reef health.

<u>Federal Governance and the Policy and Regulatory Framework (Question #2)</u>
It is widely understood that there will be a need to clarify the applicability of existing policies and regulations to mCDR research projects to expedite mCDR research project field trials and best understand technological readiness. It is most important that the regulatory and permitting regime and requirements ensure that there are parameters and safeguards that uphold and are supportive of ecological security and environmental ethics.

Recommendation:

- The NASEM Research Strategy report states, there is "no single, comprehensive legal framework specific to ocean CDR" research.[3] NWF recognizes that many mCDR technologies – given their innovative and untested nature - do not always fit neatly into standard permitting processes. To that end, NWF urges the relevant agencies to utilize their existing authorities and work together cooperatively to swiftly clarify the policy and permitting requirements that apply to different types of mCDR methodologies so that they can be

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[2] A Code of Conduct for Marine Carbon Dioxide Research, 2024 *110223_Code-of-Conduct_FINAL2.pdf
[3] NASEM Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration https://nap.nationalacademies.org/catalog/26278/a-research-strategy-for-ocean-based-carbon-dioxide-removal-and-sequestration

easily understood by permitting authorities at the federal, state and local levels, industry, and frontline communities. This should include clarifying how the National Historic Preservation Act is being considered in instances where historic and cultural areas of significance and features may reside in and under the sea.[4] Where true gaps in permitting authority do exist, those should be identified. Fundamentally, there is also a need to formally define mCDR research projects and their parameters, and how they differ from full-scale deployments.

- Guidance on permitting pathways should not only include information on likely permit types and required consultations for different projects, but also provide directions for potential applicants regarding permitting sequence or other key instructions regarding required information needed for successful and timely permit processing. To help cement interagency coordination and cooperation around processing mCDR research permits beyond the life of the FTAC, we encourage development of an interagency Memorandum of Understanding (MOU)[5] to help avoid future delays or confusion, particularly with the potential for agency staff turnover.

Data Collection and Monitoring, Reporting and Verification (Questions #2, #3 and #4)

In 2021, the National Academies of Science, Engineering and Medicine (NASEM) published the first of its kind Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration[6]. This foundational research agenda addressed benefits, risks, potential scale, and overall viability for ocean CDR and provided an initial framework to start to bridge knowledge gaps. It emphasized that technical feasibility is not enough; that it is crucial to have policy and social support; accounting and verification of carbon dioxide removal; and understanding of co-benefits, environmental and social impacts. As research projects are being deployed in the field, it will be especially important to continue to initially support small to medium-sized testing and evaluation of various lower-risk mCDR pathways and projects that can feasibly occur in conjunction with other restoration efforts and carbon removal technologies, such as offshore wind, and increase and expand knowledge and understanding of potential co-benefits and risks.

Recommendations:

- Establish and implement MRV standards that protect the marine environment and coastal communities and that encourage and support transparency of data sharing and timely sharing of research outcomes as data is gathered through public-private research efforts. This could include creation of a database of data from research and trials that can be easily contributed to and accessed by all stakeholders. With this rapidly developing field, researchers must be able to adapt their research and test sites efficiently as new information is available. This tool could help facilitate this.
- Explore the benefits of co-locating mCDR projects with existing infrastructure or deploying it alongside synergistic technologies as coastal communities are being engaged in restoration, protection, and responsible stewardship of nearshore and ocean ecosystems. This could include co-locating algae farms with offshore wind turbines, ocean alkalinity enhancement pilot projects conducted in seaweed and/or shellfish farming communities, or utilizing existing onshore water or port infrastructure, to name a few opportunities.
- It is critical that future Administration budgets, as well as Congressional appropriations, support NOAA's involvement in research in the mCDR space. The Federal funding for research, development, and

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[4] https://www.achp.gov/sites/default/files/policies/2024-03/PolicyStatementonIndigenousKnowledgeandHistoricPreservation21March2024.pdf

[5] Sabin Center For Climate Change Law, Executive Actions to Ensure Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States, Webb and Silverman-Roati, 11-2023

[6] NASEM Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration https://nap.nationalacademies.org/catalog/26278/a-research-strategy-for-ocean-based-carbon-dioxide-removal-and-sequestration

demonstration of CDR approaches and technologies applied on land has increased in the past several years, particularly through Congressionally approved funding to DOE. The FY24 Energy and Water Development bill (House Report 118-126 and Senate Report 118-72) includes funding for DOE to work with federal agency and industry partners on ocean-based carbon dioxide removal technologies. Given NOAA's expertise in the marine space, and the nature of the outstanding questions about mCDR methodologies, it is vitally important that NOAA receive resources to play a leadership role in this research in the future.

Ensuring and Maximizing Community Involvement (Questions #4 and #5)

Effective public-private partnerships that ensure and maximize community involvement are and will continue to be essential to responsible mCDR research and advancement. While there is no singular policy or pathway for success on this front, there are several key recommendations that the FTAC should consider. Codes of conduct and best practices should optimally be developed with the direct involvement of representatives from Tribal and Indigenous interests, and other key stakeholders like commercial and recreational fishing industries, shellfish farmers, and other communities that are on the front lines of proposed projects. Early and meaningful community education and engagement around mCDR research will help to prevent future obstacles by fostering community understanding and trust, and optimizing the valuable perspectives these communities provide in ensuring that mCDR is protective of the environment, fish and wildlife, and public health.

Recommendations:

- Research efforts should be interdisciplinary and include a social science/human dimensions component that embraces best practices and codes of conduct for communicating and working with impacted communities at various stages of the project development project (pre-implementation planning and design phase, during the project implementation phase, and post-construction, during the monitoring and evaluation phase). Research efforts are also an opportunity to engage, collaborate, and develop partnerships intentionally with communities that are most likely to be impacted by mCDR deployment, this might look like:
    - Ongoing collaboration and partnerships with minority-serving educational institutions including:
        - Historically Black Colleges and Universities
        - Hispanic Serving Institutions
        - Tribal Colleges and Universities
        - Asian American and Pacific Islander Serving Institutions
    - Developing robust networks made of scientific societies, Indigenous science networks, and NGOs through which opportunities/information is disseminated.
    - Developing robust networks leveraging city governments, municipalities, local businesses, and workforces as a way to reach minority owned businesses, suppliers, and community members.
    - Offering informational/workshop sessions targeted at the aforementioned communities to guide knowledge-sharing about processes and opportunities.

  Additionally, research and engagement efforts should be used as a vehicle for communities to create the sustainable futures in which they not only survive but thrive, resulting in alignment with both community goals and culture, thus allowing for more effective deployment of technologies and the creation of industries that can be sustained and well-incorporated into the community.
- The FTAC and mCDR research projects should honor Free, Prior, and Informed Consent (FPIC), a human rights principle that recognizes the right of Indigenous peoples to participate in decision-making processes that affect their lives, lands, and resources. Within the context of mCDR projects, FPIC provides an important framework for ensuring that the concerns and perspectives of Indigenous peoples are taken into account when designing and implementing projects. It requires that projects should only proceed with the express consent of the affected Indigenous communities. In the case of Tribal and Indigenous interests, it is

especially important that they have the needed support and capacity to optimally engage. Prioritizing federal funding for this purpose will help support the success of the FTAC's research program implementation. Developers of mCDR projects must engage in a meaningful dialogue with the communities, inform them of the proposed project's details, potential impacts, and benefits, and seek their approval before starting any work and the community's participation in the decision-making process is free from coercion or manipulation.[7] With much mCDR research being done by private industry partners, there must be federal guidance to best equip them with educational materials and fundamental best practices for working with local communities and advise them about the most culturally appropriate, impartial/neutral messengers when sharing knowledge about projects, data, and scientific outcomes, including risks and co-benefits. Additionally, academic organizations and NGOs have significant expertise, capacity, and extensive knowledge and relationships with local communities that can be of tremendous value when industry is seeking to do mCDR research and field trials in particular localities. Likewise, leveraging the expertise of NOAA and other federal agencies in this liaison role will help facilitate the community engagement process and ensure it is as inclusive and beneficial as possible.

- The mCDR research plan and approach should emphasize a key tenant of the Ocean Justice Strategy: "Improve co-stewardship and co-management of public lands and waters with territories, Tribes, Alaska Natives, and Native Hawaiians."[8] Representatives from these communities will be most knowledgeable about on-the-ground local, baseline and historic conditions that are fundamental to understanding of field trial efficacy and can provide valuable insights into the environment and community dynamics at different stages of project design and development.
- Federally funded mCDR grants should require a community engagement component as part of any application. Legally binding community engagement commitments, such as Community Benefits Agreements, which require prior engagement with community members should be encouraged if not required. The FTAC can look to the Department of Energy's requirement for Community Benefits Plans in the DAC Hubs as inspiration for this requirement.

The National Wildlife Federation appreciates an opportunity to provide the aforementioned comments. We strongly encourage the FTAC's research plan to incorporate aspects and measures to maximize protections and transparent communication of potential and identified risks and benefits to communities, while supporting strong data collection and science that will directly influence future project implementation and innovation. In so doing, the FTAC will provide crucial direction and oversight as America investigates the safety and efficacy of mCDR approaches in the years to come. Thank you for your consideration.

Sincerely,

Jessie Ritter

Jessie Ritter
Associate Vice President, Water and Coasts
(b) (6)

Lindsay Gardner

Lindsay Gardner
Director of Marine Conservation
(b) (6)

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[7] Community Impacts, Co-Benefits, and Co-location Opportunities of Marine Carbon Dioxide Removal Approaches, Cerci and Smith, 2023

[8] Ocean Justice Strategy, December 2023 https://www.whitehouse.gov/wp-content/uploads/2023/12/Ocean-Justice-Strategy.pdf?cb=1701982354

From: Julie Pullen (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 7:01 AM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: FTAC Propeller.docx

Please see attached response.
Thank you,
Julie

Dear Members of the Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC),

This letter is in response to the RFI released on 02/23/2024 (89 FR 13755) to inform development of an implementation plan regarding marine carbon dioxide removal (marine CDR) research. I write on behalf of Propeller Ventures, an ocean climate solutions venture fund. I'd like to contribute input on several areas detailed below.

1.How would a Marine CDR Plan affect you, your organization, or your community?

A Marine CDR Plan has the potential to provide clarity and guidance to the broader community about how efforts can be enacted and synergized to best benefit society. In particular, more research funding has the opportunity to significantly advance research and a nascent industry toward the most promising technologies that the investment community can support in a unified way.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

The federal government could be very helpful in telegraphing to the broader public the vital role of CDR in the portfolio of climate action including mitigation and adaptation. Sustained messaging on the research outcomes and criteria/metrics for success in concert with the wider research community (e.g., involving the National Academy of Sciences and non-profits like Ocean Visions and Carbon to Sea, which I work with) would go far to move forward the field and help local communities understand the benefits as well as calibrate their assessment of potential risks.

6. *What else would you like the Federal Government to consider as it develops a Marine CDR Plan?*

Specifically, streamlined ways for the federal government to partner with agility with the philanthropic and investment community would greatly accelerate R&D and commercialization (e.g. - enhanced NOPP processes and activities modeled on the new DoD Office of Strategic Capital and the Intelligence Community's investment vehicle, In-Q-Tel).

Julie Pullen

Partner & Chief Scientist, Propeller Ventures

From: Jill Storey (b) (6) [redacted]
Sent: Monday, April 22, 2024 8:56 PM
To: Light, Tricia M. EOP/OSTP
Cc: Paul Holthus; Tina Liu WOC; Lisa Simone de Grunt - European Affairs Advisor
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: WOC response- FTAC April 24 - PH signature.pdf

Dear Tricia,

The team at the World Ocean Council is delighted to have the opportunity to respond to the RFI of 23 February 2024 to assist with informing the development of a marine carbon dioxide removal research implementation plan.

Please find our response attached and do not hesitate to reach out if we can be of any further assistance.

With kind regards,

Jill

Dear Members of the Marine Carbon Dioxide Removal Fast-Track Action Committee,

We are writing in response to the RFI of 23 February 2024 regarding informing the development of a marine carbon dioxide removal (marine CDR) research implementation plan.

The World Ocean Council ("WOC") – About Us

The WOC is an international organization registered in the US with an expanding network including 35,000+ ocean industry and media stakeholders around the world.

It engages and brings together leaders from the various ocean industries, including shipping, oil and gas, fisheries, aquaculture, tourism, renewable energy (wind, wave, tidal), ports, dredging, cables, carbon dioxide removal technologies, as well as the maritime legal, financial and insurance communities, and others to collaborate on the responsible use of the seas and to to ensure that the Ocean Business Community's role in ocean sustainable development is understood by all the relevant stakeholders (decision makers, policy makers, intergovernmental bodies, etc.).

The WOC has a long history of engaging and convening key stakeholders regarding marine CDR. From 2010 onwards, the WOC focused on outreach to businesses, scientists and policy researchers involved in ocean restoration, negative emission technologies, carbon dioxide removal and blue carbon participating in the Convention on Biodiversity (CBD) re marine CDR. In 2012, the WOC developed the Ocean/Blue Carbon working group concept and from 2015 onwards, the WOC participated in UNFCCC Climate Change COPs.

In 2017, the Ocean/Blue Carbon working group concept document was advanced with interested experts, and in that same year, Ocean/Blue Carbon/NETs were included as a separate session at the WOC's annual Sustainable Ocean Summit (SOS). Also in 2017, WOC co-wrote an op-ed on Ocean CDR: 'Beyond the Horizon'.

In 2018, the WOC participated in the Negative Emissions Conference and held an Ocean/Blue Carbon/NETs event at the SOS. One year later, in 2019, WOC supported the roundtable on Ocean Engineering and contributed to the 'Ocean Climate Geoengineering' Report.

In 2020, the WOC Ocean CDR/Blue Carbon Roundtable commenced, with monthly meetings organized. These continued in 2021 with the founding president and CEO of the WOC being invited to speak on the topic of marine CDR at COP26. In 2022, WOC marine CDR panels were organised at the UN Ocean Conference and the SOS, as well as the WOC's Global Blue Finance Summit (BlueFIN) and a further speaking engagement opportunity accepted at the COP27. In 2023, the WOC was honoured to be announced as one of the partners to the EU Horizon project, "Strategies for the Evaluation and Assessment of Ocean based Carbon Dioxide Removal" and again invited to take up a speaking engagement at COP28.

Background and Context

We are grateful that this RFI has been issued and public input requested to this important area of research.

For several years, the WOC has been hosting roundtable discussions for some of the earliest Marine CDR industry pioneers and innovators in this space.

Whilst this industry is still at an embryonic stage, we have seen interest accelerating in the past 18 months as it becomes clear the marine CDR technologies will be required.

As you will be aware, The European Union's Horizon Europe research and innovation programme has funded the Strategies for the Evaluation and Assessment of Ocean based Carbon Dioxide Removal (SEAO2-CDR) project with research being undertaken by 14 European institutions including the WOC Europe.

Part of the role of the WOC Europe is to continue and accelerate our efforts to set-up a marine CDR industry association and we are in the process of progressing this task.

The WOC is working closely with Ocean Visions and the Carbon Business Council and we would also like to draw your attention to the work being undertaken in this space by both of these organisations, which are each making separate submission to this RFI.

WOC Response to RFI Questions:

Please find our comments to the RFI questions below:

1. *How would a Marine CDR Plan affect you, your organization, or your community?*

   We believe that the issuance of a Marine CDR plan will considerably raise the awareness of Marine CDR as a significant climate mitigation opportunity.

   In our view the US are leading the field in this nascent industry and such a Marine CDR Plan would be a further example of this leadership. The Plan would serve to attract wider attention and act a as catalyst for further investment and interest in this crucial field.

   Advancing the science in a government backed transparent manner will provide confidence that environmental risks are being appropriately managed assisting in developing the social licence to operate.

   McKinsey have highlighted that carbon removals could be a $1.2 trillion industry by 2050. Land based opportunities will be limited, and we are of the opinion that the ocean will have an outsized role to play in this trillion-dollar opportunity provided the potential solutions are advanced in a structure and well governed research led-environment.

   In order to scale this industry and take the public on the journey, it is essential that research funding is accelerated to determine the efficacy of marine CDR pathways as potentially safe and effective climate solutions. It is necessary to understand the ecosystem impacts and assess evidence that the Marine CDR technologies are viable at scale. We expect that the creation of a well-developed Marine CDR research plan will act as a catalyst for investment.

Creating such the Marine CDR plan will highlight opportunities for the wider marine industry and encourage collaboration and engagement from marine sectors which may have the infrastructure available to assist some of the early-stage entities advance their potential solutions.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

A. *What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?*

Questions:

Can the impact of marine CDR be measured to a sufficient degree of accuracy that enables corporations to make plausible commitments?

Does the marine CDR activity generate a measurable reduction in seawater carbon dioxide concentration?

What are the impacts to marine ecosystems of marine CDR activities and are they acceptable when compared with the impacts of the no-action alternative or of other feasible mitigation measures?

How marine CDR can contribute to Nationally Determined Contributions?

Which types of impacts to human populations are acceptable when compared with the impacts of the no-action alternative or of other feasible mitigation measures?

Further questions that require RD&D are outlined in the document created by Ocean Visions: A Comprehensive Program to Prove or Disprove Marine Carbon Dioxide Removal Technologies by 2030.

Concerns:

Ensuring that sufficient care and education is taken in the discussion about marine CDR research such that any real or perceived risks attached to advancing the field are framed as accurately as possible against the consequences of inaction.

The timeframe and complexity involved in obtaining research permits when the urgency of the research is clear.

The need for an outreach program for public engagement and education to advance simultaneously.

B. *What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?*

The Federal Government to provide monitored demonstration sites for mCDR technologies and research to aid transparency and expedite development.

Support for permit seekers to speed up the process and support to the agencies administrating the permits so that they have adequate resources to ensure an efficient and timely process.

Access to infrastructure such as offshore platforms, sensors, ships and monitoring devices and incentives for the owners of such infrastructure to assist in the process of developing and deploying marine CDR.

Identifying and developing several marine CDR 'test sites' in US waters that facilitate marine CDR testing by a range of qualified marine CDR companies, including at least one site in a US island state or territory (which will create significant implications for advancing marine CDR in Small Island Developing States).

C. *What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research?*

Various documents set out known areas for further research including - NASEM report, Ocean Visions macroalgae research framework and the ExOIS Path Forward report.

In addition, tools to assist with permitting, MRV and agreed environmental thresholds that research must not surpass will be of benefit.

D. *What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*

The research agendas set out in various documents including - NASEM report, Ocean Visions macroalgae research framework and the ExOIS Path Forward report – highlight additional knowledge required.

In addition to that already set out, we want to emphasise that additional knowledge of environmental impacts, specifically in the marine environment, for mCDR approaches must be used in life cycle assessments to comprehensively address these technologies from an environmental perspective. Literature analysis indicated that little knowledge is included in current LCA practices.

Knowledge is needed about the role of other ocean industries (e.g. shipping, ports, desalination, offshore renewable energies) and their operations and infrastructure in relation to what will be necessary for any marine CDR approach for full-scale deployment or commercial application.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

The WOC works with members who are working on solutions across a range of potential mCDR pathways and is tech-neutral at this early stage of the mCDR industry.

At this early stage, we are of the view that funding should be allocated to all potential pathways as it is too early to dismiss potential solutions given the scale of the challenge we are facing and research break throughs at any one time may change the attractiveness or otherwise of the different opportunities.

It is envisaged that a portfolio of solutions will ultimately be required.

Within that scope, consideration should be given to prioritizing the techniques and approaches that are most likely to be scaleable and replicable, especially in the context of developing countries with large EEZs and in Small Island Developing States.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

A. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders?

Education about the natural ocean cycles and how some of the approaches being discussed seek to enhance and accelerate these cycles.

Setting out the potential consequences of in action and the risks of doing nothing or delaying action.

Information about the potential risks of undertaking activities and the potential benefits for the community.

Providing estimates of the revenue potential, industry size and job creation opportunities to help engage the business community.

Information about the credibility of the companies developing marine CDR approaches, i.e. their commitment to responsible, science-based, safe, effective and environmentally-sound marine CDR, as well as to transparency, communications and stakeholder engagement.

B. How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Engage with educators and create case studies, where possible using film or video and stories.

Key for the government to start the process early before a potential experiment is announced enabling stakeholders to have helped co-create the experiment and address local and community concerns in the research.

Use some of the early-stage trials to showcase that the US is leading in this field to instil a sense of pride.

Invite and facilitate interaction between the marine CDR companies and other stakeholders, which can be effectively facilitated by working with the industry association being fostered by the WOC.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

The World Ocean Council is the only organization that has been engaging the marine CDR business community, with these efforts beginning in 2012. The WOC then began organizing sessions on marine CDR at the annual Sustainable Ocean Summit (SOS) since 2016, convening the growing number of marine CDR companies in monthly virtual roundtables in 2020-2022, organizing the only marine CDR business panel at UN Ocean Conference in 2022, convening a leadership group of marine CDR companies to develop an industry association since 2023. The WOC has been inviting the investment community to participate in many of the above activities and organizing the first-ever finance session on marine CDR (as part of the Global Blue Finance Summit (BlueFIN) in 2022.

Ocean Visions' new high level road map document titled "A Comprehensive Program to "Prove or Disprove" Marine Carbon Dioxide Removal Technologies by 2030 outlines a comprehensive program to advance the science, technology, and policy priorities needed to rigorously evaluate marine CDR.

The EU funded Strategies for the Evaluation of Ocean-based Carbon dioxide Removal project in which the WOC is participating. As part of this exercise the WOC is continuing its efforts to facilitate the development of a marine CDR Industry Association. https://seao2-cdr.eu

CO2BC The Carbon Business Council published an Issue Brief, developed with a working group of over 20 CO2BC member companies and ecosystem partners, highlighting the critical importance of marine carbon dioxide removal (mCDR) to achieving national and global climate goals.

The Carbon2Sea initiative is a philanthropically funded initiative that has raised over $50M to evaluate whether ocean alkalinity enhancement can safely remove and store billions of tons of CO_2..

The Aspen Institute has developed a code of conduct for mCDR research.

[C] Worthy is building oceanographic modelling tool to ensure safe, effective marine CDR.

Woods Hole Oceanographic Institution is developing a large-scale, full-depth, high-resolution network of advanced technologies to track carbon as it moves between the atmosphere and the ocean called the Ocean Vital Signs Network.

The Sabin Centre for Climate Change Law at Columbia University has outlined a series of recommended actions that federal agencies could take, under existing law, to ensure safe and responsible permitting and regulation of ocean carbon dioxide removal (CDR) research in U.S. waters.

The Ocean Resilience and Climate Alliance is a recently announced philanthropic initiative whose principal intent is to provide a surge of more than $250 million dollars in grants over four years to catalyse work across a handful of immediate ocean-climate priorities, including in marine CDR.

There are several initiatives led by start-ups and accelerators such as Ocean Visions through their Launchpad program and organisations like the Musk Foundation with their XPrize for Carbon Removal.

The German government has funded a project looking at mCDR from a German perspective. https://cdrmare.de/en/

Under the framework of the UN Decade of Ocean Science, there are Centres that address ocean-climate solutions such as the Global-ONCE program, with Xiamen University in China as the lead institution, and the Ocean Visions – UN Decade Collaborative Centre for Ocean-Climate Solutions.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?"

How decisions will be made as to the advancement of promising pathways to scale once further research has been undertaken.

Whether the Federal Government will assist in advancing the market through being an early-stage purchaser and standard setter – verifier.

How funding will be provided / expedited into the research priority areas.

What else can be done to assist with a high integrity system of MRV to provide integrity to the industry by actively fostering and supporting efforts that integrate and create synergies among government, science/academia and industry.

How industry can be engaged where shared infrastructure may assist with the ability to scale rapidly.

How tax and other incentives can be expanded to drive investment such as the expansion of the 45q tax credit. The WOC previously responded to the US Department of the Treasury and the Internal Revenue Service request for public Notice 2022-57- Credit for Carbon dioxide Sequestration.

The immediate focus on public and stakeholder engagement and involvement to help develop the social licence to operate.

Once again, we appreciate the opportunity to submit this input for your consideration. We are very keen to provide assistance and will contribute to further discussions and meetings as requested.

Yours sincerely,

Paul Holthus,
Founding President and CEO, World Ocean Council
paul.holthus@oceancouncil.org

Jill Storey,
Marine Carbon Dioxide Advisor
jill.storey@oceancouncil.org

From: Weina Meng (b) (6) >
Sent: Monday, April 22, 2024 11:35 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan - Final.pdf

Importance: High

Hi Tricia,

I hope this message finds you well. My name is Weina Meng, and I am an Assistant Professor in the Department of Civil, Environmental, and Ocean Engineering at Stevens Institute of Technology. Attached is the draft of the Request for Information (RFI) concerning our Marine Carbon Dioxide Removal Research Plan.

I have selected to respond to the question on technical development, aligning with our department's focus. In this draft, I leverage our collective expertise to propose an innovative approach that integrates marine energy sources with carbon dioxide removal (CDR) methods. The aim of this draft is to gather comments and feedback, and I have included comprehensive background information while emphasizing the potential of marine renewable energy in advancing CDR efforts.

It is my hope that this submission will engage the program manager's interest, encouraging the inclusion of a dedicated track for this theme in the final solicitation.

I look forward to your thoughts and suggestions.

Best regards,

Weina Meng
Assistant Professor
Dept. of Civil, Environmental, and Ocean Engineering
Stevens Institute of Technology
Office number: (b) (6)
Email: (b) (6)
Office: CEOE Rocco 307, Hoboken, NJ 07030
Website: https://web.stevens.edu/facultyprofile/?id=2315

Response to Request for Information (RFI): Marine Carbon Dioxide Removal Research Plan

Submitted by: Weina Meng (b) (6) [redacted]

Affiliation: Department of Civil, Environmental and Ocean Engineering, Stevens Institute of Technology, 1 Castle Point Terrace, Hoboken, NJ 07030

Introduction:

The initiative to develop a Marine Carbon Dioxide (CDR) Removal Research Plan (89 FR 13755) is a significant and timely response to the urgent challenges posed by global climate change. We recognize the pivotal role such strategic frameworks play in bolstering our collective endeavors to address environmental challenges. At Stevens Institute of Technology, our deep-seated expertise in decarbonization and marine renewable energy uniquely positions us to offer valuable perspectives that can significantly enhance the efficacy and reach of the Marine CDR Plan. This response draws upon extensive experience in developing sustainable solutions within marine environments. Our focus is on pioneering transformative approaches that integrate existing marine renewable energy technologies and innovative carbon removal methods. This synergy aims to enhance the efficiency and effectiveness of both systems, advancing our capacity to address climate change comprehensively.

We highlight the significant role of marine renewable energy in powering the blue economy and its promising potential for integration with marine CDR technologies. The field of marine renewable energy, which harnesses the power of waves, tides, and ocean currents, is rapidly advancing and offers a sustainable solution to meet the energy demands of various offshore and coastal activities. These marine energy sources not only facilitate operations at sea but also contribute significantly to economic development in coastal regions. Additionally, the utilization of marine renewable energy provides a robust foundation for innovative climate mitigation strategies, particularly through its potential synergies with CDR technologies. This integration represents a forward-thinking approach to leveraging natural marine resources to address global environmental challenges effectively. In this submission, we will address Question 3 from the RFI:

3.1). Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?

Response: The Federal Government should prioritize sustainable marine CDR techniques that leverage promising potential of renewable energy. The integration of these energy sources not only supports sustainable development but also drives technological advancements critical to effective CDR. Among different renewable energy resources, marine renewable energy powered marine CDR is the most promising approach. Marine renewable energy in the U.S. is a rapidly expanding field with a significant resource potential estimated at approximately 2,300 terawatt-hours per year (TWh/yr), equating to about 57% of total U.S. electricity generation in 2019, as shown in Fig.1 [1]. This vast potential is distributed across various forms of marine energy including wave, tidal, ocean currents, and ocean thermal energy, positioning these resources as key elements in the national energy strategy with the capability of powering 220M homes in U.S. The proximity of these energy sources to their utilization sites facilitates operational efficiencies by reducing the logistical challenges and costs associated with energy transmission and infrastructure.

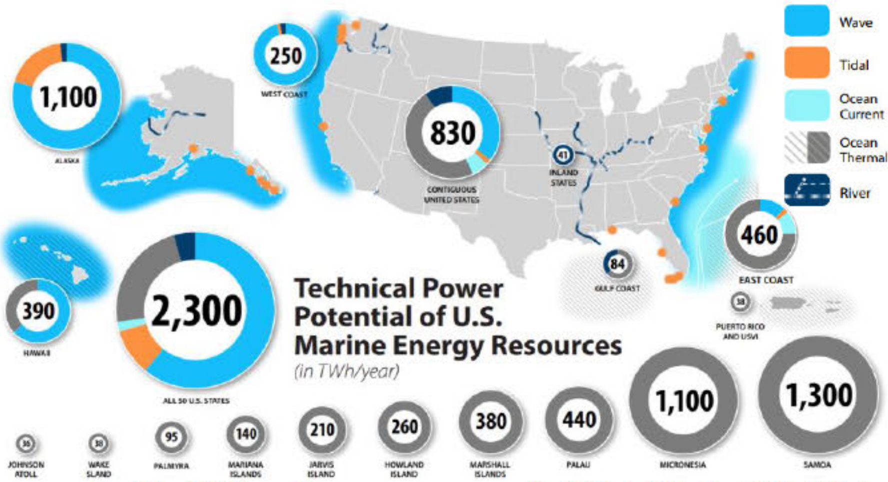

Fig.1 Technical power potential of U.S. marine energy resources (in TWh/yr) for the United States, U.S. territories, and freely associated states. [1]

Beside technical potentials, the economic implications of marine renewable energy are profound. According to [2], the deployment of marine renewable energy technologies offers robust economic growth potential within various sectors of the blue economy. For example, offshore marine aquaculture and marine algae farming are expected to benefit significantly from the application of marine energy, especially as the aquaculture market projects over $55 billion by 2020. Fig.2 shows the diverse applications of marine renewable energy in maritime markets [2]. It encapsulates the vision for a sustainable and resilient infrastructure that utilizes marine energy sources, such as wave and tidal power, to enhance various marine and coastal activities. Together, these scenarios depict a future where the integration of marine energy into the blue economy paves the way for innovative, eco-friendly, and economically viable maritime industries.

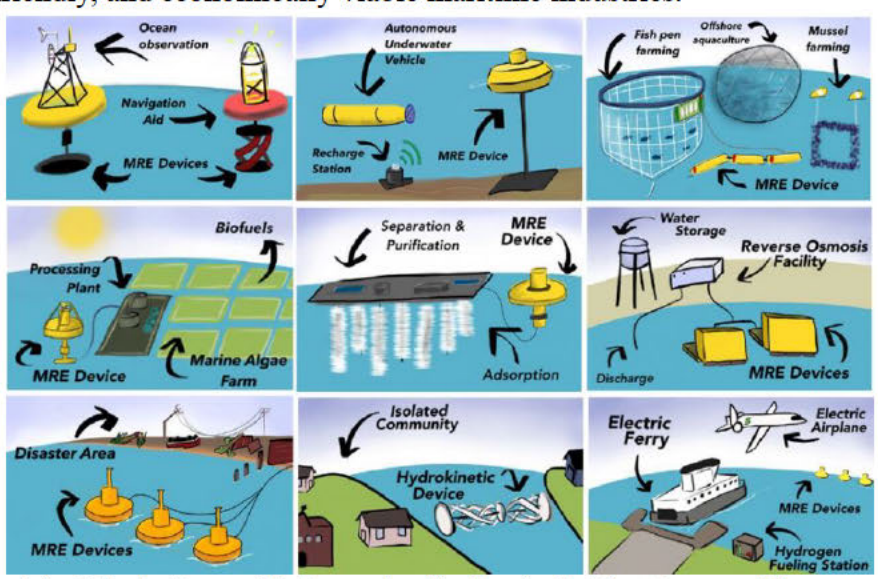

Fig.2 Marine Renewable Energy Applications in the Blue Economy [2]

Beside these scenarios, expanding these applications and incorporating with marine CDR make it possible to leverage the natural synergies between these technologies for enhanced carbon removal and energy production. Focused research could explore the efficient coupling of marine renewable energy with CDR methods, aiming to optimize energy transfer and system design for carbon capture processes directly at sea. Marine renewable energy can provide consistent and sustainable power to marine CDR, enhancing their economic viability by reducing reliance on fuel-based power systems and enabling expansion into more remote and energy-rich ocean areas with reduced environmental impact.

3.2). Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits?

<u>Response:</u> There are different marine CDR approaches, as shown in Fig. 3, including the seaweed sinking, artificial upwelling, electrochemical base addition, and electrochemical carbonate. All of these approaches require energy input to facilitate the reactions. The combination of marine renewable energy with marine CDR approaches offers significant promise for climate change mitigation. This synergy not only maximizes carbon removal efficiency but also bolsters overall energy utilization, significantly contributing to climate change mitigation [3].

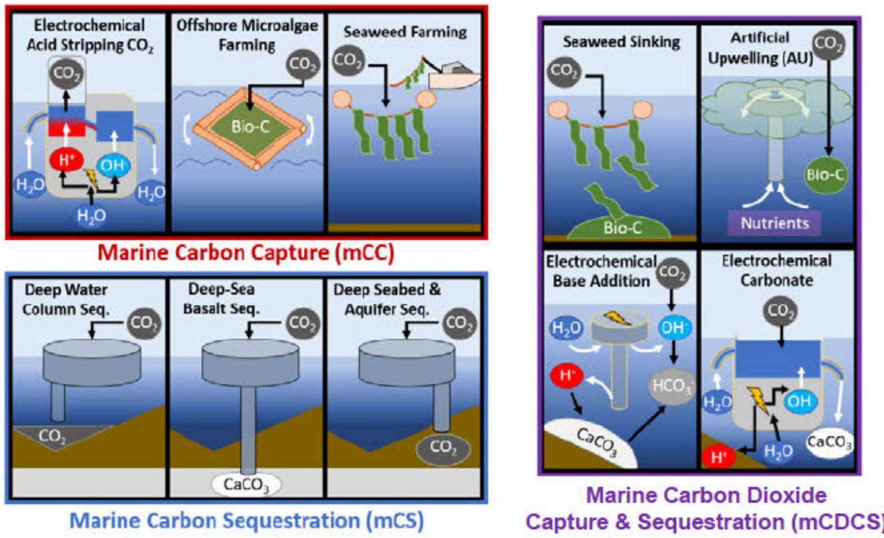

Fig. 3 Different marine CDR methods: marine carbon capture (mCC), marine carbon sequestration (mCS) and marine carbon dioxide capture and sequestration (mCDCS) [3]

Key techniques that could benefit from such integrated research include enhanced weathering and ocean alkalinity enhancement. Enhanced weathering accelerates the natural breakdown of minerals to capture atmospheric CO_2, potentially supported by marine energy-driven processing technologies. Ocean alkalinity enhancement, which could utilize electrolysis of seawater powered by marine renewables, increases the ocean's capacity to absorb CO_2 and necessitates studies on scalable deployment and environmental impacts. Additionally, the cultivation of seaweed and other marine biomass offers promising avenues for natural carbon sequestration. Research could focus on sustainable cultivation and conversion methods, transforming biomass into stable forms of carbon storage like biochar, using energy from renewable marine sources. Another potential area is bioenergy with carbon capture and storage in marine settings, which would involve generating bioenergy from marine biomass, capturing the CO_2 produced, and storing it offshore, all powered by marine renewable energy. Supporting these technical investigations with thorough techno-economic and lifecycle assessments will be crucial. These assessments should evaluate the economic viability and environmental impacts of marine CDR technologies, ensuring that they are both sustainable and effective over the long term. This comprehensive research approach will not only aid in mitigating climate change but also enhance energy security and support economic development in coastal regions.

In addition to the technical and environmental advantages, there are further benefits in terms of economics and workforce development. The deployment of these technologies will drive workforce development, creating new job opportunities across engineering, manufacturing, marine operations, and system maintenance. This growth in skilled labor is essential for sustaining the expansion and operational demands of both industries. As marine CDR technologies become more reliant on renewable energies, the demand for improved and reliable marine energy solutions increases. This demand accelerates investment and innovation within the marine energy sector, promoting sectoral growth and economic benefits. Moreover, the development of these sectors can lead to reduced costs, improved efficiencies, and increased scalability, making sustainable practices more attainable and impactful. As shown in Fig.4, the cost required per ton of CO_2 captured by the marine CDR ranges between \$10-1000/ton, and can be further reduced with technology advancement [3]. <u>A techno-economic analysis suggests potential cost reductions of 20% -37% by 2030 and 49% - 68% by 2040</u> [4].

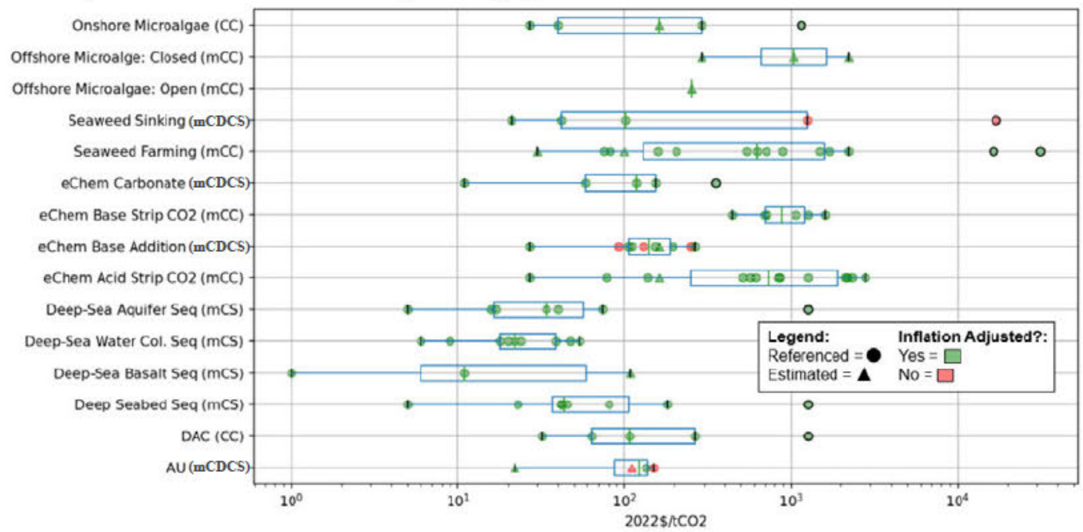

Fig. 4 Cost required per ton of CO_2 captured by the mCC, and mCS, and mCDCS strategies in 2022 dollars [3]

3.3). Are there marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

<u>**Response:**</u> It is imperative to assess the various marine CDR techniques for their environmental impact, longevity of CO_2 storage, and their full-scale potential for carbon removal. The analysis performed in [3] helps distinguish between methods that are environmentally viable and those that may pose higher risks or uncertainty. This preliminary analysis is based on the current technical statues and is worth further comprehensive assessment.

As depicted in Fig.5, marine CDR methods exhibit a broad range of potential for CO_2 removal and storage timeframes. The analysis categorized risks at scale as high (HR), unclear (UR), or low (LR), offering a roadmap for strategic decision-making:

- **High-Risk Methods:** Artificial upwelling and seaweed sinking are labeled as high-risk (HR) due to their impact on marine ecosystems and the potential to alter biogeochemical cycles.
- **Methods with Unclear Risks:** Base addition (eChem) and carbonate formation (eChem) have unclear risks (UR) because, while they may not directly interfere with marine life, the long-term effects of altering ocean chemistry are not fully understood.
- **Low-Risk Methods:** Seabed and basalt sequestration are considered low-risk (LR) methods as they involve storing CO_2 in sub-seafloor formations, which has minimal impact on marine life.

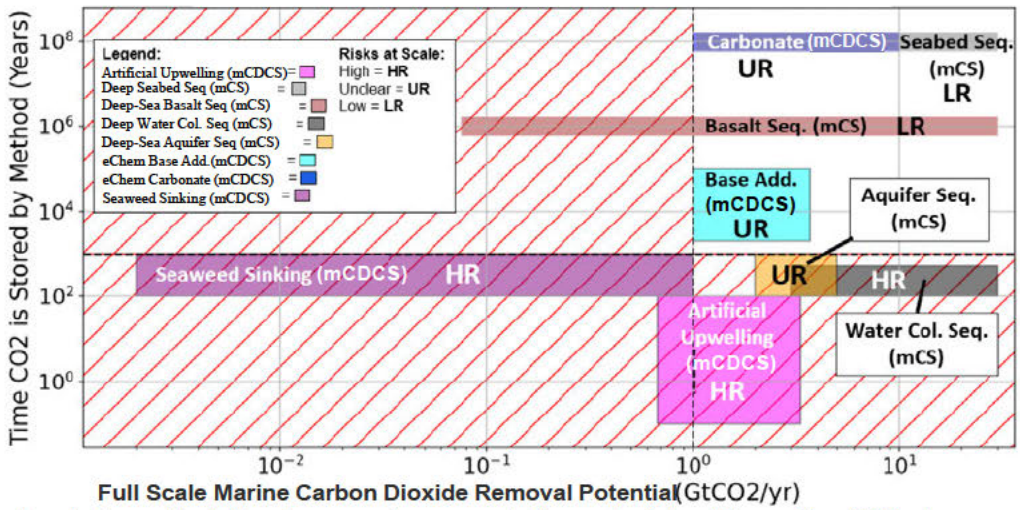

Fig. 5 Comparison between the full-scale removal or sequestration potential and longevity of CO_2 storage enabled by the types of mCDR [3]

Regarding the carbon removal potential, preliminary analysis highlights a stark contrast between different methods. For example, artificial upwelling, despite its high risk, has a low full-scale potential, whereas eChem base addition and carbonate formation, with unclear risks, show a significantly higher potential for carbon removal, potentially exceeding 1 gigaton of CO_2 per year. These findings suggest prioritizing low-risk methods with high removal potential for policy development and funding. This approach would maximize the benefits of marine CDR while minimizing environmental and community risks.

Conclusion:

The integration of marine renewable energy with marine CDR technologies presents a promising frontier in the collective effort to combat climate change. This synthesis method not only has the potential to enhance carbon removal efficiency but also to foster substantial economic growth within the blue economy. By focusing on the compatibility of these two fields, we envision the US to lead a global shift toward more sustainable and efficient carbon management practices, with the added benefits of job creation and technological advancement. Preliminary analysis found that marine CDR powered by offshore renewable energy in U.S. could meet global CDR scales needed by 2040 and 2050 to limit warming to 1.5°C by 2100. Future research on marine renewable energy powered CDR supported by this initiative holds the promise of unlocking new methodologies, improving scalability, reducing costs, and enhancing the overall viability of marine CDR strategies.

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From: Kristin Kleisner (b) (6)
Sent: Monday, April 22, 2024 10:18 PM
To: Light, Tricia M. EOP/OSTP
Cc: Mattias Cape
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: 240423_FTAC_mCDR_Research_Plan_EDF_LH_Final.pdf

Dear Tricia,
Thanks to you and the MCDR-FTAC for soliciting comments on the plan for mCDR research. We hereby remit our responses to the six questions on behalf of Environmental Defense Fund. We would be happy to follow up on any of the enclosed information if helpful.
Regards,
Kristin

Kristin Kleisner, PhD (she/her)
Lead Senior Scientist, Oceans
Associate Vice President, Oceans Science

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April 21, 2024

Dear Marine Carbon Dioxide Removal Research Plan-Fast Track Action Committee,

The UN Intergovernmental Panel on Climate Change (IPCC) has noted that we will need drastic reductions in greenhouse gas (GHG) emissions by mid-century if we are to keep rising temperatures in check. While emissions reductions are absolutely necessary, the IPCC has also noted that marine carbon dioxide reduction (mCDR) strategies that enhance the ocean's natural chemical or biological pathways for carbon drawdown and storage will also be needed to ensure we meet our targets. The oceans are already naturally sequestering large amounts of carbon dioxide, a function that must be safeguarded. mCDR, while promising, is an artificial approach to enhancing sequestration with many unknowns and possibly unintended consequences. As such these approaches require rigorous scientific research alongside appropriate governance of research, development and any potential deployment to ensure their efficacy and safety for people and nature.

Environmental Defense Fund supports the need for research into these technologies, but feels strongly that this research, particularly field-based trials, and any potential deployment, must be governed by policies that mandate safeguards, enforce compliance, and allow for decision-making that can weigh tradeoffs around the potential, efficacy, uncertainties, and risks to the environment and to communities. We believe that the goals of the MCDR-FTAC of establishing a comprehensive Federal marine CDR research program; clarifying permitting, regulatory, and other standards and policies, establishing guidelines for marine CDR research; and establishing a Marine CDR Initiative to enable public-private partnerships and establishing mechanisms to strengthen interagency coordination and promote public awareness and engagement are laudable and critical. We provide the following inputs to the six questions detailed by the MCDR-FTAC:

Question 1: Setting up a comprehensive system that is transparent, collaborative, and clearly governed would ensure that 1) research is conducted in a safe manner, adhering to an accepted code of conduct, and with an eye to impacts beyond just the anticipated climate benefit, 2) the benefits and any risks to the environment or people can be fully vetted and articulated to the public and to decision makers, 3) precious resources are directed towards the most promising mCDR approaches, and 4) those approaches that are deemed safe and effective can be deployed at scales that make a key contribution to mitigating the global

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climate crisis. It is paramount that the public and key decision-makers are equipped with the necessary information to make informed decisions and to weigh tradeoffs regarding costs, benefits and risks to the ecosystem and to society.

Question 2: The federal government, in collaboration with actors across the mCDR ecosystem, has an important role to play to enable the development of mCDR research, to ensure that it progresses in a way that is responsible and accounts for impacts on nature and people, and remains grounded in transparency and inclusivity. Key concerns regarding mCDR include the fact that currently, the mCDR industry relies on knowledge gained through Earth Science research (e.g., oceanographic, ecological studies), as well as on physical data collection (e.g., ocean observing assets, ships, satellites) and cyberinfrastructure funded by public means. These needs are vast and will continue. Therefore, investment in mCDR research should be thought of as complementary to existing and future investments in Earth Science research, and not as a replacement for current research investments. Opportunities for synergistic research should be prioritized.

While the scale of the climate problem is great, we must not cut corners in mCDR research by reducing the sample sizes, failing to fully evaluate impacts, or skirting sufficient timelines for public comment or stakeholder engagement. Such actions will only serve to undermine the mCDR enterprise as a whole. Within the framework of mCDR R&D, accelerating research should serve to increase coordination across different fields and between different approaches. For example multiple lines of inquiry on different aspects of mCDR interventions including carbon, non-carbon, and social dimensions could be pursued in parallel, with increased communication and coordination across studies informing each distinct effort. This will present a challenge given that actors in the R&D landscape include for-profit companies, and that research spans multiple countries. Sufficient time should be allotted throughout the R&D process to allow for synthesis of knowledge, re-assessment of knowledge gaps, and future planning for unexpected outcomes. To address these concerns and ensure robust R&D for mCDR, we see a need for:

1. **Development of a 'fit-for-purpose' data collection and monitoring system.** A priority should be to identify efficiencies with low-cost data collection that can be used for multiple purposes (e.g., fisheries management, weather forecasting, coastal planning).
2. **Support for research to establish environmental baselines.** The need to quantify carbon and non-carbon environmental impacts of mCDR interventions assumes the presence of a baseline against which to measure change. Environmental baselines, historically collected by hard-to-fund long-term monitoring programs, are broadly lacking when considering the scale and reach of potential mCDR interventions, particularly as impacts extend beyond the coast, potentially across jurisdictional borders and into ocean basins. Increased support for sustained environmental monitoring should be provided to enable assessment of baseline conditions, including

through support of regional and global ocean observing efforts. Guidelines should also be developed to define what variables should be measured and what length of environmental baseline is necessary and sufficient to allow for a full assessment of benefits and costs.

3. **A strong Monitoring, Reporting, and Verification (MRV) framework to assess carbon and non-carbon impacts.** Owing to the scale and dynamic nature of the ocean, a combination of observations and models will be needed to assess the effectiveness of mCDR interventions. Beyond their impacts on carbon, MRV systems should also enable assessments of implications for greenhouse gas emissions more broadly to ensure that mCDR interventions contributions are net negative for GHG emissions on timescales that matter, while also characterizing the impacts on environment and people. A greater acknowledgement of the need to measure impacts on the environment has led to the call for an 'environmental MRV' (eMRV) standard to help provide environmental guardrails for mCDR research and any eventual deployment. Robust MRV and eMRV will be critical for the periodic assessments that will help to evaluate whether any particular approach poses too much of a risk of negative impacts on the environment or humans to allow for further R&D.
4. **A life cycle analysis (LCA) approach for evaluation of mCDR interventions.** While the focus is on the removal of carbon by the ocean, mCDR interventions may have significant and material impacts on GHG emissions, including in their reliance on energy production (e.g., electrochemical methods), mining (e.g., iron fertilization and alkalinity enhancement), or shipping (offshore seaweed biomass production and sinking). An LCA framework accounting for inputs and outputs of interventions is needed to fully assess the promise of methods as a climate mitigation strategy, and their impacts and potential consequences for nature and human wellbeing. LCA can also help identify potential synergies between methods that may minimize risks and maximize benefits (e.g., waste products from one method used as inputs to another) and ensure that interventions are not associated with environmental justice concerns and negative impacts on marginalized communities, particularly with respect to waste disposal and negative environmental impacts.
5. **Promotion of research to understand the interactive effects of simultaneous CDR interventions.** Current research focuses on quantifying the effectiveness of a single marine method operating in an ocean where no other interventions are deployed. With a likely endpoint of multiple technologies across the land-ocean continuum being deployed for CDR, additional research will be needed to understand the interactive effects of multiple CDR methods.
6. **Facilitation of justice, equity, diversity, and inclusion (JEDI) in R&D and decision-making.** Federal investment into mCDR research should include strong support for social science research that could inform the shaping of a just, equitable and inclusive decision-making framework for mCDR development that includes

diverse actors. JEDI considerations should also underly the mCDR enterprise, including through stakeholder engagement prior to, during, and after any field efforts.

7. **Development of necessary guardrails, standards, and a universal code of conduct.** In conjunction with required assessments of impacts beyond carbon mitigation, new guidelines are needed to define viability thresholds for technologies and ranges of acceptable environmental and social impacts to facilitate decision making. Such standards and guidelines would act as inputs to a decision-making process that allows a stage-gate assessment as to which technologies should move forward in the R&D pipeline or which should either be reconceived or abandoned given the scale of their impact. These guidelines and standards should be precautionary, proportional to the level of potential harm or uncertainty in potential impacts, and adaptive to allow for changes as further knowledge is gathered. In parallel, mCDR research should also be grounded in a universal code of conduct which would outline procedures and processes that need to be followed to ensure mCDR research is guided by appropriate consideration of social, environmental, economic, and ethical dimensions, enhancing transparency and fostering accountability.
8. **Technical support for governance and permitting across scales.** Under a federal mCDR research plan, projects will be expected to follow rules for conducting research. However, mCDR activities will operate at more local levels, requiring interaction with tribal, state, and local authorities and regulations. mCDR remains poorly understood at the local and regional scales, with potential consequences both for the permitting of projects and evaluation of their potential impacts. The federal government should facilitate knowledge sharing across scales to enable mCDR research. This could include collaborating with stakeholders in generating tools for siting of mCDR interventions (akin to the Coastal Aquaculture Planning Portal hosted by NOAA), alongside portals for knowledge sharing.

Question 3: Much research is still needed to understand impacts of all forms of mCDR. Ultimately, for all mCDR approaches, we need to have an ability to evaluate impacts beyond just carbon removal—in particular impacts on the environment and to human communities.

Question 4: While mCDR is aiming to address the global problem of atmospheric CO_2 removal, interventions will take place at local and regional scales. Local communities and Indigenous groups need to be brought in from the start to understand their goals, needs and priorities and to co-develop and co-design a suite of potential approaches that can help them mitigate and adapt to climate impacts, including mCDR if suitable. Additionally, decision-makers at local to regional scales will need a clear framework for evaluating benefits, risks, and tradeoffs between climate, environmental and socio-economic goals and outcomes, impacts on other industries and activities, costs and capital investments.

To weigh information flowing from research programs and make decisions about which mCDR approaches are in the public interest and ready for deployment, the Federal

Government should prioritize the development of decision-making frameworks and processes capable of bringing in diverse values, perspectives, and risk tolerances, as well as years of research on some mCDR approaches. In reporting information on impacts of mCDR deployments, the government should release information on specific consequences to existing ocean users and concerned stakeholders.

Question 5: Some of the biggest challenges will concern aspects of data sharing and transparency. Specifically, with for-profit industry actors collecting extensive oceanographic datasets to meet MRV standards, there are emerging issues with data sharing and accessibility owing to the proprietary nature of either the technology, collected data, or modeling frameworks being developed and used on a project scale. These actors will also rely on existing publicly funded ocean observing assets, while also potentially working towards augmenting existing networks with privately funded assets (e.g., autonomous sensor networks). Intellectual property rights to datasets stemming from mCDR research will need to be clarified to allow public access and reuse of data that will enable independent review of the effectiveness and impacts of mCDR interventions. Clarifying these data access rights may also facilitate other uses (e.g., marine resource management, early warning systems) that can enhance the public good.

Question 6: We would like the Federal Government to ensure that any mCDR plan clearly notes that the focus must remain on emissions reductions, energy transition, and other efforts to curb production of GHGs, with mCDR serving a supplementary role. There is a risk that the promise of scaled CDR in the future could delay or deter actors from pursuing emissions cuts (commonly called moral hazard or mitigation deterrence), resulting in overshoots of climate goals. We would like to see CDR used in addition to mandated GHG reductions by industries. In tandem with investments in CDR, the federal government should also work towards exploring strategies to eliminate, minimize, and mitigate the moral hazard as it works on the national and international scale[1].

We appreciate the mCDR-FTAC calling for inputs to this process and we offer our further support as the Committee works to develop a robust mCDR plan.

Respectfully,

Dr. Kristin Kleisner, AVP of Ocean Science and Dr. Mattias Cape, Marine Biogeochemical Scientist (on behalf of Environmental Defense Fund)

[1] See for example Carbon Gap (2023) - How to avoid carbon removal delaying emissions reductions. Available at https://carbongap.org/how-to-avoid-mitigation-deterrence/

From: Matthew Long [redacted]
Sent: Monday, April 22, 2024 6:08 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Lertter to mCDR FTAC .docx

Dear Tricia,
Please see the attached comments.
Thank you,
Matt

Dr. Matthew H. Long

Associate Scientist

Woods Hole Oceanographic Institution

Department of Marine Chemistry and Geochemistry

MS #08

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Co-Founder, Subtidal, Inc.

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Dear MCDR–FTAC, *4/22/2024*

I will focus my brief comments on the first two questions, as I am sure you will have substantial amounts of responses to sift through, and these I think are the most important parts.

1. How would a Marine CDR Plan affect you, your organization, or your community?

Marine CDR is already significantly affecting me. I am an ocean scientist (Woods Hole Oceanographic Institution) and entrepreneur (Subtidal) and much of my time and energy is spent thinking about mCDR, its impacts, and how to measure it.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

I would like to emphasize the importance of permitting and the related size/scale of pilot CDR testing to enable signal detection and substantive measurements of carbon removals. Currently very few measurements of carbon fluxes and ecosystem impacts are being undertaken as CDR efforts are focused on industrial processes that can enhance C removal, as opposed to their effectiveness or environmental impacts. Therefore, testing must be conducted at relevant scales where ocean measurements of carbon flux can be conducted and verified. Much of the current focus on the measurement, reporting and verification (MRV) is related to modeling, but modeling will have limited usefulness in validating these new processes, especially considering most efforts are in coastal areas at spatiotemporal scales that models do not resolve. Thus, measurements of carbon flux and ecosystem impacts are paramount to enabling mCDR (ranging from scientific to social licensing viewpoints). To enable this validation with hard data, pilot scales must be of sufficient size so that signals can be resolved and verified.

Almost every mCDR effort I am aware of is currently being conducted at the coast – either within estuarine systems, rivers, or immediately on the coastline. A small handful of research efforts are being conducted just offshore (i.e. a few miles), which most scientists would still characterize as coastal. These are dynamic ecosystems where substantial amounts of carbon are already stored but are poorly resolved globally due to the dynamics of coastal carbon cycling (e.g. Mathis et al. 2024, Nature Climate Change). From conversations with experts and CDR developers, and my own scientific (and government funded) research, it is apparent that upwards of 50% of carbon removals can occur in the near-field, within the first 2-5 days after mCDR interventions. This is due to the shallow nature of coastal ecosystems, their complicated hydrodynamics, their interaction with the atmosphere (on a volumetric basis), and the fact that mCDR developers will act to maximize their local air-sea exchange and carbon storage through available mechanisms (shallow, dynamic coastal systems, existing buoyant plumes, industrial discharges) and yet-to-be-invented human interventions that maximize air-sea exchange and/or carbon storage – with all efforts focusing on scales that can be easily measured and verified.

Finally, I want to emphasize the importance of carbon flux as the only way to directly measure, report and verify carbon removals. These measurements are also the only way to effectively train and validate new models for estimations of carbon removals via new mCDR methods. ***Measurements of carbon flux and marine carbonate chemistry are challenging, but that is not a reason not to do them. We have already learned from the terrestrial carbon markets that simple measurements and scaling models will eventually be devalued and discredited – let's not repeat these same mistakes.***

Please do not hesitate to contact me for any further information,

Sincerely,

(b) (6)

Dr. Matthew H. Long

From: Jessica Stigant (b) (6) [redacted]
Sent: Monday, April 22, 2024 4:51 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: ONC_response_mCDR Fast Tract Action committee response apr_2024.pdf

Please find attached Ocean Networks Canada's response to the National Science Foundation's request for input in the development of a Marine Carbon Dioxide Removal Research Plan regarding marine carbon dioxide removal (CDR) research.

Please let me know if you have any questions.

Kind Regards,
Jessica

Jessica Stigant (she/her) | Associate Director Government Relations & Partnerships
Ocean Networks Canada | T (b) (6) [redacted] | M (b) (6) [redacted] | oceannetworks.ca
University of Victoria Queenswood Campus
#100-2474 Arbutus Road, Victoria, BC V8N 1V8

A UNIVERSITY OF VICTORIA INITIATIVE

Questions To Inform Development of the Strategy

1. How would a Marine CDR Plan affect you, your organization, or your community?

A marine plan would help Ocean Networks Canada advance our in situ infrastructure so that it is tailored to assist researchers and companies advance their mCDR technologies to a higher readiness level. Our in situ infrastructure represents a wide range of ocean environments (shallow to deep; low oxygen to normal oxygen, areas of ocean acidification, areas of upwelling, areas of pelagic export to the deep sea, observation near municipal outfall infrastructure).

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Oceans Visions (oceanvisions.org) has developed road maps for mCDR solutions that include gaps and needs in the regulatory area.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

All areas outlined in the NASEM report would be worth pursuing with alkalinity enhancement, biomass sinking, electrochemical stripping, and nutrient fertilization as top priorities. Upwelling/downwelling is a challenge, but experiments could be designed to assess its potential.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Ocean Networks Canada is committed to fully open and transparent data. Without this approach, there would be slowdown in decision-making regarding what options should be pursued. As mCDR advances technically, co-design studies should include public engagement and economic benefits (e.g. jobs)

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

The ocean is global. Ensuring that Federal funding opportunities are framed to enhance international collaboration is key to more rapidly advancing technology through knowledge sharing. A bilateral cooperative approach between the US and Canada would be a great first step.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

The plan should incorporate the risks of doing nothing compared with enhancing ocean solutions of this kind.

Ocean Networks Canada (ONC) *in a not-for-profit that operates world-leading observatories in the deep ocean, in coastal waters, and on land of the Pacific, Atlantic, the Arctic coast of Canada. Recently it also expanded to the Antarctic through partnership. The observatories collect ocean data in real-time that accelerates scientific discovery and makes possible services and solutions that support life on our planet. ONC, an initiative of the University of Victoria, is Canada's national ocean observatory. ONC has installations and local partnerships with Indigenous and coastal communities on all three of Canada's coasts, and more than 32,000 users of its scientific data from around the world.*

If you would like to follow up with Ocean Networks Canada on these comments please reach out to Jessica Stigant, Associate Director Government Relations and Partnerships: (b) (6) [redacted]

** This document is intended for the National Science Foundation's request for input in the development of a Marine Carbon Dioxide Removal Research Plan regarding marine carbon dioxide removal (CDR) research. Please don't share this document outside of the intended audience or please contact Ocean Networks Canada for permission.*

From: Thomas Peacock [redacted] >
Sent: Monday, April 22, 2024 4:25 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: 24.04-FTAC-Peacock.pdf

Dear Tricia

Please find my response to the RFI for the mCDR-FTAC attached.

If you need any further information, please let me know and I will be happy to provide.

Sincerely

****

Prof Thomas Peacock
Fellow of the American Physical Society

Room 3-360
Mechanical Engineering
MIT
Tel: [redacted]
Web: http://web.mit.edu/endlab

Thomas Peacock
ENDLab

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Apr 22nd 2024

Credentials: Prof. Thomas Peacock is a Professor of Mechanical Engineering at the Massachusetts Institute of Technology, and a Fellow of the American Physical Society. His research group, the Environmental Dynamics Laboratory, is a leading US-based research group for modeling and monitoring of Ocean Interventions. They are currently conducting monitoring operations of Captura in the Port of LA and developing advanced GPU-based modeling for mCDR calculations.

Recommendations on addressing question 2, 3 & 5

I am writing to provide feedback on questions 2, 3 and 5. Rather than responding individually to each question, I provide overarching feedback regarding MRV that applies across all three questions.

Many of the items raised for these three questions can only be addressed by developing independent third-party Monitoring, Reporting and Verification (MRV). mCDR involves complex physical processes, and its quantification requires highly integrated in-situ monitoring with complex multiscale numerical simulations. As such, the operational implementation of MRV methodologies is more important than the methodology itself in obtaining high-certainty carbon removal assessments, which amplifies the conflict of interest associated with self-assessment of pilot and research interventions.

In addition, current research efforts rely on short-term case studies that cannot adequately capture the inherent variability of the ocean and its response to mCDR interventions. These case studies are also not aimed at providing operational solutions to quantify the mCDR over the lifetime of an operation, instead addressing specific subsets of fundamental scientific questions. Until highly scalable and operational MRV solutions are developed, it will not be possible to assess the commercial viability and risk/benefit balance of the various mCDR pathways. Examples of non-operational or non-scalable MRV solutions include costly supercomputing simulations that can only simulate a limited window of time, or singular and very expensive scientific instrumentation that typically only exists within academia.

My recommendations for a federal research program that can advance mCDR solution via trustworthy and operational MRV are therefore to require that for any DoE supported research project, the following be so:

1. MRV be conducted by a third party that is independent from the entity performing the intervention. This should be an explicit requirement of any funding for a project. There needs to be a distinct line item in the budget for the cost of the independent third party MRV and a description of how they will operate at arm's length.

2. The MRV for any funded operation needs to be demonstrably scalable and operational. An MRV study that is purely an academic study will not result in capabilities that can be transitioned to the marketplace.
3. Any MRV strategy funded by a federal research program should have continuous, adaptive management as a core principle, and not be limited to a short-term case study approach.
4. Since computer modeling will lie at the heart of MRV, there should be explicit federal funding for novel, energy-efficient and scalable computational approaches.

Sincerely,

(b) (6)

Thomas Peacock
Professor of Mechanical Engineering
Massachusetts Institute of Technology
Fellow of the American Physical Society

From: Rick Murray (he/him) (b) (6) [redacted]
Sent: Monday, April 22, 2024 3:08 PM
To: Light, Tricia M. EOP/OSTP
Cc: Peter Hill; Peter de Menocal (he/him)
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: FTAC_FRN_WHOI_Institutional_Statement_Apr22_2024.pdf

Dear Tricia:

Attached please find Woods Hole Oceanographic Institution's input to this very important subject.

Regards,

Rick Murray

****

Richard W. Murray, Ph. D.
Deputy Director / VP for Science & Engineering
Woods Hole Oceanographic Institution
266 Woods Hole Road, MS #40A
Woods Hole MA 02543
p:(b) (6) [redacted]
c: (b) (6) [redacted]

WOODS HOLE OCEANOGRAPHIC INSTITUTION

To: Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR–FTAC)

From: Woods Hole Oceanographic Institution
POC: Richard W. Murray, Dep. Director, VP Science & Engineering

Re: Marine Carbon Dioxide Removal Research Plan Federal Register Notice

Date: April 22, 2024

Dear mCDR FTAC Committee,

As humanity faces the current and future challenges associated with a changing climate, the immediate priority must be to rapidly cut carbon emissions. The importance of cutting emissions cannot be overstated. Emissions cuts must occur as part of any mitigation or adaptation scenario moving forward. However, to achieve the Paris Agreement goals and avoid the worst impacts of climate change, cutting carbon emissions is no longer enough—society must also seek ways to remove carbon dioxide from the atmosphere.

The ocean is the largest carbon reservoir on Earth. As such, it is appropriate to consider ocean-based approaches in addition to others as part of the development and evaluation of broader carbon dioxide removal strategies.

However, because the ocean is central to many of the planetary systems that make Earth livable, it is imperative that any deployment of marine carbon dioxide removal (mCDR) strategies be grounded in independent, transparent, and equitable science and observations to evaluate the efficacy and safety of these approaches before they are deployed at scale. Comprehensive carbon and environmental monitoring, reporting, and verification (eMRV) protocols must be established to assess the effectiveness of mCDR techniques at removing and durably storing carbon and to evaluate their impact on marine ecosystems and processes as well as their potential societal implications.

The scale and range of science and observations needed will require global collaboration among ocean science institutions, policymakers, NGOs, and philanthropic organizations, prioritizing active communication and consensus-building that only federal support and leadership can help realize. Woods Hole Oceanographic Institution (WHOI) is firmly committed to independent science that advances understanding of our ocean's role in Earth's climate system and the role it can play in averting the climate crisis. **WHOI respectfully offers the following recommendations to the Marine Carbon Dioxide Removal Fast-Track Action Committee** to help realize the Committee's three overarching goals:

<u>FTAC Goal 1: Establish a comprehensive Federal marine CDR research program</u>

1.1. A range of several marine carbon dioxide removal (mCDR) techniques are attracting interest, yet research and infrastructure to evaluate and measure their effectiveness, scalability, safety, and environmental impacts are insufficient. mCDR strategies must be led by and grounded in independent and high-integrity science, leveraging detailed ocean data to assess environmental impacts and establish advanced carbon and environmental monitoring, reporting, and verification protocols (eMRV). MRV efforts primarily track the ocean's absorption of atmospheric CO_2, but we also need to understand its fate within the ocean to deploy efforts focused on systematically assessing environmental impacts (hence, "eMRV").
RECOMMENDATION: Federal funding for academic mCDR research and eMRV ocean observing infrastructure and protocol development must be prioritized and mobilized quickly to enable independent research to ensure the feasibility and safety of mCDR techniques.

1.2. Collaborative research across institutions is paramount to determine the efficacy and risks associated with mCDR interventions.
RECOMMENDATION: Along with funding, the Federal government should provide interagency support, coordination, technology development, and capacity building, for robust, non-biased, and sustainable mCDR research and eMRV infrastructure and protocol development across a wide range of institutions.

1.3. Regional coordination and sustained funding support is necessary to bring together cohesive collaborations and support the longevity of large scale mCDR and eMRV test beds. Testbeds with interagency support for a consortium of academic institutions can provide a managed environment where scientists can test potential mCDR methods and refine eMRV protocols.
RECOMMENDATION: The Federal government can play a crucial role in establishing and coordinating testbeds in key locations. In so doing, the Federal government should coordinate shared resources such as ships, observing networks, and other assets supporting ocean observations while providing funding for projects to use such resources to accelerate a comprehensive research agenda that will rapidly advance the best possible science.

1.4. mCDR and eMRV research must be guided by independent science, ensuring transparency and open access to data**.**
RECOMMENDATION: The Federal government should require that data collected in the course of federally funded mCDR research and development of eMRV protocols, is made freely available in a timely manner to ensure transparency and verification.

FTAC Goal 2: Clarify permitting, regulatory, and other standards and policies, and establish guidelines for marine CDR research

2.1 Research on mCDR techniques and eMRV protocols must be guided by an ethical framework that establishes community-wide best practices, protects shared marine resources, and prioritizes trust within indigenous populations, local communities, and society at large.
RECOMMENDATION: Along with scientific research funding, the Federal government should provide comparable levels of funding to support community and stakeholder engagement to ensure that societal priorities are integrated into the mCDR research agenda and eMRV protocol development.

2.2 Efficient pipelines are needed to streamline the permitting process and enable scientists to focus on conducting thorough and ethical science.
RECOMMENDATION: The Federal government should prioritize the establishment of a streamlined permitting process that recognizes the importance of ongoing and collaborative programs encompassing a suite of long-term field testing and deployments (i.e. within a testbed and/or for regional scale eMRV).

FTAC Goal 3: Establish a Marine CDR Initiative to enable public-private partnerships and establish mechanisms to strengthen interagency coordination and promote public awareness and engagement

3.1. The scale and range of science and observations needed to ensure a safe, effective, and comprehensive mCDR research portfolio will require global collaboration among ocean science, policy, and philanthropy organizations. mCDR and eMRV successes and growth hinge on synergistic engagement across all sectors of society, as well as within the broader ocean sciences community.
RECOMMENDATION: The Federal government should foster mechanisms that enable and coordinate collaborations and interdisciplinary communication within the scientific community and across the widest possible spectrum of sectors and stakeholders (e.g., academia, industry, governmental). With this, the Federal government can establish communication and consensus among ocean science leaders and organizations to build interdisciplinary leadership and accelerate innovation.

3.2. The vast majority of the global ocean has no baseline measurements of geochemical and carbon flows or plankton dynamics. Establishing mCDR additionality or environmental impacts will be severely hampered by the lack of such a baseline.
RECOMMENDATION: The Federal government should ensure that key elements of largescale and effective ocean carbon and biological observing and modeling systems and technology development are sustained and expanded, including but not limited to maintaining the surface flux measurements, repeat hydrographic lines and work to fully implement and sustain BGC Argo.

From: Blythe Taylor <(b) (6) [redacted]>
Sent: Monday, April 22, 2024 7:20 AM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Seaweed Generation- response to Q3.pdf

Please find attached our response to the RFI.

As an organization we have chosen to respond to *Q3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?*

Many thanks for providing the opportunity to be part of discussions.

Best regards

Blythe Taylor
seaweedgeneration.com

Seaweed Generation Ltd

Seaweed Generation

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Among the emerging marine CDR techniques, the concept of deep sea carbon storage using macroalgae, particularly the problematic Sargassum seaweed in the Great Atlantic Sargassum Belt, presents a compelling case for prioritized research by the NSF.

With the latest reports from the IPCC suggesting that CDR must reach an astonishing 10 GtCO2 per year by 2050, we need to be looking at approaches that can scale - quickly but also sustainably. Sinking naturally occurring macroalgae into the deep ocean is, in our view, one of the few pathways that can tick both these boxes.

The Azolla event can provide some hints to help us understand how a biomass based CDR solution in our oceans could work. This biogeological event occurring in the middle Eocene saw atmospheric CO_2 content drop from up to 3500 ppm (parts per million) to just over half this figure.[1] Over an 800,000 year period, freshwater Azolla ferns grew in abundance, absorbing CO_2. As the biomass naturally died and sank, the carbon captured was sequestered to the Arctic sea floor. It can be argued that this process was a contributing factor that essentially saw the Earth shift from a greenhouse climate, to the much cooler global temperatures that we see today.

Deep sea carbon storage that looks to mimic and speed up the impacts of the Azolla event, could also be viable through the sinking of macroalgae.

Macroalgae grows photosynthetically, utilising the CO_2 in the ocean. As it grows the pCO_2 of the water around it lowers, causing more CO_2 to enter the sea from the atmosphere. Seaweed grows without the need for artificial fertilisers or freshwater, it increases biodiversity (when grown sustainably), and can absorb CO_2 faster than terrestrial plants.

Just as we saw in the Azolla event, dead macroalgae naturally sinks and ends up in deep sea sediments. An estimated 130,000 t/yr of giant kelp (*Macrocystis spp.*) is exported to the deep sea down the canyons of the Monterey Peninsula.[2]

If seaweed is *sent* to the deep ocean seabed (at depths of 1000m or more), the carbon it has naturally absorbed is essentially removed from the surface carbon cycle for at least 100

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[1] Bujak. J and Bujak A. The Arctic Azolla event, available at: https://www.geolsoc.org.uk/Geoscientist/Archive/June-2014/The-Arctic-Azolla-event (accessed March 2023)

[2] Krause-Jensen, D., Duarte, C. Substantial role of macroalgae in marine carbon sequestration. *Nature Geosci* 9, 737–742 (2016). https://doi.org/10.1038/ngeo2790

years. [3]

Many seaweed species are a fast growing biomass with potential to be used in many key areas where fossil fuels currently dominate. They include, but are by no means limited to: fuel; fertiliser; packaging/materials; animal feed and supplements; human food and cosmetics.

However, some species of seaweed are proving problematic. *Sargassum* is a genus of brown algae that grows from temperate to tropical regions. There are 400 species of *Sargassum* and two species are free floating, *S. fluitans* and *S. natans.* Mats of it drift around the ocean especially in the Caribbean and West Coast of Africa, held afloat by gas-filled bladders that look like tiny grapes.

The Great Atlantic *Sargassum* Belt is a recent phenomena (since around 2009) and is most likely a reaction to excessive nutrient and soil runoff into the oceans. Record amounts are now washing up on the shores of the West Coast of Africa and the Caribbean with detrimental environmental effects.

Sargassum material in the Great Atlantic *Sargassum* Belt is conservatively estimated to number in excess of a 20 million tonne[4] standing stock. It grows rapidly throughout the summer months in particular, and makes landfall in substantial amounts over a 6-8 month period. Tens of millions of tonnes (up to 100 million tonnes) of problematic *Sargassum* inundates the Caribbean every year. These influxes cause environmental degradation, loss of tourism and health threats.

Sargassum material which is not intercepted offshore, rots when it becomes beached and releases the CO_2 that it has previously absorbed back into the atmosphere and surface waters.

Under anaerobic conditions (which occur when oxygen cannot penetrate, both on land and in water), methane[5] gas will be produced. This will occur on the beaches, as well as in landfill sites where *Sargassum* is most commonly disposed of. Methane is even more potent than CO_2 as a greenhouse gas.

While it's clear that many species of seaweed are ideally placed for the development of useful commodities, *Sargassum*, and the limitations that are associated with a free floating, uncontrollable, seasonable biomass is not conducive to sustainable industrial manufacturing processes.

Sargassum, when dried, contains between 27.41% - 29.23% carbon[6]. Conservatively, 6.861

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[3] Baker, C. A., Martin, A. P., Yool, A., & Popova, E. (2022). Biological carbon pump sequestration efficiency in the North Atlantic: A leaky or a long-term sink? *Global Biogeochemical Cycles*, *36*, e2021GB007286 https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021GB007286.

[4] Wang, Mengqiu, et al, The great Atlantic *Sargassum* belt (5 Jul 2019) https://www.science.org/doi/10.1126/science.aaw7912

[5] Maneein, Supattra et al. Methane production from *Sargassum muticum*: effects of seasonality and of freshwater washes (2020) https://doi.org/10.1016/j.enbenv.2020.06.011

[6] Milledge J, et al Inundations in Turks and Caicos: Methane Potential and Proximate, Ultimate, Lipid, Amino Acid, Metal and Metalloid Analyses (March 2020) https://www.semanticscholar.org/paper/Sargassum-Inundations-in-Turks-and-Caicos%3A-Methane-Milledge-Maneein/71c2e61151c778d562a6fec4ecd6137b5af895b3

tonnes of wet *Sargassum* has absorbed 1 tonne of CO_2 from ocean waters. *Sargassum* that naturally dies and sinks, has already been reported in deep sea trenches around Japan, in the guts of deep sea crustaceans and is abundant on the seafloor in the Atlantic.[7] It is therefore an ideal candidate for carbon sequestration in the deep ocean.

CDR though biomass sinking is an approach that different companies are exploring. We at Seaweed Generation are developing automated robotics to conduct the process. The *AlgaRay* is a simple, solar powered system, designed with automation and rapid scalability in mind. Travelling at around 3knts, it takes less than 1 minute to fill with *Sargassum* at the surface of the sea offshore. The AlgaRay takes the biomass to around 200m deep and releases it (unbound, unbaled and free to disperse) where it spreads out and passively falls to the deep seabed under the force of gravity.

With time, the biomass deposited on the seafloor will either be sedimented or remineralised (i.e. dissolved into the deep sea water), and therefore difficult to monitor. However, the long term durability of deep ocean carbon is well documented.

First, because of the high pressure, low temperatures and lack of oxygen, decomposition of material is extremely slow at depth so there is a high likelihood that the biomass will become sedimented. (See Figure 3 in Hain et al)[8].

Second, assuming carbon is nevertheless remineralised into the surrounding water and not sedimented, the cycling of deep sea water into the upper layers is understood to be in excess of 100 years. It then takes several hundred more to reach the surface.

It is therefore generally accepted that for seaweed that reaches the sea floor at depths of more than 1000m and becomes sedimented, the removal of the absorbed CO_2 in that biomass is indefinite - on geological timescales. For remineralised material it becomes a depth and time factor. Below 300m - 0.6% could return within 50 years. Movement of material to depths below 2000m (way below the bottom of the thermocline, where the oceans become stably stratified by temperature), enhances longevity by reducing mixing. A study published in 2022[9] indicated that below 2000m 94% of particulate organic carbon that is remineralized would not reach the mixed layer and interact with the atmosphere for over 100 years. Below 3000m - just 0.2% returns within 1000 years. Diel vertical migration of zooplankton and nekton occurs largely in the euphotic zone (upper 400m of ocean) and is therefore also unlikely to impact on deep ocean material.

Unplanned disturbance will only happen due to a natural disaster such as an earthquake or deep sea volcanic activity. Some minor, but planned, localised disturbance will occur through Seaweed Generation's monitoring program as we remove samples to ensure that the

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[7] Baker et al, Potential contribution of surface-dwelling *Sargassum* algae to deep-sea ecosystems in the southern North Atlantic (2017) https://doi.org/10.1016/j.dsr2.2017.10.002

[8] Hain et al, The Biological Pump in the Past (2014) https://earth-system-biogeochemistry.net/wp-content/uploads/2021/05/Hain_et_al_2014_ToG.pdf

[9] Baker et al, Potential contribution of surface-dwelling *Sargassum* algae to deep-sea ecosystems in the southern North Atlantic (2017) https://doi.org/10.1016/j.dsr2.2017.10.002

environmental and ecological consequences (or lack of) are measured appropriately.

We're working with local governments to guarantee that the areas will remain undisturbed long term (which is also highly likely even without a guarantee, given the depths).

Tens of millions of tonnes (up to 100 million tonnes) of problematic *Sargassum* inundates the Caribbean every year. These influxes cause environmental degradation, ecological disruption, loss of tourism and health threats to these small island nations who don't have the finances or resources to deal with this ever increasing burden of biomass.

The potential co-benefits of this approach extend beyond environmental remediation. By working directly with local governments and communities impacted by Sargassum inundations, we can prioritize environmental justice and economic development. A percentage of the revenue generated from CDR activities would be directed towards these communities, creating climate-positive jobs and fostering knowledge-sharing and resource exchange. This approach aligns with the principles of a just transition, ensuring that the burdens and benefits of climate action are equitably distributed.

Moreover, Seaweed Generation's proposed approach leverages cutting-edge technology and automation to enhance scalability and cost-effectiveness. The AlgaRay system, a solar-powered and autonomous robotic system, can efficiently collect and transport Sargassum biomass to deep sea storage sites. This innovative approach reduces operational costs, increases safety, and enhances resilience to extreme events, paving the way for rapid scaling and deployment.

While the potential benefits of deep sea carbon storage using macroalgae are compelling, it is imperative to address the knowledge gaps and uncertainties surrounding this approach. Rigorous monitoring, reporting, and verification (MRV) protocols must be developed to accurately quantify the CO2 uptake, permanence of storage, and environmental impacts.

In this regard, the NSF can play a crucial role in fostering collaboration between researchers, industry, and regulatory bodies to establish robust MRV frameworks. Investing in cutting-edge monitoring technologies, can provide crucial insights into the ecosystem dynamics and inform decision-making.

Comprehensive environmental impact assessments should be conducted to evaluate the potential risks and develop mitigation strategies. Concerns regarding the impact on deep sea ecosystems, marine life, and trophic interactions must be thoroughly investigated through in-situ studies and long-term monitoring programs.

By prioritizing research in this area, the NSF can help unlock the potential of this innovative MCDR approach, contribute to climate change mitigation efforts, and foster economic development and environmental justice for communities impacted by Sargassum inundations. With robust MRV protocols, environmental impact assessments, and a commitment to responsible stewardship, this MCDR approach could become a vital component of the global climate action strategy.

From: Marcela Mulholland (b) (6)
Sent: Friday, April 19, 2024 1:56 PM
To: Light, Tricia M. EOP/OSTP
Cc: Giana Amador
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: CRA mCDR RFI.pdf

Hi Tricia!

Please see the Carbon Removal Alliance's RFI response attached. Thanks for all your work supporting the FTAC and please let us know if there are other ways we can be helpful.

Warmly,
Marcela
--

Marcela Mulholland (she/her)
Deputy Director of Partnerships
Carbon Removal Alliance
(b) (6)

Carbon Removal Alliance

RFI Document Citation: 89 FR 13755
Re: Marine Carbon Dioxide Removal Research Plan
April 19, 2024

To whom it may concern,

The Carbon Removal Alliance appreciates the opportunity to provide a response to the NSF RFI on the Request for Information regarding the Marine Carbon Dioxide Removal Research Plan.

The Carbon Removal Alliance (CRA) narrows the gap between innovators and policymakers working to remove carbon from our atmosphere. We're a coalition of 25 of the industry's most promising companies, including leaders in marine CDR (mCDR) like Carboniferous, Equatic, Ebb Carbon, Planetary Technologies, Running Tide and Vesta. Unlike typical trade associations, we're a nonprofit driven by our principles of high-quality and permanent carbon removal (CDR). We're working to build an industry worthy of investment — one that's good for the climate, economy and people.

We believe that mCDR is an essential part of the carbon removal portfolio needed for the United States to meet its climate goals. Because many of these technologies are early-stage, the federal government has a critical role in spurring their development and deployment of these technologies. CRA and our members look forward to working with the Fast Track Action Committee (FTAC) on advancing its work related to mCDR. Our recommendations in the pages below focus on the following themes:

1. Improving clarity and timelines across existing permitting regimes, including those established through the Clean Water Act (CWA) and the Marine Protection, Research, and Sanctuaries Act (MPRSA). We support the development of fit-for-purpose regulatory regimes that appropriately value the potential climate benefits of mCDR and mitigate any potential risks where current regulation is inadequate to govern responsible innovation,
2. Scaling RD&D on mCDR at a scale commensurate with its role in our portfolio of climate mitigation options.This work must also make certain that programs and policies are aligned with the realities of mCDR innovation, particularly supporting projects that have *both* research and commercial goals, and
3. Ensuring the government is equipped with the staff, tools, resources, systems and policies needed to support emerging mCDR companies, researchers, and communities.

Sincerely,

Giana Amador
Executive Director

Question #1

We view mCDR as a critical piece of a national climate strategy alongside steep emissions reductions and other carbon removal technologies. Research from the National Academies has found that mCDR technologies like ocean alkalinity enhancement (OAE) and electrochemical processes could each contribute more than 1 Gt CO_2 per year of removals, out of the 10-20 Gt per year of removals needed by 2100. These technologies are critical components of a comprehensive US CDR strategy.[1]

The future of our member companies, particularly those working in mCDR, will be significantly impacted by the Administration's mCDR plan — investor confidence, site selection, and future business development plans are directly influenced by the outcomes of the mCDR FTAC. With this in mind, we hope to see the Administration's mCDR plan include:

1. Near-term timeline clarity for permitting mCDR and long-term fit-for-purpose regulatory and permitting pathways for mCDR.
2. Policies and incentives that support mCDR research, demonstration, and deployment commensurate with the carbon removal potential of the ocean.
3. Increased administrative mCDR staff capacity and expertise.
4. More effective interagency coordination, specifically between NOAA, DOE, EPA, DOI (BOEM), NSF and NASA.
5. Recognition that mCDR innovation and commercialization are inextricably linked.

Question #2

CRA and our member companies are committed to developing and deploying mCDR technologies responsibly, working hand-in-hand with regulators and impacted communities. As the Administration is looking to better understand and establish the safety and efficacy of various mCDR approaches, they can and should consider companies as partners in those efforts — early stage research and demonstration taken on by companies can give us critical information on the efficacy of mCDR approaches. However, there are barriers to responsible RD&D in the US due to current regulatory regimes. Without more clarity, companies may move abroad to clearer regulatory environments, or worse, companies may pursue poorly regulated deployment outside of the US — risking our ability to meet our climate goals, reducing the US' competitive advantage, and decreasing the health of the earth's oceans. Clear permitting processes would facilitate a range of field tests and demonstrations of different mCDR technologies to ultimately determine which technologies are most effective at delivering impactful climate and co-benefits with the lowest environmental risks.

On Regulation & Permitting

Existing permitting statutes, including the CWA and MPRSA, provide essential legal protection to our oceans and natural ecosystems. This is paramount. Simultaneously, to better understand the efficacy of mCDR technologies, these legal frameworks must be updated to ensure responsible RD&D efforts and eventually, to govern deployment of mature technologies. To facilitate better processes, we recommend the following:

1. Setting clear timelines for permitting processes.
2. Establishing a multi-agency pre-permitting consultatory process in which individual companies can meet with agencies involved in permitting.
3. Making transparent the high-level takeaways from projects that have already successfully navigated the permitting process.

[1] National Academies of Sciences, Engineering, and Medicine; Division on Earth and Life Studies; Ocean Studies Board; Committee on A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington (DC): National Academies Press (US); 2022.

Within the CWA and MPRSA, we also believe that the FTAC has a role in clarifying and refining these regulations to more accurately address the unique benefits and risks of mCDR, specifically:

1. Clarify that coastal carbon capture projects, including those led by the Army Corps of Engineers, fall under the CWA. This applies to projects that raise the height of the ocean floor in coastal areas and those designed to enhance coastal protection.
2. Refine total suspended solids (TSS) limits in the CWA to account for the specifics of various outflows from mCDR projects, including addressing specific solid types and ocean geographies (e.g. mixing zones).
3. Clarify that mCDR projects that have *both* research and commercial outcomes are eligible under MPRSA, and consider leveraging special permitting authority to grant permits in the near-term for mid-sized nth-of-a-kind projects.
4. In addition, we recommend that EPA take an ecologically adaptive approach to regulating mCDR.

Traditionally, regulatory frameworks treat any environmental impact as negative and seek to minimize or avoid them altogether. In contrast, mCDR approaches seek to maximize a beneficial ecological impact — net removal of CO_2 — while minimizing all other impacts to living ecosystems. As such, traditional permitting frameworks do not account for the pressing need to remove atmospheric CO_2 by active intervention, like mCDR. To address this, EPA could first define a permitting approach based on potential negative environmental impacts which are independent of the scale of mCDR activities and then actively regulate the project using an ecologically adaptive approach. This means establishing baseline environmental parameters for specific ecosystem properties we wish to maintain. Depending on the ecosystem and mCDR approach in question, these will differ for every project. This framework could be built into existing or future fit-for-purpose regulations.

Take a hypothetical mCDR project that sinks terrestrial biomass in an anoxic basin. To ensure the safety and health of impacted marine ecosystems, a key set of environmental parameters (such as pH, dissolved inorganic carbon or methane, or water oxygen and nutrient levels, among others) should remain at predetermined, safe levels. The EPA could use their authority under MPRSA to issue a general permit for mCDR that requires these parameters — established on a project-by-project basis — are actively monitored throughout the project's life cycle and for some time after completion.

On Staff Capacity

Sufficient mCDR expertise and staff capacity is critical among agencies involved with mCDR. Without it, there's a risk that regulators impose requirements that aren't workable for the sector or under-protect against hazards. To this end, we recommend expanding NOAA's Knauss Fellowship Program to 1) create fellowship positions focused on mCDR, 2) embed these mCDR fellows in other agencies involved with funding and permitting mCDR, like DOE and EPA, and 3) provide pathways for career progression for these mCDR fellows. We also recommend leveraging the Intergovernmental Personnel Act (IPA) to bring mCDR experts from NGOs into government positions.

On Research and Commercialization

We'd like to clarify mCDR *research* activities and mCDR *commercialization* activities, and why the distinction at this stage in the sector and in light of concerns raised by the London Protocol could be a limiting factor. Meeting the Administration's climate goals will require swiftly deploying a technology development playbook — used historically for other climate technologies like solar and wind — for mCDR. This type of innovation must harness the capital, capacity, and expertise of the private sector and recognize the positive feedback loop between research and commercialization. The vast majority of global in-field trials on mCDR today are pursued by at least one private sector company. While these companies are focused on large-scale commercial deployments in the long-term, their RD&D activities today have critical learnings on the efficacy and safety of mCDR technologies as a whole. Many of these companies and this research would not exist without advance market commitments like those developed by Frontier Climate or other potential for commercial sales. For this reason, we would discourage the Administration from creating unnecessary distinctions between mCDR research activities and mCDR commercialization activities. Doing so would leave private sector funding on the sidelines and hamstring our ability to test and develop mCDR technologies. In addition, funding only research led by academic institutions may hamstring our ability to scale proven technologies with the urgency required by the climate crisis. We believe the best way to advance responsible mCDR research is to integrate research with pilot-scale projects that may have commercial outcomes while building basic science and monitoring capabilities within the agencies. Without practical programs and policies that integrate commercialization and research, there is a real risk of pushing the industry as a whole toward “the valley of death.”

Question #3

CRA works with companies developing a wide-array of permanent mCDR technologies that are durable over timescales comparable to the atmospheric lifetime of carbon emissions. To give you a snapshot: Carboniferous harnesses plants’ ability to fix carbon and pair it with preservation in anoxic basins; Equatic electrolyzes seawater to remove atmospheric CO_2; Ebb uses electrochemistry to enhance the ocean's natural ability to safely store CO_2; Planetary Technologies uses OAE to accelerate the geochemical carbon cycle; Running Tide couples carbon buoys with their open ocean verification fleet to deliver verifiable carbon removal; and Vesta adds a carbon-removing sand made of the natural mineral olivine to coastal systems. Many of these technologies are still in development — it will be key for the government to pursue a portfolio approach for mCDR research and be careful to not choose technology “winners” too soon.

One of the major barriers facing mCDR technologies today is around monitoring, reporting, and verification (MRV). The federal government should make significant investments in setting the bar for high quality MRV by developing rigorous and transparent quantification standards for mCDR. In addition, the government can support private sector and civil society work on MRV through efforts on MRV technology development, ocean systems and numerical model development, associated computing infrastructure, and data collection and management. All of these investments can improve our certainty of the climate impacts of mCDR technologies.

Lastly, a federal mCDR research agenda must explore both the risks and potential non-CO_2 co-benefits of mCDR technologies. Many of the technologies used by our member companies may have a wide array of ecosystem and community benefits including supporting local fisheries, creating jobs, and reducing coastal acidification. It will be important to better understand these benefits so that companies can honestly and transparently engage with communities about potential benefits of projects, alongside their risks.

Question #4

The federal government has a unique role to play in providing public resources to shape the future of mCDR in the following areas.

Education & Technical Assistance:

- Establishing the government's formal, public position on mCDR.
- Leveraging NOAA's existing relationships with coastal communities to pave the way for mCDR education.
- Providing direct technical assistance to state and local agencies permitting mCDR projects in their jurisdictions.
- Creating publicly available resources on the potential co-benefits that mCDR technologies projects can generate for host communities.
- Creating an institution — similar to the Regional Wildlife Science Collaborative for Offshore Wind — to facilitate collaboration between ENGOs, industry, and state and federal agencies working on mCDR.
- Providing best practices for companies and academic institutions on community engagement related to mCDR technologies including, but not limited to, with Indigenous and disadvantaged communities.

Permitting: As stated in our response to question #2, we encourage the EPA to go beyond existing guidance and issue fit-for-purpose permitting pathways for mCDR solutions. The mCDR sector would benefit from further permitting clarity to support commercialization and financing efforts and ensure that RD&D and development stays in the US. This includes publishing high-level takeaways from projects that have already successfully navigated the mCDR permitting process.

Standards: As the DOE's CDR Purchase Prize is implemented, we hope to see DOE, in collaboration with FTAC, set high standards to inform the work of mCDR technology developers as well as private sector, voluntary buyers of CDR. We believe the most influential thing the federal government can do to support safe and effective deployment of mCDR is to purchase mCDR credits and publish the MRV standards, safety protocols, and community benefit guidelines used to assess these credit purchases. This type of data would create a blueprint for other buyers on how to evaluate mCDR technologies.

Question #6

We would like to see the federal government 1) increase funding for mCDR RD&D, 2) put in place fit-for-purpose regulations that balance safety with pace, and 3) install policies and incentives supporting the development and commercialization of mCDR. Funding for mCDR should be proportional to its potential as a climate solution. For example, the National Academy of Sciences (NAS) recommends that mCDR RD&D would need a minimum of $125 million of funding over the next 2 to 10 years to carry out activities including development of standardized monitoring and carbon accounting methods, development of a domestic mCDR legal framework specific, and research to improve community engagement. Additional funding is also needed to advance research for specific approaches. For example, the NAS recommends that OAE research, including lab and field experiments and research into appropriate monitoring and accounting schemes, receive $125 to $200 million in dedicated funding and that electrochemical processes receive a minimum of $350 million in funding over the next 5 to 10 years.

We believe that mCDR should receive the same types of commercialization and technology support that the federal government provides for other other CDR pathways and climate technologies more generally. It is our hope that the federal government will embrace an approach to mCDR that recognizes both the urgency of scaling this sector and the need to do so safely. Ultimately, effective public-private collaboration is key here — our companies have a host of information on project details and stand ready to work with members of the FTAC.

From: Jaime Palter (b) (6)
Sent: Wednesday, April 10, 2024 2:18 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: FTAC_Response.docx

Dear Dr. Light,

Please find my attached response to the RFI on Marine Carbon Dioxide Removal research. I am an Associate Professor of Oceanography at the University of Rhode Island and I am currently engaged in research on mCDR. I have contributed to organizing 3 academic workshops on this topic since 2020.

Best regards,
Jaime
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Jaime Palter (she/her)
Associate Professor
Graduate School of Oceanography
University of Rhode Island
313 CACS
(b) (6)
Website:
>https://jaimepalter.wixsite.com/urigso/<

1. How would a Marine CDR Plan affect you, your organization, or your community?

As an academic scientist trying to learn about processes in the ocean, both in basic and applied research areas, I would benefit from mCDR funding as a new way to support this research. Moreover, our mission is to educate a new generation of oceanographers and funding for graduate students and postdoctoral researchers included in federal mCDR funding would benefit my research group and our University. Finally, some mCDR approaches (particularly blue carbon restoration projects, enhanced coastal weathering, and ocean alkalinity enhancement) may bring environmental co-benefits worthy of investigation.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

I believe the Federal Government should prioritize research on the following techniques because of their potential to scale for meaningful climate change and/or ocean acidification mitigation:

a. Ocean Alkalinity Enhancement and Coastal Enhanced Weathering
b. Direct Ocean Removal of CO_2 and sequestration

Salt marsh and mangrove restoration should retain its longer-lived priority funding despite relatively low likelihood of scaling as a climate mitigation solution, but because these strategies may carry considerable co-benefits for coastal resiliency, biodiversity, and health of coastal fisheries.

I am very concerned that mCDR strategies that target photosynthetic fixation of carbon to induce a surface pCO_2 deficit (iron fertilization, macroalgae cultivation, artificial upwelling) are dead-end distractions from more promising approaches. Given that the total organic carbon that now sinks into the deep ocean represents roughly 20 billion tons of CO_2, mCDR via iron fertilization or macroalgae cultivation would need to increase the global export productivity by 5% to have even a chance of achieving 1 $GtCO_2$ removal per year. It seems extremely unlikely that humans could intentionally alter ecosystems at this scale without causing enormous disruption to existing marine life. With this simple logic test, one should immediate be alerted to the unfavorable risk/reward ratio for this approach.

On the other hand, Ocean Alkalinity Enhancement and Direct Ocean Removal would act on a background of vigorous exchange (gross exchange of about 350 $GtCO_2$ per year, with a net uptake by the ocean of about 10 $GtCO_2$) and can be thoroughly investigated to find the most benign to ecosystems in laboratory, mesocosm, and small-scale field experiments along the path to larger, commercial deployment.

Prolonging work on solutions that have little ability to scale without harm is not a value-neutral proposition: The work has the potential to poison public sentiment against more promising techniques, and it consumes precious financial resources and our limited capacity as oceanographers.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Community engagement should be treated with the same urgency as the science, with earmarked funding for the appropriate, knowledgeable practitioners.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

The end goal (which may take a decade or two to build) should be a regulated market, with very strong protocols for MRV, including requirements for data reporting.

From: Connor Mack (b) (6) [redacted]
Sent: Tuesday, March 19, 2024 2:22 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan

Hi Tricia,

Thank you for all the work you guys are doing through the FTAC. I have a general, more informal comment around graduate student funding that I would like to add to the conversation.

My broad recommendation is this: A federal funding mechanism should be created for the express purpose of funding graduate student research in mCDR.

With relatively little funding, dozens if not hundreds of graduate students could be funded to pursue mCDR research. This would be transformative for the industry for a number of reasons.

First, it would help educate the next generation of marine science and policy leaders and equip them with the skills and knowledge they'll need to work on the difficult research problems mCDR presents.

Additionally, an independent funding mechanism would allow students the freedom to operate outside of the funding constraints of particular PI's research interests. The incumbent generation has been slow to adapt to the emergence of mCDR and a federal funding mechanism for graduate students to pursue mCDR would help shift the research conversation far more quickly than would otherwise happen using traditional research grants.

The recent NOAA and DOE funding announcements for example were a great step in the right direction, but represent only a small number of projects with a few graduate students involved. With much less funding, a federal funding mechanism could fund hundreds of research projects led by graduate student researchers which would foster collaboration between more senior scientists who can advise them without having to directly fund each project.

The interdisciplinary nature of mCDR would also lend itself towards more diverse advisory teams for each of these graduate projects that could help address questions around not only the science but policy and stakeholder engagement as well.

In terms of ROI, funding graduate students directly could arguably be one of the highest impact ways for the federal government to allocate dollars towards mCDR.

Thank you for your time,
Connor

--
Connor Mack
MAS Climate Science & Policy
PhD Student
Scripps Institution of Oceanography, UC San Diego

From: Alexander Facey (b) (6) [redacted]
Sent: Wednesday, April 24, 2024 4:52 AM
To: Light, Tricia M. EOP/OSTP
Cc: Management
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan.pdf

Hi Tricia, I am an entrepreneur submitting the following letter regarding the RFI for the Marine Carbon Dioxide Removal Research Plan.

Alexander Facey
Cofounder & CTO
Samudra Oceans

Alexander Facey
Samudra Oceans, Shoreditch Exchange, Senna Building
Gorsuch Pl, London E2 8JF, UK
April 24, 2024

To the National Science Foundation.
I am a greenhouse gas removal entrepreneur working on ocean-based carbon removal through my company Samudra Oceans.

I’m writing to express my strong support for the establishment and expansion of startup incubator programs specifically tailored for startups focused on ocean-based carbon removal technologies. As the global community seeks viable solutions to combat climate change, the ocean presents a vast and relatively untapped resource for carbon sequestration.

Ocean-based carbon removal technologies, including methods like algae cultivation, artificial upwelling, and electrochemical conversion, hold significant potential to reduce atmospheric CO2 levels. However, the development of these technologies faces unique challenges, such as high initial research and development costs, regulatory hurdles, and the need for specialized scientific and business expertise.

Incubator programs dedicated to this sector could provide crucial support in the form of mentorship, funding, and strategic partnerships, thus facilitating rapid technological advancements and commercial scalability. For example, my startup participated in the AirMiners Launchpad accelerator, and it was catalytic for our success. Such initiatives would not only foster innovation but also accelerate the deployment of effective carbon removal strategies, contributing significantly to global efforts to mitigate climate change.

The leadership of the NSF in supporting these endeavors is vital. By prioritizing and investing in accelerator programs for ocean-based carbon removal, the NSF can play a pivotal role in nurturing the growth of startups that may hold the keys to our future sustainability.

Thank you for considering this vital initiative. I am eager to see how the NSF’s support can transform our capabilities in fighting climate change through innovative and sustainable ocean-based solutions.

Sincerely,
Alexander Facey
(b) (6)
Samudra Oceans

From: Grace Andrews (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 10:37 AM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan RFI response
Attachments: FTAC mCDR RFI Response.docx

Hello,

Please find attached responses to the mCDR RFI. These are being submitted on behalf of Hourglass Climate, a nonprofit organization focused on independent and transparent scientific research into Ocean Alkalinity Enhancement strategies.

Thank you for the consideration,
Grace Andrews

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Grace Andrews, PhD
Executive Director

MCDR-FTAC Marine Carbon Dioxide Removal Research Plan RFI Response

1. How would a Marine CDR Plan affect you, your organization, or your community?

We represent a nonprofit research organization that is focused on marine CDR strategies. A primary aspect of our mission is to facilitate transparent and informed stakeholder knowledge around marine CDR. A federal marine CDR plan is critical for demonstrating to stakeholders that our mission, and the research we conduct in support of this mission, is aligned with government priorities. This is an essential proof-point for community trust building conversations, federal and state field trial permitting, as well as our ability to generate non-federal (e.g. philanthropic) dollars to further bolster net investment in this space.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Our primary concern around marine CDR research regulation is the lack of clear, timely and common-sense regulatory pathways for acquiring field trial permits. In our experience, the lack of regulatory pathway has resulted in incredibly drawn out (multi-year) timelines for field trial permits. No entity (academic, nonprofit, or startup) currently undertaking field trials in this space has the readily available resources (personnel, capital) to wait out these long and uncertain timelines. Permitting uncertainty will end up being a major catalyst for the failure of these entities, and in turn, for the field to develop on climate-relevant timelines.

The federal government could support marine CDR field research by 1) establishing clear and considered regulatory pathways for immediate field trial permitting - keeping in mind that not all marine CDR strategies are necessarily best regulated by the same legislation, 2) committing to the development of bespoke, fit-for-purpose marine CDR legislation on longer timescales 3) establishing a technical advisory committee to work with states and help them make informed decisions during marine CDR field trial permitting (e.g. best practices for field research).

The federal government also needs to commit substantially more funding to support research into marine CDR strategies. A 2022 report by National Academies of Science, Engineering and Medicine (NASEM) called for $301.5 million annually in funding, for a ten-year investment of $2.41 billion. Currently, the federal government is falling significantly short of that. According to a Carbon to Sea Initiative 2024 report, the federal government provided only $61.5 million in FY23 funding.

The most commonly cited research needs for marine CDR are real-world field trials of the range of mCDR techniques currently in development with the goal of assessing their true safety and efficacy. We echo this call, and note the key role the federal government can play in supporting field trials by issuing the significantly-sized award amounts that are necessary to conduct scientifically rigorous field trials. Based on our experiences, we estimate that individual field trials cost around ~$6M each because of their multi-year nature (project planning → permitting → execution → assessment of short-term AND long-term impacts), their interdisciplinary nature (oceanography, geochemistry, ecology, microbiology, etc.), and the substantial community engagement that is required. These large award amounts are typically too much for VC capital interest or individual philanthropic donors.

However, we also want to emphasize that there is much more research than just field trials that need federal funding support. Often overlooked is the need for tool development to help in the responsible and transparent planning, permitting, and MRV (measurement, reporting, and verification) of mCDR projects. We need quantitative, model-based environmental risk assessments bespoke to mCDR projects and their unique ecological impacts. We need open-sourced carbon removal quantification models to produce rigorous estimates of CDR and their uncertainties. We need long-term data repositories.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

We advocate for the development of Ocean Alkalinity Enhancement strategies based on alkaline mineral dissolution. In general, OAE techniques are incredibly promising because they are believed to have low potential for environmental impact relative to other mCDR strategies. Mineral-based OAE techniques in particular, however, have some of the lowest energy requirements and highest scale potentials of all OAE techniques. They require upfront grinding of rock and one-time placement by boat, but otherwise require no on-going energy unlike electrochemical OAE, for example. Their long-term scale potential has few constraints as the ingredients for these techniques are essentially just rock and continental shelf. The Earth happens to have quite a bit of both. Estimates of their potential suggest they could capture ~1 Gt CO_2 per year (Pamieri and Yool, 2023).

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

The government should issue a report on the need for mCDR including an assessment of scientific knowns and unknowns in the style of IPCC reports that allow for qualitative assessment (e.g. low, medium, high confidence) and research priorities.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Field trials are being conducted by startups (e.g. Ebb, Vesta, Planetary), NGOs (e.g. Carbon to Sea, CWorthy, Hourglass Climate), and academics (e.g. Woods Hole Oceanographic Institute). Currently, many startups are conducting rigorous science, but when the federal government engages with start-ups, particularly through funding and permitting, they should require partnerships with independent scientific entities that lack profit motives (NGOs and academics) to ensure that the research and results can be trusted by the public. Similarly, the federal government should require data transparency for the same reason. We appreciate that some startups may be resistant to full data transparency due to IP considerations, but at this early stage in technological development, we nonetheless feel it should be mandated. These climate interventions are occurring in the commons. The public has the right to know the results of field trials and make informed judgements and decisions about these technologies. We do not believe there is a meaningful difference between “research” and “commercial” field trials as long as independent scientific entities are always involved and data is transparent, and we encourage the federal government to take a similar viewpoint.

From: Albert K Liu (b) (6) >
Sent: Tuesday, April 23, 2024 3:06 PM
To: Light, Tricia M. EOP/OSTP
Cc: Tessa Hill; Alyssa Jean Griffin; Ana Lucia Cordova
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan RFI Response
Attachments: NSF Marine CDR RFI Response - UC Davis.pdf

To whom it may concern,

The UC Davis Office of Research and Coastal and Marine Sciences Institute are pleased to provide a response to the NSF Marine Carbon Dioxide Removal Research Plan Request for Information. We thank you for the opportunity to comment on this subject and look forward to future collaboration.

Best,
Albert Liu

Albert Liu, Ph.D.
Strategic Initiatives Coordinator
Interdisciplinary Research & Strategic Initiatives
Office of Research
(b) (6)

UCDAVIS

April 23, 2024

Subject: Marine Carbon Dioxide Removal Research Plan Request for Information (RFI)

To Whom It May Concern:

The University of California, Davis Office of Research is pleased to provide a response to this RFI from the National Science Foundation regarding the Marine Carbon Dioxide Removal Plan. The UC Davis Coastal and Marine Sciences Institute (CMSI) addresses research needs and engages in educational and outreach activities in support of Californian coastal regions. With the locational capabilities of the Bodega Marine Laboratory and Bodega Marine Reserve, the UC Davis CMSI is uniquely positioned to further study the effects of climate change on our oceanic ecosystems.

Enclosed are responses from faculty members Professors Alyssa Griffin and Tessa Hill to the questions outlined in the RFI. Dr. Alyssa Griffin specializes in marine biogeochemistry, with a specific research emphasis on the marine carbon cycle and carbon storage. Dr. Tessa Hill's research focuses on the effects of climate change on coastal habitats and ocean acidification, as well as carbon flux through seagrass ecosystems.

Questions about this RFI response can be directed to Dr. Alyssa Griffin, [redacted], and Dr. Tessa Hill, [redacted].

The UC Davis Office of Research and the UC Davis CMSI appreciate the opportunity to comment on the Marine CDR Plan and look forward to future collaboration.

Tel: [redacted]
One Shields Avenue, Davis, CA 95616
ucdavis.edu

1. How would a Marine CDR Plan affect you, your organization, or your community?

There are several UC Davis faculty engaged in mCDR research who would be interested in the development of a research framework. Additionally, these faculty regularly engage in public-private and community engaged partnerships, so would be interested in support for a research plan that addresses these axes of mCDR research as well. The mCDR industry continues to move forward and it is imperative that ocean scientists collaborate and codevelop frameworks for mCDR methods, field piloting, and MRV (monitoring, reporting, and verification). Currently, the industry and subsequent markets are highly unregulated and without more guidance and oversight, the industry may move forward without the required expertise or safeguards against potentially negative environmental and societal consequences. A framework and research plan can still provide opportunities for fundamental research while also training the next generation of scientists in applied ocean biogeochemistry and related fields.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

***What questions or concerns do you have about the regulation of marine CDR, including marine CDR research*?** Much of the work on MCDR is currently being driven by private industry and has been a bit of a race to develop techniques without typical research protocols and practices employed by federal/state agency oversight that are usually in place. The rapidity and intensity of research driven primarily by private industry has the potential to not carefully consider negative consequences including ecological and environmental disruption associated with MCDR techniques.

In order to be effective, mCDR strategies must be both additional, meaning it would not have occurred without the intervention, and durable, meaning it is removed from the atmosphere for centuries to millennia. In order to demonstrate this, monitoring, reporting, and verification (MRV) that is both rigorous and transparent must be developed and regulated. Without regulation, there is no motivation for mCDR industries to be forthcoming about the true effectiveness of their strategies -or- the methods used to determine purported effectiveness. An additional concern is that MRV in the ocean, particularly in the coastal ocean where many mCDR strategies are piloted, is not a trivial task. MRV requires the establishment of a baseline (to demonstrate additionality) which is a task ocean biogeochemists have been working towards (and continue to work towards) for decades prior to the emergence of mCDR.

What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? Contributing the resources necessary to provide quality baseline data and understanding of marine carbon cycling in a variety of marine environments will be essential to meet MRV standards and to assess the safety and efficacy of mCDR strategies. This includes, but is not limited to, resources that support rigorously vetted biogeochemical models, autonomous sensors for broader data collection (e.g., BioARGO), development of additional sensors (e.g., in situ alkalinity sensor), fundamental science in how carbon moves through the ocean and interacts with marine life, potential ecological and organismal responses to specific mCDR strategies and resulting biogeochemical changes, and transdisciplinary research on the societal impacts and equity of mCDR approaches.

Additionally, large-scale pilot studies should not move forward until a framework is in place and the mCDR has been rigorously and transparently vetted at bench or mesocosm scales. An example of unregulated pilot experiments in mCDR with unintended consequences is an ocean iron fertilization experiment that resulted in a toxic diatom bloom which negatively impacted surrounding ecosystems and food webs. Pilot studies and field trials are critical to assessing mCDR strategies, however, agencies must find a way to balance ability to conduct these experiments while also requiring (to a reasonable degree) that preliminary research has demonstrated scalable safety and efficacy.

What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? Like all natural systems, the ocean is complex with several interacting processes playing out over broad spatial and temporal scales. Quality MRV will not be possible if a baseline or fundamental understanding of carbon cycling in the ocean is not achieved. Although scientists broadly know how carbon moves through the ocean, there are nuanced processes that have yet to be elucidated. I have listed a few fundamental questions that must be answered to move forward with any effective mCDR strategies:

- Is the system where the strategy is being deployed currently a source or sink of carbon to the global ocean and/or atmosphere?
- What are the dominant processes responsible for the cycling of carbon in the system of interest/deployment?
- What are the potential biological, ecological, and organismal responses in the system to predicted biogeochemical changes resulting from the proposed mCDR strategy?

What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

See above with emphasis on MRV to demonstrate additionality and durability (efficacy) and biological/ecological/organismal response (safety). Data from these efforts should be publicly available, accessible, and quality-assured to promote equity and transparency.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

- Ocean alkalinity enhancement via enhanced mineral weathering
- Restoration and conservation of blue carbon ecosystems: Least risky in regards to the environment, public health, communities and other uses of the sea
- Combination of the two strategies above (using minerals that when weathered, enhance alkalinity to restore and protect coastal blue carbon ecosystems): Has the potential to provide additionality while preserving and perhaps enhancing the natural carbon removal and capture of vegetated coastal ecosystems (blue carbon ecosystems). Additionally, preserving these ecosystems maintains the copious ecosystem benefits (and monetary value) these systems already provide.
- Sinking of kelp/other organic matter has little to no promise as an mCDR strategy. I have not seen clear evidence that this strategy can demonstrate efficacy at the scale required for impactful mCDR.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Field testing should not be conducted without rigorous public engagement of coastal communities, particularly those who are most vulnerable to climate change. In addition, general public outreach and education should be prioritized so the public understands the general science behind climate and ocean change as well as mCDR strategies/approaches.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Resources and emphasis should be placed on mutually beneficial partnerships between researchers, private industry, and/or non profit organizations or communities. A challenge in effectively developing these partnerships is the time involved in relationship building between the entities involved; a Federal research plan could emphasize different opportunities/pathways to develop those relationships.

Non-profit organizations such as Ocean Visions have made tremendous efforts to bring together information, people, and data on mCDR. Their website has several resources which include a field trial database and a document titled "A Comprehensive Program to Prove or Disprove Marine Carbon Dioxide Removal Technologies by 2030". Also, the mCDR community has produced several reports and white papers regarding specific mCDR strategies as well as best practices (e.g., https://sp.copernicus.org/articles/special_issue1269.html). These efforts are in their infancy, but should continue to be supported to create unity across the mCDR research, technical, and financial communities.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

The rate at which mCDR research is moving is staggering and shows no sign of slowing. These efforts will continue to move forward around the world with little to no oversight if things are not addressed proactively. In order to meet global net negative emissions, technological approaches like mCDR will be required worldwide. If we do not act quickly, the US will be left behind in developing innovative solutions to the global climate crisis.

From:	Alyson Myers
To:	Light, Tricia M. EOP/OSTP
Subject:	[EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Date:	Tuesday, April 23, 2024 11:58:34 PM

White House mCDR Fast-Track Action Committee (FTAC),

We are delighted to see the Biden Administration's engagement with mCDR through the FTAC. We are aware through the IPCC, the National Academy of Sciences (NASEM) and others, Carbon Dioxide Removal at large scale is essential to stabilize our atmosphere and ecosystems which depend on historic parameters of temperature, rainfall, biogeochemistry of our oceans and more. CDR has the potential to benefit multiple ecosystems, including combating ocean acidification.

Fearless Fund (fearlessfund.org) is an ocean research and innovation organization committed to a stable climate through cautious and scaled research in the ocean. We own several sites on ocean-fed bodies of water where we would like to set up test beds, agnostic across methods but focused on highly productive methods that would have broad public acceptance and meet economic feasibility.

Our work has focused to date on photosynthetic macroalgae, funded by DOE for biofuels. The same work can be directed to mCDR. Accordingly, we seek to integrate Ocean Alkalinity Enhancement (OAE) as a way of optimizing our team's CDR through macroalgae. Permitting is a major concern, and we would like to see faster permitting for small scale research. We agree with public engagement early. This work must be on a fast track.

Please let us know how we can assist, and we look forward to the development of this essential activity for our economy and for the protection of species. Thank you.

Best Regards,

Alyson Myers
Fearless Fund President
>www.fearlessfund.org<
Direct: 2022979743

From: Jeanine Ash (b) (6)
Sent: Tuesday, April 23, 2024 10:10 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] mCDR FTAC RFI comments
Attachments: Capture6 FTAC mCDR RFI Response.pdf

Dear Ms. Light,

Attached are comments on the mCDR FTAC RFI for your consideration. Thank you so much,

Jeanine Ash

Jeanine Ash, PhD
She/Her
Director, Head of OAE and MRV
(b) (6)
(b) (6)
>www.capture6.org<
Follow us on LinkedIn
Our global project pipeline is expanding. Learn more!
Confidential. Capture6 proprietary work product. Do not distribute.

April 23rd, 2024

Tricia Light
White House Office of Science and Technology Policy
Re: Marine Carbon Dioxide Removal Plan
Submitted via email to (b) (6) [redacted]

Dear Ms. Light and colleagues,

Capture6 is a US -based public benefit corporation developing direct air capture (DAC) linked to ocean alkalinity enhancement (OAE) for the removal of carbon dioxide (CO_2). Our mission is to advance affordable and scalable carbon dioxide removal (CDR) that both produces additional freshwater and improves ocean health — allowing us to deliver gigaton-scale carbon removal globally while improving local water security for drought-prone communities and counteracting ocean acidification. Capture6 has four demonstration CDR projects globally that leverage technologies operating in large industries like desalination to catapult CDR delivery from 1,000 tCO_2/year to >1 $GtCO_2$/year by 2050.

We are in strong support of the committee's work and the attention being given to the development of an mCDR plan by the mCDR-FTAC. Within, we provide comments on the "*Questions to Inform Development of the Strategy*" as listed in the RFI.

1. *How would a Marine CDR Plan affect you, your organization, or your community?*

The National Academies of Science, Engineering and Medicine estimate that at least $1.5 billion USD funding is needed within the decade to facilitate the research, development, and deployment (RD&D) of mCDR technologies. We hope that the mCDR Plan will address the current funding gap and drive a means to deploy that funding via a federal research framework designed to advance mCDR RD&D. Within this framework, we request a roadmap for the responsible deployment of mCDR (i.e., via programs like the DAC Hubs rollout of DAC). A key part of that roadmap should be a clarified route to permitting mCDR research and deployments.

2.
   a. *What questions or concerns do you have about the regulation of marine CDR, including marine CDR research?*

      We are concerned that mCDR technologies (which involve the removal of carbon regardless of the methodology) will be conflated with climate adaptation activities like marine solar radiation management (mSRM) which may be a source of confusion to policymakers, regulators, and communities. It is our hope that the definitions of mitigation activities like mCDR remain distinct from adaptation activities like mSRM in the output of the committee.

capture6.org info@capture6.org

b. *What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field?*

We desire to see funding support for public institutions with existing marine observational and modelling activities (i.e., ‘test beds” to drive accelerated, pre-permitted field trials for a range of mCDR technologies. The challenge of each startup individually funding, permitting, staffing, and running its own mCDR field trial will be a significant roadblock to responsible but rapid mCDR deployment. Hosting field trials on communal test beds will be an excellent way to leverage the facilities and strong capabilities the US has already invested in (i.e., PNNL at Sequim) and to leverage the vast knowledge base staff scientists and engineers associated with those facilities have acquired through years of ocean observation, modelling, and engineering.

c. *What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research?*

We encourage the establishment of a permanent interagency working group to facilitate RD&D regulations.

d. *What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*

We urge the committee to recognize that public-private partnerships will be the fastest way to responsibly deploy mCDR and mitigate climate change, and in practice withdraw the distinction between “research” and “commercial” activities. We suggest that other distinguishing features of projects such as their scale, TRL stage, scope, and other impacts (i.e., community benefit) can be used in lieu of the research/commercial distinction.

3. *Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities or other uses of the sea?*

   At this stage, we encourage the Federal Government to initially develop a method-neutral portfolio of approaches to be supported in RD&D. We suggest that a research framework includes “gating criteria” to determine indicators of environmental, public health and

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social impacts that will increase the likelihood of responsible deployment and adjust future RD&D support accordingly, i.e., increased funding/support to mCDR approaches with low risk/high reward and reduced funding/support to high risk/low reward.

4. *What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?*

   We agree with the RFI response written by the Carbon Business Council which Capture6 provided input to which we quote here: *"The Federal Government has a critical role to play in public engagement and education with respect to mCDR. While public awareness is currently very low, initial polling suggests that coastal communities are open to the mCDR opportunity and concerned about the effects of climate change. We encourage the mCDR Plan to include significant funding and operating support for public engagement and education, and capacity building for marine NGOs.*

   Providing resources and support to state and local permitting authorities who may be unfamiliar with mCDR can potentially help to advance responsible RD&D. Similarly, the Federal Government can beneficially provide materials to support public engagement for mCDR RD&D and templates for effective and equitable community benefit plans.

   Initial mCDR field trials and pilot deployments are starting to scale and represent an excellent opportunity for the Federal Government to showcase the mCDR opportunity with site visits supported by clear, evidence-based communication and transparent data sharing."

5. *What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?*

   There are many institutions performing significant mCDR work including Ocean Visions, the Carbon 2 Sea Initiative, [C]Worthy, WHOI, MBARI, Ocean Networks Canada, the Indigenous Greenhous Gas Removal Commission, Sea Grant organizations and the Sabin Center for Climate Change Law.

   We suggest once again that public-private partnerships will be key to responsible but rapid deployment of mCDR RD&D. Questions about our ability to impact the atmospheric CO_2 burden through mCDR will not be answered by a single sector, but by an ecosystem of mCDR workers in collaboration.

capture6.org info@capture6.org

6. *What else would you like the Federal Government to consider as it develops a Marine CDR Plan?*

   High-quality, transparent, and socially just measurement, reporting and verification (MRV) methodologies must be developed in tandem with mCDR RD&D. We would welcome the introduction of federal standards for these measurements.

   Expansion of the 45Q tax credit to include mCDR will be a key accelerant for the field.

We thank you for your consideration of these comments and hope you find them helpful in your task. We're greatly appreciative of your work and the opportunity to submit input.

Sincerely,

Jeanine Ash, PhD
Director, Head of OAE and MRV
CAPTURE6 (b) (6)

capture6.org info@capture6.org

From: Galen McKinley <(b) (6) [redacted]>
Sent: Tuesday, February 27, 2024 8:08 AM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] mCDR
Attachments: Knowledge Gaps Ocean Carbon 12Nov2022.pdf

Dear Tricia Light -

This response that myself and colleagues provided in November 2022 to the OCAP development process remains highly relevant to the current development of an implementation plan, and thus I attach it here as I would like it to be taken also as input on the implementation plan.

Summary — The background ocean carbon sink is already taking up ~3 PgC/yr, and it will be orders of magnitude larger than mCDRs for decades to come. Yet our quantification of this critical carbon sink continues to have large uncertainties, particularly at the small time and space scales of mCDR. At a time when the observing system for the background sink should be strengthened instead, disinvestment is occurring; thus our monitoring system is increasingly fragile. Reasonably expected future change or variation in the background sink should be so large as to swamp any mCDR effects, and yet we are unable to adequately constrain such variability.

The mCDR implementation plan must take into account the need to improve monitoring and assessment of the background ocean carbon sink — if this is not done, we are wasting money to grow a few trees while increasingly losing sight of what the rest of the forest is doing. *I wish to impress upon you that it is the "forest" (=the background ocean carbon sink) here that will determine how much CO2 remains in the atmosphere to cause climate change, while the "few trees" (=mCDR) will have only a modest impact.*

I am quite concerned that this industry/government mCDR community is moving forward under the mistaken assumption that the background ocean sink is well-constrained today, accurately predicted for the future, and will be sufficiently monitored forever. This is simply not the case.

Thank you for taking this feedback and please let me know if you would like to discuss these points further.

Galen McKinley

Galen A. McKinley
Professor of Earth and Environmental Sciences
Columbia University, New York, NY
Lamont Doherty Earth Observatory, Palisades, NY
(b) (6) [redacted] (b) (6) [redacted]
mckinley.ldeo.columbia.edu leap.columbia.edu

Response to Ocean Climate Action Plan Request for Information (87 FR 60228)
Critical knowledge gaps in ocean carbon dioxide removal and sequestration
November 12, 2022

We are responding to this question as individuals with scientific expertise in the ocean carbon cycle, the global carbon cycle, and in ocean and climate science. As contributors to recent community activities on integrated ocean carbon research, observation-based estimates of air–sea carbon fluxes and marine carbon dioxide (CO_2) removal (mCDR), we are addressing the topic of ***efficacious ocean-based carbon dioxide removal and sequestration***.

Since the preindustrial era, the ocean has removed about 40% of fossil-derived CO_2 from the atmosphere (Friedlingstein et al. 2022[1]). Over the next ten thousand years, the ocean will absorb at least 80% of fossil CO_2 emitted by humans. The ocean is, without any human intervention, already performing *efficacious ocean-based carbon dioxide removal and sequestration*.

The ocean's uptake of anthropogenic carbon, or "ocean carbon sink," (Figure, right) occurs in response to the accumulation of anthropogenic CO_2 in the atmosphere, and is also influenced by the ocean's overturning circulation. The ocean carbon sink overlies the ocean's natural carbon cycle (Figure, left), which includes effects of ocean biological processes and circulation. The natural carbon cycle is quantitatively dominant (Figure, center) and drives large-amplitude air–sea CO_2 fluxes across the globe. However, when globally averaged for the modern ocean, these natural carbon cycle fluxes sum to approximately zero. This cancellation of natural carbon fluxes applies only at the global scale, while locally and regionally, natural carbon fluxes are, by far, dominant to the total ocean carbon cycle (total = natural + anthropogenic).

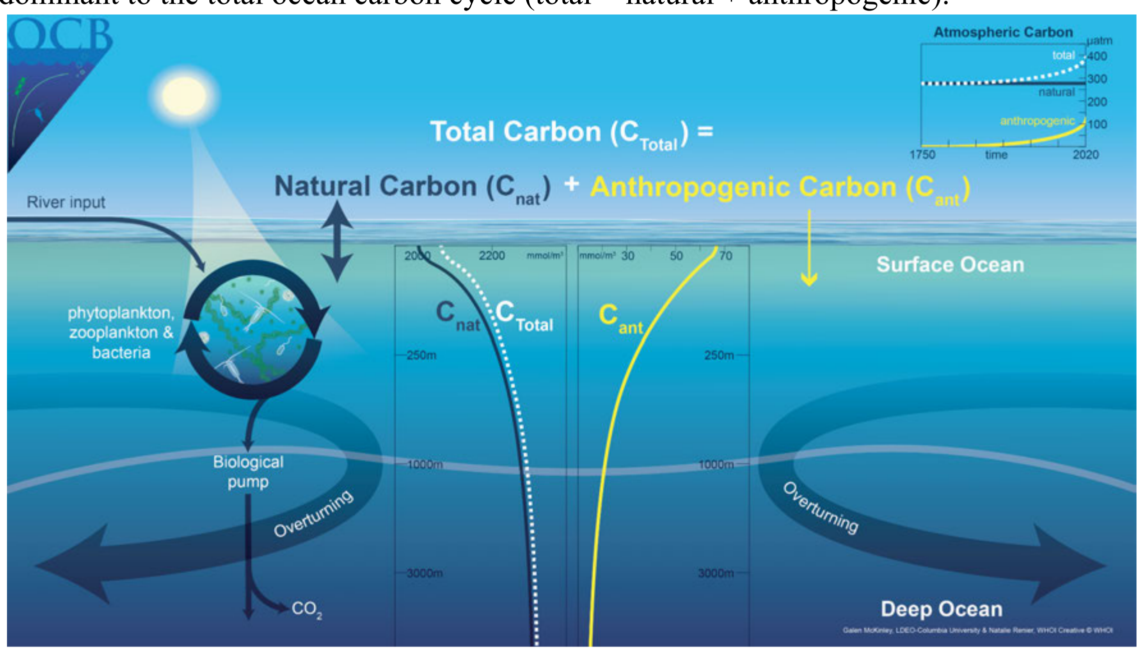

Figure 1: In the ocean, total carbon is the sum of natural carbon and anthropogenic carbon. While the global mean anthropogenic carbon uptake can be quantified with approximately 15% uncertainty, local and regional exchanges have much greater uncertainty(Crisp et al. 2022[2]).

1 https://doi.org/10.5194/essd-14-1917-2022
2 https://doi.org/10.1029/2021rg000736

In 2020, the global-mean magnitude of the ocean carbon sink was 2.9 ± 0.4 petagrams of carbon (10.6 ± 1.5 petagrams of carbon dioxide, Friedlingstein et al. 2022). Over the industrial era, this ocean sink has grown steadily in response to the atmosphere's continued accumulation of anthropogenic CO_2. The long-term decline of ocean pH, ocean acidification, is the inevitable consequence of this ocean CO_2 uptake. The ocean uptake of anthropogenic carbon dioxide will change significantly in the future due to the changing growth rate of atmospheric CO_2 and in response to climate change (Canadell et al. 2021[3]).

At present, a rapidly growing industry is promising to develop engineered approaches to enhance the ocean's carbon uptake, i.e. engineered ocean-based carbon dioxide removal and sequestration (or marine CDR, mCDR). As highlighted in the NASEM (2021)[4] report, there is much unknown about how these engineered sinks could be implemented, if they would have deleterious side effects, and if their efficacy could be measured.

We would like to emphasize a key issue that should not be ignored in the context of the enthusiastic pursuit of potential engineered sinks. This is the critical need to improve our ability to measure and model, understand, and quantify the ocean's total carbon cycle, which is the sum of massive and vigorous natural processes and the anthropogenic ocean carbon sink (Figure).

Globally averaged, the current uncertainty on our best estimate of the ocean carbon sink is about 15% of its mean value (numbers above). However, these uncertainties grow significantly as a percentage of the mean from global to regional scales, due primarily to the quantitatively dominant natural components of the carbon cycle (Bushinsky et al 2019[5], Hauck et al 2020[6], Fay and McKinley 2021[7], Regnier et al. 2022[8], Crisp et al. 2022, DeVries 2022[9]). The biological, chemical, and physical processes that lead to enormous carbon removal to the deep ocean are insufficiently observed and thus are characterized by significant knowledge gaps (Siegel et al. 2023[10]). Understanding of the ocean circulation processes that transport and mix carbon to the deep ocean must also be improved (Bronselaer and Zanna, 2020[11]). To summarize, despite a high level of scientific agreement across various studies as to the magnitude for the global average, there is large uncertainty in the cycling of ocean carbon at the local to regional scales on which engineered sinks could be implemented. These uncertainties are central to the challenge of quantifying the efficacy and assessing the durability of engineered sinks.

Moreover, the total ocean carbon cycle is dynamic over time and space, and in most regions it will be substantially larger than any engineered carbon sink for the foreseeable future. Thus, change or uncertainty in the ocean carbon sink will overwhelm the impacts of engineered sinks. If we do not develop better quantification and understanding of the ocean carbon sink across space and time scales, we will be effectively throwing away the potential to determine whether

[3] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter05.pdf
[4] https://doi.org/10.17226/26278
[5] https://doi.org/10.1002/2016gl068539
[6] https://doi.org/10.3389/fmars.2020.571720
[7] https://doi.org/10.1029/2021gl095325
[8] https://doi.org/10.1038/s41586-021-04339-9
[9] https://doi.org/10.1146/annurev-environ-120920-111307
[10] https://doi.org/10.1146/annurev-marine-040722-115226
[11] https://doi.org/10.1038/s41586-020-2573-5

or not additional *efficacious ocean-based carbon dioxide removal and sequestration* has occurred through engineered efforts.

Looking several decades into the future, engineered efforts will hopefully drive many additional petagrams of carbon dioxide into the ocean. From now until then, the ocean carbon sink will continue to evolve in response to changing atmospheric CO_2 levels and to climate change. When we do achieve widespread engineered sinks, we will still have the challenge of quantitatively diagnosing the effects of these technologies, and distinguishing them from the ocean carbon sink that occurs naturally. This will require detailed understanding of the complex and evolving interactions between natural and engineered processes. In other words, in order to account for carbon flows and thus to manage the climate in the long-term, we must have a sustained capacity to quantitatively understand the ocean carbon sink.

The US has long led the world in ocean observations, including carbon measurements. NOAA scientists are leading the collection of essential carbon observations and developing new platforms and sensors. Academics, other federal scientists and the private sector also contribute enormously to observations, technology development and essential scientific investigations, largely supported by federal grants. However, much of the funding is obtained through research grants that last only a few years. With this approach, we cannot adequately quantify the ocean's current *efficacious ocean-based carbon dioxide removal and sequestration*, or predict its future.

What do we need to achieve? In the US and internationally, we need an operational capacity to continually quantify ocean carbon air–sea fluxes and interior storage from the local to global scale. Just as the National Weather Service today provides continual diagnosis and prediction of evolving weather conditions, we need a "National Carbon Service" that continually updates decision-makers, private and public stakeholders and the general public about where carbon is coming from and going to in the Earth System. There is no doubt that such a system will be required for effective management of Earth's climate. This is a challenging, but achievable goal.

To achieve the ocean component of this grand vision, we must invest in:

- A robust and sustained network of observations of ocean carbon and related parameters that operates on >5-year grant cycles (e.g., www.aoml.noaa.gov/ocd/gcc/SOCONET)
- New platforms and technologies (e.g., new sensors to measure different forms of carbon in the ocean) to improve our capacity to measure the rapidly changing ocean carbon cycle
- Dedicated support for FAIR (Findable, Accessible, Interoperable, Reusable) management and provision of these data to support research and broader applications
- Meaningful, regularly updated derived data products for carbon accounting to inform research and decision making–today's data products are maintained by volunteers
- Improved computational models at local to global scales that support mechanistic understanding of critical processes and allow for robust future projections
- Mechanisms for collaboration with international partners, including UN-based organizations, in support of robust global ocean carbon observing and accounting system (Aricò et al. 2021)[12]

[12] https://unesdoc.unesco.org/ark:/48223/pf0000376708.locale=en

In closing, we ask that the new Ocean Climate Action Plan provide needed attention to measurements and quantification of the total ocean carbon cycle, which is already responsible for a huge amount of *efficacious ocean-based carbon dioxide removal and sequestration*.

We appreciate the opportunity to provide input to OSTP on the Ocean Climate Action Plan.

Galen A. McKinley, PhD | (b) (6) [redacted] | galenmckinley.github.io
Professor of Earth and Environmental Sciences, Columbia University
Chair, Ocean Carbon and Biogeochemistry Working Group on Air–Sea Carbon Flux Gaps
Member, NASEM Ocean Studies Board
Member, JASON Advisory Group

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Oceanographer, NOAA Pacific Marine Environmental Laboratory
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Member, Ocean Carbon and Biogeochemistry Working Group on Air–Sea Carbon Flux Gaps
Member, Scientific Steering Group for the International Ocean Carbon Coordination Project

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Member, Ocean Carbon and Biogeochemistry Working Group on Air–Sea Carbon Flux Gaps
Member, Ocean Acidification Research for Sustainability Working Group
Member, Scientific Steering Committee for the NCAR Community Earth System Model

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Distinguished Professor of Marine Science, University of California, Santa Barbara
Science Lead, NASA EXport Processes in the global Ocean from RemoTe Sensing (EXPORTS) field campaign
Executive Committee, Joint Exploration of the Twilight Zone Network, a UN Ocean Decade Programme

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Senior Advisory Board ICOS; Founding member of the Surface Ocean Carbon Observing Network (SOCONET)

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Research Scientist, Cooperative Institute for Climate, Ocean, and Ecosystem Studies, University of Washington, Seattle

Heather Benway, PhD | (b) (6)
Senior Research Specialist, Woods Hole Oceanographic Institution

From: Tito Jankowski (b) (6) [redacted]
Sent: Wednesday, April 24, 2024 11:48 AM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Re: Marine Carbon Dioxide Removal Research Plan
Attachments: AirMiners - Marine Carbon Dioxide Removal Research Plan.pdf

Whoops here's an updated version that includes more specifics about our focus on carbon removal.

On Wed, Apr 24, 2024 at 8:44 AM Tito Jankowski (b) (6) [redacted] wrote:

> Hi Tricia,
> I'm the founder of AirMiners, a DOE-funded startup incubator that has supported 150 carbon removal startups. I'm submitting the following letter regarding the RFI for the Marine Carbon Dioxide Removal Research Plan.
>
> Tito
>
> --
> **Tito Jankowski** (he/him)
> CEO @ AirMiners
> (b) (6) [redacted]
> phone: (b) (6) [redacted] (just call, we can get a lot done in 2 minutes)
> My weekly newsletter is "It's Go Time", sign up here

--
Tito Jankowski (he/him)
CEO @ AirMiners
(b) (6) [redacted]
phone: (b) (6) [redacted] (just call, we can get a lot done in 2 minutes)
My weekly newsletter is "It's Go Time", sign up here

AIRMINERS

Tito Jankowski
PO Box 5143 South San Francisco, CA, 94080
April 22, 2024

To the National Science Foundation.
I am writing on behalf of AirMiners to express our enthusiastic support for the NSF's initiative to back startups focused on marine-based carbon removal. This emerging field presents unique challenges and opportunities, which makes the role of accelerator programs critical in nurturing early-stage companies.

Accelerator programs are not just catalysts for technological innovation; they also play a crucial role in market formation. In the realm of carbon removal—a technology and market still in their infancy—the uncertainties faced by startups are magnified. Investors, customers, and manufacturers are currently assessing the viability of building a new industry capturing invisible gases from the atmosphere. Our experience shows that targeted support can bridge these gaps significantly.

AirMiners has directly witnessed the profound impact of such incubator programs. With a budget of about $2 million, including $100,000 from the DOE EPIC DAC Phase I, $300,000 from DOE EPIC DAC Phase 2, and $150,000 from DOE EPIC Round 3, we have supported 150 carbon removal startup companies, including ocean-based carbon removal as well as direct air capture, enhanced rock weathering, and biochar. Our graduates have raised over $110 million in further capital. This illustrates a substantial multiplier effect, where each dollar invested in acceleration not only propels technological advancements but also leverages significant additional investment.

Given the dual nature of the challenges—in both technology and market development—focused accelerator programs for marine-based carbon removal are indispensable. They equip startups with the necessary tools, mentorship, and networks to succeed in a competitive, uncertain market. Therefore, we advocate for the NSF's continued and expanded support in these areas, ensuring that the U.S. remains at the forefront of combating climate change through innovative marine-based carbon removal technologies.

Thank you for considering our perspective. We look forward to the possibility of further dialogue on how we can collectively advance this crucial sector.

Sincerely,
Tito Jankowski
Tito Jankowski, CEO, AirMiners
Email: (b) (6) Phone: (b) (6)

From:	Peter Fiekowsky (b) (6) [redacted] >
Sent:	Monday, April 22, 2024 6:34 PM
To:	Light, Tricia M. EOP/OSTP
Cc:	Carole Douglis
Subject:	[EXTERNAL] Re: mCDR FRN
Attachments:	NSF Questions to inform development of Marine CDR Research Plan.pdf

Hi Tricia,

Thank you again for our valuable discussion last week. Attached is our recommendation for a marine CDR Research Plan. To be blunt, this is critically important to the survival of our civilization and our nation. We look forward to further discussions.

In summary, we recommend:

1. Focus on climate restoration for our children and future generations. This must become a fundamental American value.
2. Fund a Pinatubo CO2 pause replication program this year.
3. Establish a Climate Restoration Moonshot that President Biden can introduce this year. This would validate the work on restoration to the science and funding communities.

Best regards,
Peter (and Carole)

From: Light, Tricia M. EOP/OSTP (b) (6) [redacted]
Date: Thursday, April 11, 2024 at 8:53 AM
To: pfieko@gmail.com <pfieko@gmail.com>
Subject: mCDR FRN

Hi Peter,

Thanks for coming by today. The federal register notice on marine carbon dioxide removal is linked below, and you can follow the instructions there to provide a written response by April 23.

[Federal Register :: Marine Carbon Dioxide Removal Research Plan]

Best,
Tricia

Tricia Light, PhD (she/her/hers)
Knauss Ocean Policy Fellow
Office of Science and Technology Policy
(b) (6) [redacted] /(b) (6) [redacted] *(calls only)*

NSF Questions to inform development of Marine CDR Research Plan

April 22, 2024
Peter Fiekowsky, Founder, Foundation for Climate Restoration (b) (6) [redacted]
Carole Douglis, Foundation for Climate Restoration (b) (6) [redacted]

Question 1: How would a Marine CDR Plan affect you, your organization, or your community?

As American citizens, a Marine CDR plan consistent with restoring a historically safe climate for our children is vitally important. It would confirm that the U.S. Government is concerned about maintaining a safe environment for our children, even while the UNFCCC plans only consider outcomes that no experts consider to be survivable for life as we know it. Today's net-zero goal results in 2050 with CO2 levels 50% higher than humans have actually survived long-term, and higher than our planet has seen in 14 million years, long before humans evolved 3 million years ago. Americans know about ice ages and wonder why we don't plan to use the method Nature used to remove CO2 before ice ages. We should test this obvious hypothesis.

Most Americans agree that "we have a moral responsibility to create a safe and healthy climate for ourselves and our children." The climate that has proven safe for humans over the long-term is characterized by CO2 averaging 280 ppm and below 300 ppm. To regain these conditions will require the removal of roughly a 1000 Gt of CO2 plus any continued emissions. To accomplish this by 2050 implies CDR on the scale of 60 Gt of CO2 / year starting in 2030.

A Marine CDR plan that includes approaches with the potential to achieve this scale could significantly reduce climate chaos for American communities. Furthermore, it will help mobilize private funders so the bulk of the cost does not fall on the U.S. Treasury or reluctant corporations.

Question 3: Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research?

We believe the Federal Government should prioritize CDR methods with demonstrated ability to restore safe CO2 levels by removing 1000 Gt CO2, and which can be easily financed (i.e. without costing the entire Federal budget). The relevant mCDR method is ocean iron fertilization (OIF), which regularly draws down CO2 on that scale before ice ages. The widely accepted "iron hypothesis of ice ages" and a series of field expeditions point the way to biomimicry that replicates and accelerates Nature's method.

Field trials of intentional OIF halted over a decade ago due to political and social controversy. Researchers and regulators alike appear to assume that OIF remains politically infeasible. In addition, opponents of this powerful CDR approach cite "moral hazard"--the argument that it would allow the fossil fuel companies to continue selling us fossil fuel with impunity.

In contrast, the mCDR approaches that receive most attention (and funding) today are designed to help attain net-zero with minimal corporate and economic disruption. Their business model relies on the carbon market and the continued use of fossil fuels, and their expense prohibits their scaling anywhere near 1% of what is needed. Net-zero is important and is now a major industry… but citizens need a safe climate as well.

Today's popular mCDR (mainly ocean alkalinity enhancement and electrochemical CDR) cost around $500 per ton CO2. While they may help achieve net zero, were these techniques scaled to remove a trillion tons of CO2 over 20 years, they would cost $30 trillion per year, a third of all global economic activity. Even if their cost drops to $100/ ton CO2—restoring safe CO2 levels would require $6 trillion a year. That's nearly the entire annual U.S. Federal budget. Clearly such an enterprise is not financially viable.

Perhaps it is just this inability to make a real difference that enables these unscalable mCDR approaches to maintain social license and political support. Few call them "geoengineering," or advance the moral hazard argument since their minute effect cannot be consequential to Earth's CO2 levels and the climate.

In contrast, OIF is projected to cost around $1 billion per year at full scale, based on the estimates published in the NAS ocean CDR report (a couple of cents / ton.) In other words, our best bet for restoring the atmosphere, OIF, is also literally tens of thousands of times cheaper than other mCDR options. Yet it gets approximately zero Federal support. Literally nothing is more urgent and important than redressing this omission.

Question 6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

We recommend that the Federal Government and its scientists make plain to the public what its experts know: that net-zero will leave us with CO2 levels 50 percent higher than humans and our ancestors ever survived. It would make a huge difference if officials and researchers admit the obvious: that our goals of "stabilizing greenhouse gases" and "avoiding the worst consequences of climate change" are outdated and insufficient to offer future generations a decent feature.

Instead, the Federal Government could help set our national compass toward restoring a historically safe climate—one in which we know humanity and current ecosystems have thrived. It is politically necessary to continue work on net-zero projects too. In that case, Federal research agendas would sustain the latest high-tech CDR work but focus on the most promising pathways to restoring a historically safe atmosphere and climate.

We invite the Government to consider a contemporary "climate restoration" moonshot or Manhattan project. What made these projects successful was their specific, measurable goals, e.g. Send a man to the moon and bring him back safely, by the end of the decade.

In this case, it would be "Restore a safe atmosphere with CO2 below 300 ppm by 2050." Then research, funding, and implementation can mobilize all necessary partners—public, private business, activist, philanthropic—toward that goal.

Some critical research topics for mCDR for climate restoration:

1. **Investigate, isolate and optimize the natural mechanism that removed up to 20 Gt of CO2 in the year following the Mt. Pinatubo eruption.** Few realize that the world saw 15 months of net-zero—the removal of human-caused emissions—following the Mt. Pinatubo eruption in 1991. (This CDR is unrelated to the better known iron-sulfate effect that cooled our planet for 18 months.) Our paper, The Mt. Pinatubo Pause—Net-zero in 1992 challenges us to repeat it intentionally by 2030 analyzes proposed theories for how this large-scale, natural CDR occurred and concludes that the only plausible mechanism was nutrients, especially iron, in the ash born out to sea which accelerated the accumulation of carbon into the ocean depths.

   Field research to replicate the massive CO2 removal is truly urgent. Whether the cause was OIF (as preceded ice ages) or something else, the Pinatubo CO2 "pause" shows that the potential for marine CDR is far above the currently accepted level of 4 Gt of CO2 per year. Note that 20 Gt was removed, likely from the small ash-fall area comprising less than 0.1% of the ocean area. Further, replicating the pause will provide methods for large-scale CO2 removal through biomimicry, and enable us to optimize the process to reach the needed rate of 60 Gt / year.

2. **Publicly consider the related criteria of cost and scalability–far beyond net zero— when evaluating mCDR methods.** Methods that would collectively bankrupt the world economy–or which, if their costs plummet by 90 percent, would still cost more than the entire Federal budget—should be de-prioritized.

We offer our paper as a starting point for this research: Cost-Effectiveness of Carbon-Dioxide Removal Methods: Costs determine scalability, and costs vary by a factor of 30,000.

3. **In addition to CDR, support research and development of one or more enhanced atmospheric methane oxidation methods (EAMO), which would also take place over the ocean.** The iron-salt aerosol (ISA) method has been demonstrated in laboratories and in the field, so that should be developed rapidly. Permafrost melt is accelerating rapidly, increasing methane emissions from those vast inaccessible regions. Implementing ISA to maintain safe methane levels even through a possible severe burst appears to be doable at an annual cost around $1 billion. Full-scale Methane Oxidation Implementation to Halve Methane Levels by 2030

4. Define a climate restoration moonshot that the U.S. President could initiate: Validate a plan to restore a safe climate. A starting point could be our paper: Climate Restoration Roadmap 2024

From: Sara Nawaz (b) (6)
Sent: Tuesday, April 23, 2024 6:33 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Re: National Science Foundation Request for Information on Development of Marine Carbon Dioxide Removal Research Plan
Attachments: FTAC submission IRCR.pdf

Dear Ms. Light,

Please see attached for the FTAC submission from the Institute for Responsible Carbon Removal at American University.

Sincerely,

Sara Nawaz, PhD (she/her)
Director of Research
Institute for Responsible Carbon Removal
American University

INSTITUTE *for* RESPONSIBLE CARBON REMOVAL

April 23, 2024

Tricia Light
Office of Science & Technology Policy
Executive Office of the President

By email: (b) (6)

Re: National Science Foundation Request for Information on Development of Marine Carbon Dioxide Removal Research Plan

Dear Ms. Light,

The Institute for Responsible Carbon Removal at American University ("the Institute") respectfully submits these comments in response to the National Science Foundation's Request for Information ("RFI") to inform the development of a marine carbon dioxide removal ("mCDR") implementation plan by the mCDR Fast-Track Action Committee ("FTAC"). The Institute strongly supports the FTAC's work to advance research into mCDR as a possible climate change mitigation tool and develop legal and policy frameworks to ensure that mCDR research and any subsequent deployment occur in a safe, responsible, and just way. We believe that mCDR research and any subsequent deployment should be pursued in an open and transparent manner, with robust public engagement and effective government oversight. Below, we highlight a few important aspects of doing this. This is not a comprehensive list, but rather focuses on governance and social dimensions of mCDR, a crucially important but under-resourced aspect of this work.

- Governance and social science considerations are essential to explore questions of whether, when, where and how we pursue mCDR. These 'non-technical' aspects of mCDR will be essential to responsibly and effectively developing mCDR, and must be funded generously.
- Engagement with local communities and interested and/or affected rightsholders and stakeholders must occur. This engagement needs to be substantive and significant, such that these groups are involved in the design and implementation of projects, and is essential to environmental justice principles prioritized by the Biden Administration. With any mCDR projects, there should be a pathway to engagement that occurs before an official permit request is submitted; the time to engage the public is not when you've decided to do a project, but as you are exploring a site's potential. Strong social license moves at the pace of community. The federal government can play a much needed and more central role in this engagement in order to ensure that it is robust and effective. This might entail providing more funding for engagement activities, setting a high-standard for effective engagement by supporting regional-level engagement on mCDR, and/or leading on engagement itself. A national carbon-focused extension program—modeled after the National Sea Grant College Program and US Cooperative Extension Service—might be an effective way to engage coastal communities and support informed public decision making about mCDR.
- Engagement might be integrated into regional test-bed approaches, as these are important ways that the federal government might facilitate interdisciplinary research on technical and

non-technical aspects of mCDR. Testbeds are ideally regional, capitalizing on the resources, natural environment, and culture that is unique to a particular place. Since all mCDR implementation will be place-based, adopting a place-based approach to testing would ground CDR development in good practices. Regional test beds should provide the infrastructure and the interdisciplinary, cross-sectoral engineering, economic, and energy expertise that supports a "graduation process" across multiple scales of testing– including the bench, the mesocosm, and the eventual field environment. Sites incorporated into regional test beds should be chosen for their natural features benefitting carbon removal testing; "prework" that supports baselining, community relationships, and infrastructure; and accessibility, including strong data management practices that support data transparency.

We are so pleased to see the federal government prioritizing this important area of work. For mCDR to be implemented in ways that are not only responsible but also successful, much collaboration is needed, with federal agencies collaborating with Tribes, states and local governments on mCDR. A more permanent federal body will also be needed to coordinate on mCDR research and deployment after the FTAC.

Sincerely,

Sara Nawaz, PhD
Director of Research
Institute for Responsible Carbon Removal
American University

From: BRAD WARREN (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 10:25 PM
To: Light, Tricia M. EOP/OSTP
Cc: Daryl Williams; Micah McCarty; Wil Burns; Tommy Moore
Subject: [EXTERNAL] Response to NSF request for information development of mCDR research plan
Attachments: FTAC comment draft 4.23.24, 4signed641pmC.pdf

Dear Ms. Light,

Thank you for your work. We are pleased to pass along this group response the RFI for the FTAC's implementation plan.

Best regards,

Brad Warren
Daryl Williams
Micah McCarty
Wil Burns
Tommy Moore

We write as individuals who have spent the last several years working to build the capacity of US Native American tribes to evaluate, govern, and develop projects of their choosing in the emerging field of carbon dioxide removal, including marine forms. We are pleased to see the FTAC undertaking the work to advance research on marine carbon dioxide removal (mCDR).

We wish to emphasize several broad points that we believe should guide this work:

1. We support the five basic points regarding governance of mCDR R&D suggested by the Sabin Center for Climate Change Law at Columbia University[1]. Notably, the call for greater federal coordination speaks both to a longstanding concern of Tribes and a conspicuous theme in climate response: governments (and especially agencies) cannot "go it alone" against a coherent, transboundary, global shift in the planet's life-support systems. The need for coordination among agencies will only grow as marine carbon removal comes of age and grows to scale. The ocean is the largest carbon sink on the surface of the planet. It sprawls across jurisdictional boundaries, statutory authorities, and institutional capacities multiple levels of government, including local governments, tribes,

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1 Romany M. Webb & Korey Silverman-Roati, *Developing Model Federal Legislation to Advance Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States*, Sabin Center for Climate Change Law, Columbia Law School, March 2023. Available at: https://scholarship.law.columbia.edu/sabin_climate_change/199/

states, federal agencies and international bodies. Working together is vital.

2. A specific gap in governance should be addressed during this R&D phase of development for mCDR: to govern this new field competently and comprehensively, the federal government (together with Tribes and other relevant governments) must create a resource management regime for this new use of the ocean's sequestration capacities. Specifically, the marine carbonate system and the deep ocean's capacity to trap and hold carbon constitute key public trust resources, and they renew very slowly. This situation requires a management system that encourages and controls their use within acceptable parameters, preserving fundamental ecosystem services and characteristics—much like management of the Bering Sea pollock fishery is conducted to prevent overfishing and to control impacts on non-target species. Sound use of ocean sequestration resources is a compelling public purpose which cannot be appropriately governed under laws (such as MPRSA) that mischaracterize many mCDR activities as "dumping." Instead, a statutory framework must be developed that recognizes and builds on fundamental principles for management of public trust resources for public benefit. Tribes have deep expertise in this field and have much to contribute to this important policy design work.

3. It has been suggested that the White House Office of Science and Technology Policy and FTAC should initiate direct government-to-government consultations with coastal Tribes regarding this R&D plan. We agree. During the R&D phase, the federal government must ensure not only safe and comprehensive development and testing of mCDR technologies; it must also forumulate and test a governance regime for this new field. By some estimates, marine carbon dioxide removal could grow during this century to create the largest ocean footprint in human history. If the world's oceans were tasked to remove and store only half of the billions of tons of CO_2 that must be drawn down from the atmosphere in this century, the volume of marine CDR would grow to as much as 100x the size of the world's fish catch by 2100, dwarfing the global fishing industry. This new sector could transform coastal economies and shoreline land uses, while driving major new extractive industries (i.e. mining for alkaline mineral supplies). It could generate a massive wave of shipbuilding and marine construction. It most likely will require unprecedented volumes of marine scientific data. This transformative potential presents important risks and benefits for Tribes. It could exert profound influence —for better, for worse, or both— on Tribal foods, cultural resources, and sacred sites. It would affect marine and coastal areas that fall under Tribal jurisdiction, with major implications for Treaty

rights, co-management authorities, and unextinguished aboriginal rights both at sea and on land.

Because time is short we write solely as individuals, not representing Tribes or other entities we work with.

Sincerely,

Micah McCarty, former Chairman, Makah Tribe

Brad Warren, CEO, Global Ocean Health, Seattle

Daryl Williams, President, Qualco Energy (a joint venture of Tulalip Tribes and partners)

Tommy Moore, oceanographer, Northwest Indian Fisheries Commission

Wil Burns, co-founder, Institute for Responsible Carbon Dioxide Removal, American University (also visiting professor, Northwestern University)

From: Basia Marcks (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 12:35 PM
To: Light, Tricia M. EOP/OSTP
Cc: Sarah Guy
Subject: [EXTERNAL] RFI Response: Marine Carbon Dioxide Removal Research Plan
Attachments: RFI Response mCDR Research Plan OSTP.pdf

Hello,

Thank you for the opportunity to submit comments regarding the RFI for the Marine CDR Research Plan (89 FR 13755). Please find the attached pdf document with responses to relevant questions from the Center for the Blue Economy, GreenLatinos, Natural Resources Defense Council, and Ocean Defense Initiative.

Please let me know if you have any issues processing the document,
Basia Marcks

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Basia Marcks, Ph.D.
Program Director
Ocean Defense Initiative
(b) (6) [redacted]

TO: (b) (6)
Subject Heading: “RFI Response: Marine Carbon Dioxide Removal Research Plan”
Deadline: 11:59 pm ET April 23, 2024

To Whom It May Concern:

The undersigned organizations greatly appreciate the Request for Information regarding a Federal marine carbon dioxide removal research plan (Marine CDR Plan) as part of the Biden-Harris Administration’s commitment to leveraging the ocean as a source of climate solutions through the Ocean Climate Action Plan.

To determine if marine CDR at a scale sufficient to have a meaningful beneficial impact is feasible and ethical, US leaders must facilitate both research and governance structures for this emerging technology and ensure that marine CDR is not overlooked or under-studied as opportunities emerge in this issue area. The Marine CDR Plan will be critical for consideration of these issues.

We are a broad group of organizations working to advance ocean climate action at the local, state, and Federal level, and we appreciate the opportunity to submit the following comments as the Plan is developed. Please see below for our responses to relevant questions to inform development of the Plan:

1. How would a Marine CDR Plan affect you, your organization, or your community?

A Marine CDR Plan will have significant implications for ocean users, coastal communities and Americans impacted by the climate crisis, including our coalition members and the communities and ecosystems they strive to protect. If implemented properly, a Marine CDR Plan will establish key safeguards and research requirements essential to protecting the marine environment, minimizing risk and maximizing benefit to marine-dependent communities, and ensuring transparency and legitimacy of marine CDR research. It will play a foundational role in scaling up ocean climate action and determining the extent to which marine CDR can aid in the removal of legacy and hard to abate emissions.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to *support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?*

We have concerns regarding the ability to monitor ocean conditions on temporal and spatial scales necessary to ensure the safety and effectiveness of marine CDR research and to inform decisions about the readiness of any marine CDR approach.

Impacts from some approaches may take years or decades to become clear, and many impacts may be difficult to directly link to any one experiment. Comprehensively understanding the impacts associated with these marine CDR projects will require an understanding of the baseline ocean conditions including natural variability and how conditions may change due to other factors, like seasonal weather patterns, storms, or climate cycles like El Niño. Monitoring for physical, biological, chemical, and geologic changes to the marine ecosystem will be necessary prior to, throughout, and in the years or decades following marine CDR project duration.

Approaches that alter ocean chemistry, nutrient availability, or currents may have both direct and indirect impacts which occur far from the project site and initial experiments should use tracers and other sensing technology to map the spatial extent of impacts when possible. Long term monitoring at relevant spatial scales will likely rely on a combination of measurement techniques with rigorous ground truthing. The ability to conduct the measurement and monitoring necessary will require expansion of, and sustained investments in, existing ocean observation systems like biogeochemical ARGO floats and similar technology.

While individual projects may deploy unique or proprietary technology to monitor project impacts or carbon drawdown, the Federal government should ensure it retains observation technologies necessary to verify project impacts and monitor ocean changes across large spatial and temporal scales. Data and information resulting from proprietary technology or methods should not be used to inform Federal decisions or actions unless that information or data is validated and assessed, with fully transparent methodology and technology, for quality assurance and quality control by a Federal agency with relevant expertise to minimize bias and conflicts of interest in the Federal decision making process.

Federal support will also be necessary to maintain a publicly available database which hosts information and data related to or resulting from Federally-funded research projects and proposals. The database should facilitate data intercomparison and contain enough data to verify impacts and carbon sequestration outcomes. Statements identifying any possible conflicts of interest and financial disclosures should be included with publicly available data for any mCDR permits, proposals, and other relevant information. Research papers and reports resulting from Federal investments through the Marine CDR Plan or resulting funding opportunities should also be open-access and publicly available.

The Marine CDR Plan should also recognize that each marine CDR approach will require different conditions and locations to ensure safety and effectiveness. Appropriate locations will vary depending on the methods used as well as existing protections, affected marine life, and cultural or other significance of a location to communities. Communities could benefit from a preliminary map or spatial guidance which identifies broad areas which could be suitable for different methods based on existing ocean and coastal conditions and infrastructure. This will require baseline data and an understanding of relevant physical, chemical, biological and geological parameters.

The ability to obtain baseline data, monitor and verify projects across large temporal and spatial scales, and make results available to the public hinges on sustained Federal investment for ocean observing technologies and research. NOAA's Integrated Ocean Observation System (IOOS), already plays a central role in the management of ocean observation technology and data dissemination, however, significant cuts to funding for IOOS in recent budget proposals are concerning. Increased investment in ocean observation systems and research programs will be necessary to accurately monitor and assess impacts of marine CDR research.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

We appreciate the Biden-Harris Administration's acknowledgement that rapid and deep emissions reductions are necessary to meet climate goals. While marine CDR may have a role to play in reducing legacy and hard-to-abate emissions, it cannot replace or delay rapid decarbonization and emissions reductions. Similarly, any marine CDR approaches which, when operating at scale, do not result in net emissions reductions should not qualify for support through a marine CDR research program. Additionally, special attention must be paid to ensure that marine CDR projects are actually increasing CDR, not merely changing the location of carbon drawdown. This will be especially important for nutrient fertilization experiments which may change the location of nutrient and carbon drawdown, ultimately stripping nutrients from a downstream location without increasing net carbon drawdown.

Priority should be given to projects which minimize risk and maximize carbon sequestration and co-benefits to ecosystems and coastal communities. The Marine CDR Plan should also consider opportunities to collaborate with existing activities, like beach renourishment, water treatment, or algae and shellfish aquaculture, which may serve as opportunities for integration with marine CDR research. Integration with existing activities may pose unique risks which need to be rigorously assessed prior to application deployment. Approaches that do not pose significant risk to marine dependent communities or ecosystems, increase marine CDR, and meet community needs should be prioritized for investment.

The Marine CDR Plan should ensure that robust public engagement is a priority, with affected communities provided accessible information and education to make informed decisions about proposed marine CDR projects. This will require continued investment and engagement as local communities process permitting applications and engage in public comment periods.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Early outreach, education, and opportunities for public comments which are meaningfully integrated into permitting or Marine CDR Plan decisions will be necessary to foster trust and understanding of the full range of risks and benefits of different marine CDR approaches. Many local communities do not have specific expertise or technical assistance to process permits or understand the breadth of impacts which could arise from different marine CDR approaches. Some communities may need greater levels of support and education to allow communities to make informed decisions.

Additionally, the Federal Government should maintain a public database containing data necessary to make informed decisions about the safety and efficacy of marine CDR projects and approaches. Research products such as posters, papers, and reports should also be made publicly available with plain language summaries of important key points.

Thank you for your consideration of these comments and once again for the opportunity to provide our perspective as the Marine Carbon Dioxide Removal Fast Track Action Committee continues its work to increase knowledge on the safest and most effective marine CDR approaches. We look forward to continuing to engage in this process to build a future that includes responsible carbon removal for our ocean, people, and planet.

Sincerely,

Center for the Blue Economy
GreenLatinos
Natural Resources Defense Council
Ocean Defense Initiative

From: Sifang Chen (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 4:43 PM
To: Light, Tricia M. EOP/OSTP
Cc: Erin Burns
Subject: [EXTERNAL] RFI Response: mCDR Plan
Attachments: Carbon180 Response - mCDR Plan RFI.pdf

Hi Tricia,

Please find Carbon180's response to the mCDR-FTAC RFI attached. Thank you in advance for your consideration.

Sifang Chen • she/her
Managing Science & Innovation Advisor • Carbon180
c. (b) (6) [redacted]

Carbon180.org has a new look. Find the facts on CDR pathways, search our resources, and learn about the people and pathways scaling just and equitable CDR.

RFI Number: 2024-03758
Re: Request for Information on Marine Carbon
Dioxide Removal Research Plan

April 23, 2024

To Whom It May Concern,

Carbon180 submits the following comments in response to the Notice of Request for Information for the National Marine CDR Plan.

In light of the urgency of the climate crisis, governments and companies are increasingly interested in developing marine carbon dioxide removal (mCDR). However, all mCDR approaches are still in the early stages of development. The growing interest in mCDR also highlights the importance of improving public engagement and community capacity building around these technologies.

We believe that for mCDR to become an effective and just climate solution, it must be developed in a responsible and equitable way, centered on building trust, maximizing climate benefits, and minimizing harm. Developing and deploying mCDR at the gigaton scale will take years of public research, standard setting, infrastructure support, and public trust-building. Below, we provide specific recommendations regarding high-impact actions the federal government could take on mCDR. Specifically, we recommend creating a fit-for-purpose regulatory framework to govern mCDR, expanding research programs to close knowledge gaps and advance MRV capabilities across mCDR pathways, developing tools and resources to enable meaningful community and public engagement, and strengthening public-private partnerships to facilitate learning and standards development towards highly accountable mCDR scale-up.

Sincerely,

Erin Burns
Executive Director (b) (6)

Question 2.

<u>Response:</u> Fit-for-purpose regulation can spur innovation in mCDR and protect the public, enabling critical field testing to take place and ensuring mCDR is developed responsibly to safeguard our ocean ecosystems and coastal communities. However, existing regulatory frameworks relevant to mCDR were developed with other marine activities in mind, and therefore not adequate for governing mCDR RD&D. A lack of regulatory clarity creates room for legal loopholes and gray areas, which could lead to low-accountability projects that take place with little to no oversight, or push project developers to deploy in jurisdiction with looser regulatory enforcement. Further, cumbersome permitting processes can stifle innovation, as small companies have limited resources for navigating complicated regulatory regimes.

Recommendation: Clarify permitting to advance responsible mCDR research and develop fit-for-purpose regulations to govern mCDR research, demonstration, and deployment.

1. In the short term, clarify the permitting process for mCDR research activities under the current regulatory framework.
    a. The mCDR-FTAC should clarify areas where existing regulations, including the Marine Protection, Research and Sanctuaries Act (MPRSA) and Clean Water Act (CWA), apply to mCDR activities, where they are insufficient, and identify any new authorizations needed to enable fit-for-purpose governance of mCDR.
    b. The mCDR-FTAC should clarify the role each agency currently has in regulating different mCDR pathways.
    c. Relevant regulatory agencies should clearly define the timing, steps, and requirements, under the current regulatory regime, for project developers to apply for and obtain permits, and create documentation that quickly and clearly disseminates this information.
    d. Permit applications, reviews, and public commentary should be shared on publicly accessible databases; the EPA should create a database of permits granted under the MPRSA, similar to the existing NPDES database for CWA.
    e. Relevant regulatory agencies should ensure permitting processes include opportunities for the public, including state, local, and tribal governments, to comment and meaningfully engage in permitting decisions. Support from relevant public stakeholders should be an essential criterion for granting permits to conduct mCDR research.
2. In the long term, build adaptive regulatory frameworks designed to meet the unique needs and challenges of mCDR (i.e. fit-for-purpose regulations).
    a. To enable clear and streamlined permitting processes, we recommend Congress to designate a lead agency with exclusive authority to issue mCDR project permits and to set up and manage a unified digital portal for processing permit applications. The roles of all relevant agencies in regulating mCDR research, such as EPA, NOAA, and BOEM, should be clarified.

b. Congress should direct funding to NOAA, EPA, NIST, BOEM, DOE, and other relevant agencies to bolster technical staff capacity on mCDR, to support the development of mCDR regulations based on evolving scientific knowledge.
c. A task force should be assembled to build the blueprint for an adaptive and fit-for-purpose governance framework for mCDR, taking into consideration risk-risk analyses on the benefits and risks of mCDR and existing work on mCDR codes of conduct[1,2]. The task force should include members of government, industry, and civil society. This blueprint can serve as the basis for a tailored framework of mCDR governance.
d. The lead agency should work with local, tribal, and state governments to develop region-specific regulations, emphasizing a regional approach to field testing and centering local stakeholders and rightsholders in decision-making.
e. The lead agency and the State Department should collaborate to coordinate with international partners on the global governance of mCDR, develop multilateral collaborations on mCDR, and increase capacity to work with researchers from the Global South.

Question 3.

<u>Response:</u> Investing in cross-cutting research activities, including expanding ocean monitoring capabilities and social science research, has the potential to increase the likelihood for all mCDR pathways to succeed towards scale-up. While we support a portfolio approach to funding mCDR during this initial phase, as we learn more from future mCDR projects, pathways with the potential to redress past injustices, mitigate environmental damages, and offer co-benefits should be prioritized.

Recommendation: Fund a comprehensive set of research programs to significantly accelerate learning across mCDR pathways and integrate mCDR as part of broader climate strategies.

1. Congress should increase funding to existing NOAA[3] and DOE[4] programs to basic and applied research across a diverse range of mCDR pathways. Various mCDR research roadmaps and reports can guide the allocation and priorities of this funding.[1,5,6,7]
2. Fund the development of key enabling technologies and data infrastructures for ocean observation and mCDR MRV.
    a. Leverage and expand the capabilities of existing ocean-sensing infrastructure and systems — such as NOAA's Ocean Acidification Program, Global Ocean Monitoring and Observation Program, and Ocean Carbon Network — to establish baselines and monitor and quantify impacts from mCDR projects.

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[1] Rouse, J. (2023, December 8). *A Code of Conduct for marine carbon dioxide Removal research - the Aspen Institute*. The Aspen Institute. https://www.aspeninstitute.org/publications/a-code-of-conduct-for-marine-carbon-dioxide-removal-research/
[2] *Ethical Framework for Climate Intervention Research | AGU*. American Geophysical Union. https://www.agu.org/learn-about-agu/about-agu/ethics/ethical-framework-for-climate-intervention
[3] NOAA Ocean Acidification Program. (2024, April 2). *Carbon Dioxide Removal - NOAA Ocean Acidification Program*. https://oceanacidification.noaa.gov/carbon-dioxide-removal/
[4] *SEA-CO2*. (2023, February 16). arpa-e.energy.gov. https://arpa-e.energy.gov/technologies/programs/sea-co2
[5] *Uncharted Waters*. (2020). EFI Foundation. https://efifoundation.org/reports/uncharted-waters/
[6] *Strategy for NOAA Carbon Dioxide Removal Research*. (2023). PMEL. https://sciencecouncil.noaa.gov/wp-content/uploads/2023/06/mCDR-glossy-final.pdf
[7] *U.S. congressional action needed to accelerate Ocean-Based carbon dioxide removal solutions*. (2024). https://carbontosea.org/wp-content/uploads/2024/03/FY2025.pdf

b. Establish or expand research programs at NOAA, ARPA-E, and DARPA to improve modeling and sensing capabilities for mCDR MRV.
c. NOAA, NIST, and EPA should coordinate to develop standardized environmental monitoring and carbon accounting methods for mCDR, and promote interoperability and transparency in quantification standard setting and data collection, in collaboration with financially unconflicted technical experts, given the history of mistrust in the carbon markets.
d. NOAA and NSF should facilitate and support mCDR model intercomparison projects, provide a map of existing sources of data on ocean models, and plan for incorporating mCDR data into existing databases to promote consistency and transparency across marine research.

3. The mCDR-FTAC should establish a 5-year interagency group, with participation from NOAA, EPA, the Department of Energy (DOE), BOEM, and other relevant agencies, to assess the climate, environmental, social, and economic impacts of mCDR and align mCDR with broader climate goals.
    a. The interagency group should conduct cross-sectoral research analyzing the interactions between mCDR activities, fisheries and aquaculture, energy and resource use, sustainable development goals, mitigation and adaptation strategies, and other systems, sectors, and industries
    b. The interagency group should develop strategies for planning and implementing larger and longer-duration mCDR research projects, including the use of holistic models that integrate ecological, geochemical, and socioeconomic factors, when assessing potential benefits and risks.
    c. By 2030, the interagency group should identify and begin scaling ocean carbon removal pathways with clear climate, environmental, and social benefits, low ecosystem and socioeconomic risks, and the capacity to achieve one gigaton of ocean carbon removal by 2050.

Question 4.

Response: mCDR can only scale by gaining and retaining the social license to operate. Public and private actors in mCDR should build capacity and provide resources for coastal communities to identify desired benefits and opportunities from mCDR, such as jobs, economic growth, ecological benefits, etc. Communities should be empowered to make decisions to select and deploy projects that can provide these benefits, and reject projects that do not align with community priorities.

Recommendation: Develop tools and resources to support public and community participation in mCDR and to empower local stakeholders and rightsholders to make informed decisions about mCDR project development and deployment.

1. Develop strategies for public education and community engagement regarding mCDR.

    a. All permitted mCDR projects should be required to include robust public engagement and community participation strategies, including a schedule for ongoing public engagement after project commencement.
    b. The mCDR-FTAC should recommend creating a dedicated position at NOAA to coordinate and host two-way listening sessions and public workshops with environmental justice groups, coastal communities, local and Tribal governments, mCDR companies, and relevant experts from government and academia.
    c. Congress should fund a public outreach initiative at NOAA and EPA to engage, educate, and raise awareness about mCDR.
2. The lead agency on mCDR (see Rec 1.2.a) should establish a framework to integrate environmental and climate justice into mCDR with the following considerations:
    a. Conduct environmental justice assessments to identify potential social, economic, and environmental impacts of mCDR;
    b. Ensure that the benefits derived from mCDR, such as job creation, revenue generation, and improved environmental quality, are shared equitably among all stakeholders, particularly those who bear the brunt of climate change impacts;
    c. Establish mechanisms for accountability and transparency in carbon removal projects, including monitoring, reporting, and independent oversight;
    d. Make adjustments as needed based on feedback from communities, stakeholders, and evolving scientific knowledge. Embrace a learning-oriented approach to ensure that justice considerations remain central to mCDR efforts over time.
3. Evaluate and report on any environmental harms associated with the testing and deployment of mCDR that could impact local communities.
    a. The mCDR-FTAC should recommend coordination between EPA, DOI BOEM, NOAA, and USGS to identify and assess potential environmental harms from mCDR-related activities, such as concerns for water and air pollution associated with mining minerals for enhanced weathering and ocean alkalinity enhancement.
    b. Relevant agencies should ensure that the results from these assessments are promptly shared with the public and communicated effectively to community stakeholders.

Question 5

Response: Regional mCDR innovation clusters can bring together stakeholders from industry, government, and civil society, leveraging local expertise and connections to facilitate learning and the exchange of information and ideas. A regional focus could be especially important for mCDR development since tailoring to regional social, economic, and geographical conditions is critical to project success.

Recommendation: Create regional mCDR innovation clusters to facilitate cross-sectoral and interdisciplinary learning.

1. Increase funding to regional ocean research programs, such as Sea Grant, to build mCDR innovation clusters through collaboration with local research institutions, community stakeholders, and innovators.
2. Develop robust processes for information and data sharing within and between innovation clusters to accelerate learning, ensure transparency, and build trust.

From: Sue Sayer (b) (6) [redacted]
Sent: Tuesday, April 9, 2024 1:32 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Seal Research Trust submission mCDR Listening Session Theme 3: Mechanisms to enable public awareness and engagement
Attachments: White House mCDR Community Listening Session Seal Research Trust NGO in UK.pdf

Hi Tricia
Fascinating session
Thankyou for enabling our attendance at this meeting
Attached are the comments I made during the session
I hope they are of use and we are happy to provide further input should it be deemed beneficial
Many thanks
Good luck with your mCDR developments

Sue
x

Cornwall needs Marine Rangers: Research Connect Inspire Conserve.
Sue Sayer MBE (>https://www.cornwallsealgroup.co.uk/2023/01/its-an-honour-mbe/<)
Seal Research Trust
Est. Cornwall 2000

Aka Cornwall Seal Group Research Trust (Charity number: 1162936)
>www.cornwallsealgroup.co.uk<
Cornwall's internationally renowned, multi award winning seal conservation charity
Identifying and monitoring local seals and protecting their marine environment

2023 Seal Secrets by Sue Sayer >https://sealresearchtrust.com/collections/all-items/products/sue-sayer-seal-book<
2023 Sea Change: Seals Impacts of Climate Change on Seals (6 mins) https://youtu.be/KaJWpcP5p4g
2023 Seal Alliance Masterclass https://youtu.be/fHjHDJ10Sqo?si=bQJm1TZgft15UvBl
2023 SW Marine Ecosystems Seal Webinar https://youtu.be/Hj_ppyR45jY
2023 SWCP Podcast https://tinyurl.com/4f6cxt2u
2023 All About Animals Podcast https://rss.com/podcasts/allaboutanimals/826848/2022
2022 Remarkable Ruen Podcasts Part 1 https://open.spotify.com/episode/1dcKYtkmxUuy7ZC35Tp4j6 and Part 2 https://open.spotify.com/episode/1nAFsdvAawrGQGixzCcAry
Climate change impacts on seals: Cornwall Climate Care Documentary (15:30 minutes) >https://www.cornwallclimate.org/films/under-the-surface<

Get free:
*Seal SW Newsletters and Updates including invites to our monthly online Seals SW Sessions http://eepurl.com/dHdy3j
*Family Activities >https://sealresearchtrust.com/pages/family-activities<
*Talks about our seal conservation work https://www.youtube.com/channel/UCuzvSLkxvtdgbnccHqibILQ/videos
*Access to our online volunteer training to help from seals from the comfort of your own home email seals@cornwallsealgroup.co.uk

Adopt our wild seals: Real seals, real stories, real time! >https://sealresearchtrust.com/pages/wild-seal-support-pack<
Shop for beautiful gifts: Treat yourself, your friends and family >https://sealresearchtrust.com/<

Facebook: Instagram: Youtube: Twitter: Linkedin

Seal Research Trust NGO in UK: A multi award winning citizen science network aimed at marine conservation for seals

Sue Sayer MBE

Barriers to community involvement

Current hierarchy of process needs to turned on its head

- Policy
- Funding
- Licensing
- Science/Academia
- Community engagement

Carbon mitigation hierarchy should be followed with priority to top of list

- Emission reduction
- Nature based solutions
- Bio engineering solutions
- Geoengineering solutions which are riskier for the marine environment

We have had a mCDR project on our patch for over a year, which has demonstrated:

A LACK OF:

- Global governance
- Site specific knowledge in terms of seawater, ecosystem and community
- Baselining spatially and temporally
- Public and community consultation (even to the extent of being patronising)
- Robust science
- Measurable CDR (only modelled currently)

Our recommendations for committee

- Effective governance led by US
- Robust research protocols
- Code of Conduct
- Community lens priority – set up community advisory board at a national level
- Effective management of carbon credits
- Overall substantial carbon budgets
- Substantial environmental net gain

From: Alexis Valauri-Orton (b) (6) [redacted]
Sent: Tuesday, April 23, 2024 10:04 PM
To: Light, Tricia M. EOP/OSTP
Cc: Mark Spalding; Bobbi-Jo Dobush; Madeline Warner; Kaitlyn Lowder
Subject: [EXTERNAL] The Ocean Foundation submission to RFI re: Marine Carbon Dioxide Removal Research Plan
Attachments: The Ocean Foundation (TOF) RFI for NSF Marine Carbon Dioxide Removal Research Plan.pdf

Good evening,

Please find attached The Ocean Foundation's submission to the Request for Information issued by the National Science Foundation for comments regarding a national Marine Carbon Dioxide Removal Research Plan. The staff who prepared this response are cc'ed as well as listed on the response.

Best,
Alexis Valauri-Orton

--
Alexis Valauri-Orton (*she/her/hers*)
Program Officer
(b) (6) [redacted]
ATTN: The Ocean Foundation | The Cloud Room | 1424 11th Ave STE 400 | Seattle, WA 98122
oceanfdn.org

THE OCEAN FOUNDATION

TO: National Science Foundation
RE: Request for Information Regarding Marine Carbon Dioxide Removal Research Plan

Document Citation: 89 FR 13755
Document Number: 2024-03758

FROM: The Ocean Foundation, https://oceanfdn.org/
1320 19th St, NW, Suite 500, Washington, DC 20036
(202) 887-8996

Contributors: Mark J. Spalding, President, (b) (6) Bobbi-Jo Dobush, (b) (6), Alexis Valauri-Orton, (b) (6) Dr. Kaitlyn Lowder, (b) (6) Maddie Warner, (b) (6)

DATE: Submitted April 23, 2024 via email

1. How would a Marine CDR Plan affect you, your organization, or your community?

As the only community foundation for the ocean, The Ocean Foundation (TOF) seeks to embrace a regenerative ocean that supports all life on earth. We strive to improve global ocean health, climate resilience, and the blue economy. We create partnerships to connect all peoples in the communities in which we work to the informational, technical, and financial resources they need to achieve their ocean stewardship goals.

Two of TOF's Core Initiatives focus on work that directly engages with marine CDR - the Ocean Science Equity Initiative and the Blue Resilience Initiative. The Ocean Science Equity Initiative seeks to ensure all countries and communities can monitor and respond to these changing ocean conditions – not just those with the most resources. The Blue Resilience Initiative works to support coastal community resilience by restoring and conserving coastal habitats like seagrasses, mangroves, coral reefs, seaweeds, and salt marshes. Both initiatives focus on ensuring and enabling locally led action by providing technical, administrative, and financial services and supporting regional and local experts.

TOF often works closely with the U.S. Government to implement activities across all of its programs, but in particular through its Memorandum of Agreement with the National Oceanic and Atmospheric Administration. Through this MOA, TOF co-implements projects focused on building capacity of scientists and restoration experts internationally to build climate resilience, improve scientific capacity for carbonate chemistry and ocean observations, and support coastal restoration.

A national Marine CDR Plan will guide national action and investments for years to come. As we have seen interest in marine CDR accelerate dramatically, particularly from private sector parties and including from those without backgrounds in the fundamental science underpinning the technology, we are concerned. We support precautionary approaches that consider long-term impacts and evaluate benefits from an equity lens. A Marine CDR Plan will provide information on the understanding and positioning of the US Government on this topic and enable TOF to thoughtfully continue to co-implement projects in its areas of expertise.

*2. What **questions or concerns** do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to **support the safety and effectiveness of marine CDR research**, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to **inform the safe and effective regulation** of marine CDR research? What knowledge exists and what additional knowledge will be needed to **inform decisions about the readiness** of any marine CDR approach for full-scale deployment or commercial application?*

Regarding concerns, TOF is concerned that mCDR projects may be rushed into development without understanding their short and long-term costs and effects. A Marine CDR Plan should be developed with a lens of caution and precaution. Unprincipled and under-researched ocean carbon management projects have the capacity to cause widespread harm to people and the environment directly and indirectly. Conversations around mCDR must be considered through the lens of the environmental Precautionary Principle, human rights, and equity. Engagement with climate-vulnerable communities is key to embracing international standards of environmental justice. Decision-making bodies responsible for regulating mCDR activities should include representation from frontline communities and leading science experts.

Outpacing regulatory or project development without a Code of Conduct may cause projects to ignore human rights, and fail to implement Free, Prior, and Informed Consent for potentially affected communities. TOF is further concerned that mCDR may be used as a replacement for or distraction from reducing carbon emissions. Marine CDR projects should only be undertaken in addition to robust plans to reduce carbon dioxide emissions. Reducing carbon dioxide emissions and other greenhouse gas emissions should remain the priority, and alternative methods of carbon management like climate geoengineering should not supersede the known benefits of reducing carbon dioxide emissions in managing the impacts of climate change.

Discussions on mCDR should also recognize that other forms of climate geoengineering may also indirectly affect the ocean. Terrestrial-based climate geoengineering projects may include wastewater and runoff, introducing pollutants into freshwater and ocean cycles that may affect fisheries, tourism, and marine life. Projects proposing to modify the atmosphere would affect the ocean differently than the land, and ocean impacts have been studied even less than terrestrial ones. The many unknowns regarding the effects of climate geoengineering projects introduce actual and perceived equity risks that may exacerbate geopolitical tensions.

Regarding the available science and understanding, research on mCDR is still nascent. More independent research is needed to build an understanding of the intended and potential unintended consequences of mCDR. Significantly, baseline data in understudied waters hinders the ability to fully evaluate the results of any field trials conducted in these areas. NSF should continue supporting basic oceanographic research and long-term monitoring sites to ensure these data exist. International aid from other agencies can increase the capacity for these data to be collected in other areas of the ocean, which, in addition to improving the ability of the greater ocean community to evaluate these approaches, results in side benefits to US research such as improved carbon budget modeling. The US is already a leader internationally in scientific disciplines related to mCDR, including carbon chemistry, and has invested significantly in supporting international capacity for carbon chemistry monitoring, including through its partnership with TOF. This work can be continued and strengthened through the lens of mCDR to ensure a robust network of local experts in all ocean basins who can evaluate and lead mCDR activities.

Furthermore, any research studies considered for support from government funds should be evaluated based on the technical expertise of PIs and collaborators, particularly regarding carbonate chemistry and air-sea interactions knowledge. As many mCDR techniques rely on complex chemical, physical, and biological dynamics for successful removal, proper evaluation during a project necessitates the technical backgrounds of PIs. Given the ocean acidification research's rigor in measuring carbonate chemistry, this community is an essential source of expertise and technical approaches.

*3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should **prioritize** for research? Are there particular marine CDR approaches that you believe are **especially promising** with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are **particularly more or less risky** with regard to the environment, public health and communities, or other uses of the sea?*

Regarding priorities, The Ocean Foundation suggests focusing on nature-based solutions that we already know work and for which we understand the effects. Additionally, the Federal Government should emphasize key factors of mCDR approaches that are crucial for realizing long-term climate and ecosystem health goals but may not be inherently prioritized by other actors in the mCDR field. For example, the durability of carbon drawdown is critical and a major question of many approaches, but private companies often pursue incentives that are realized on much shorter timescales. Additionally, proposed projects should be forced to examine potential negative externalities, such as those of mineral mining.

The Ocean Foundation also suggests supporting increased capacity for science that underpins mCDR, both domestically and internationally. In order to adequately test proposed methodologies, significant additional capacity is needed. Through its robust investments in ocean acidification capacity, there is already a model for increasing capacity for carbonate chemistry work. There is similar infrastructure for air-sea exchange research. There is an opportunity to further increase domestic and international scientific capacity to ensure an mCDR-ready scientific workforce. This network of local experts will also enable any field trials to be grounded in local expertise and community relationships and will reduce the risk of a small group of experts being responsible for a large number of trials.

The risk for unintended adverse effects from mCDR techniques is vast: iron fertilization promotes plankton blooms and anoxic zones; enhanced weathering or alkalization is energy-intensive, requires terrestrial mining, and may introduce toxic components to the ocean; and macroalgae cultivation and sinking can alter deep sea nutrient cycling or bury seafloor habitats. The ocean's ability to act as a natural carbon sink and other natural systems may also face challenges stemming from mCDR and climate geoengineering.

Other forms of climate geoengineering may affect the ocean, and the transboundary and other widespread outcomes should be considered. For example, marine cloud brightening may cause increased ocean acidification; solar radiation management would reduce sunlight available in the photic zone; and one form of arctic refreezing may introduce tiny glass beads easily mistaken by zooplankton as food. All risks should be viewed from an equity and just transition lens to ensure that any costs and benefits associated with any proposed methodologies are equitably borne.

*4. What **kinds of information** about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?*

Regarding the kinds of information publicly available, understanding the decision making and investment strategy behind the Federal Government's current efforts, research, and investment in mCDR research would be helpful. This would allow The Ocean Foundation and other organizations with strong relationships to local communities and stakeholders to make connections, identify potential partnerships, and elevate knowledgeable voices that will strengthen any investments in the realm of mCDR that the government has chosen to make. It would also be helpful to know the key research and knowledge gaps that exist and what efforts are underway to address them.

Regarding the engagement of stakeholders, we recommend utilizing direct consultation, an open comment process, and comprehensive information sharing. We also recommend creating representative decision-making bodies that include frontline communities and vetted science experts. Any potential implementation of mCDR projects should obtain the Free, Prior, and Informed Consent of Indigenous Peoples, as recognized by the UN Declaration on the Rights of Indigenous Peoples. Consent, after consultation, should also be required from any and all potentially affected communities, including those who have been historically marginalized, including Black, Indigenous, and people of color (BIPOC). Transparency and open dialogue need to be at the forefront of any mCDR effort.

*5. What are the **most significant marine CDR efforts being undertaken** by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?*

As noted above, we are concerned about significant current mCDR efforts involving mechanical, chemical, and artificial mCDR methods that may result in unintended consequences. We see mCDR and other forms of climate geoengineering on a continuum in which some are ready to go (NbS such as blue carbon conservation and restoration), some we are very concerned about (mirrors in space), and some in the middle that should be the subject of research spending. As a result, we must prioritize spending to focus society on the most promising solutions. We can start by synthesizing known science, law, and economic information and then project which solutions should be started immediately, warrant research, or are unlikely to have much impact (or be timely to help address climate change before it is too late). It is also important that multiple endpoints are studied in any federally funded research. For example, if an OAE experiment solely looks at coral growth rates, but not the structural integrity of coral, and a coral species grows very quickly but is very brittle, then the benefits of OAE are lost. Careful studies including a multidisciplinary assessment of risks and benefits are essential.

Regarding collaboration, it is imperative that all research projects meet best practices in transparency and data-sharing. Those engaged in mCDR research do not have the luxury of waiting for a key trial or pilot project's results to be published in a scientific journal years later, or worse, learnings that will remain in corporate file drawers. This risks repetitive work that shrinks limited resources (including time) or even unnecessary harm if the costs of one approach are found to consistently outweigh benefits. A collaborative mindset should inform dialogue between researchers studying a particular mCDR approach, enabling more rapid assessments of efficacy, relevant factors for effectiveness, and potential unintended results.

Regarding partnerships, countries without sufficient tools to monitor baseline conditions and evaluate potential impacts are particularly vulnerable to unregulated and under-researched marine and terrestrial climate geoengineering projects. Transboundary harm and impacts are likely due to the connections between natural systems. Both along our own US coastlines and abroad, we encourage any discussion on mCDR to invite representative voices from local communities to ensure transparency and facilitate communication on this important topic. Any international trials should be led or co-led by local scientists.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Reducing carbon dioxide emissions should remain a priority to reduce the impacts of climate change, as mCDR is not a holistic solution to climate change. In the research, development, and testing of any potential mCDR project, the effects on the environment and local communities must be understood before any large-scale deployment. These potential effects may reach beyond the immediate vicinity of the deployment due to the connectivity of oceanic systems, potentially into neighboring countries, and have unintended consequences regarding geopolitical tensions. Any project requiring significant energy inputs should consider where that energy is sourced. Sourcing energy from nonrenewable sources for marine CDR would be counterproductive.

From: Joshua Herwig (b) (6)
Sent: Wednesday, April 24, 2024 7:00 PM
To: Light, Tricia M. EOP/OSTP
Cc: Arturo Santa
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan - Oasis CDR Response
Attachments: Oasis CDR - MCDR FTAC Marine CDR Research Plan RFI 4.24.24.pdf

Dear Tricia and Committee Members,

Thank you for your patience in accepting Oasis' response to the Marine Carbon Dioxide Removal Research Plan Request for Information.

We're pleased to contribute to the Committee's request, and believe that these early actions are not only warranted, but are clearly necessary in light of the rapid pace of climate degradation caused by human activities.

We are heartened by the Federal Government's commitment to dedicate time and resources to one of the most viable solutions to this current crisis. Our team is committed to supporting these activities and looks forward to future opportunities for support and collaboration.

On a personal note, as a member of a generation that has grown to adulthood with a persistent awareness of our changing climate, I can say that I'm hopeful for the future, not in small part because of the actions of this Committee and the larger domestic and international community daring to preserve our special place in the Cosmos.

Kind regards

Joshua Herwig
Chief Technology Officer | Oasis CDR
Ph: (b) (6)
[linkedIn](#) | [website](#)

Response to NSF/NSTC MCDR-FTAC
Marine Carbon Dioxide Removal Research Plan
Request for Information (89 FR 13755)

Responding Organization: Oasis CDR | www.oasiscdr.com
Prepared by: Joshua D. Herwig | Chief Technology Officer
Date: April 24, 2024

Oasis is pleased to contribute to the Committee's request for input and believes that these early actions are not only warranted but are clearly necessary considering the rapid pace of climate degradation caused by humanities activities.

We are heartened by the Federal Government's commitment to dedicate time and resources to one of the most viable solutions to this current crisis. Our team is committed to supporting these activities and looks forward to future opportunities for support and collaboration.

We have chosen to answer questions 1-4 and 6.

Question 1

The development and implementation of federal legislation specifically addressing marine carbon dioxide removal (MCDR) would significantly impact our organization along with the broader community of stakeholders engaged in ocean-based climate solutions. We anticipate the following effects:

1. **Regulatory Clarity and Support:** The introduction of specific federal legislation for marine CDR projects could provide a more defined regulatory pathway for research and deployment activities. This would help organizations, such as ours, navigate the legal landscape more effectively and reduce regulatory uncertainties that currently complicate ocean-based CDR efforts.
2. **Funding and Resources:** A consolidated plan signals Federal support for MCDR and opens avenues for both public and private-sector funding and resources. For early-stage companies, this would mean a strategy to provide and communicate access to grants, public investments, and partnerships that are critical for innovative high-risk, high-growth-potential projects.
3. **Standardization of Practices:** Legislation could lead to the establishment of standardized guidelines and best practices for conducting marine CDR activities. This would be beneficial in ensuring that all operations are conducted responsibly, minimizing negative impacts on marine ecosystems, and enhancing the credibility and public trust in these emerging technologies.
4. **Community and Stakeholder Engagement:** Effective legislation would emphasize the importance of stakeholder and community engagement in marine CDR projects. This would aid in fostering public trust and gaining social license to operate, a potentially overlooked, but critical concern for project developers.

5. **Long-term Policy Support**: A marine CDR plan, leading to a robust legal framework, would provide long-term stability and policy support, essential for securing the financial backing needed for large-scale and high-risk projects. This would assist us not only in operational planning but also in strategic decision-making and long-term business sustainability.

Question 2

Questions and Concerns:

1. **Regulatory Clarity:** As the industry matures beyond the intended scope of existing legislation (e.g. MPRSA[1]), what specific regulations will govern marine CDR research and deployment, especially in international waters or areas beyond national jurisdiction? How will these regulations address transboundary environmental impacts?
2. **Intellectual Property and Data Sharing:** How will data and findings from publicly funded research be shared? Will there be provisions to protect intellectual property while promoting open collaboration?
3. **Climate-relevant Timelines:** How will the government create, enact, and enforce regulation to meet the exigent need for large-scale carbon removal?
4. **45Q Expansion beyond Geologic Sequestration**: Enactment of section 45Q[2] represented a major step forward in incentivizing the private sector to invest in carbon emission mitigation. A similar, or expanded framework for novel CDR methods, specifically ocean-based methods, has a tremendous potential to catalyze innovation and support basic science research in our oceans. How would such an expansion be feasible?

Tools and Resources Needed from the Federal Government:

1. **Funding for Research and Development:** Significant investment in R&D to develop, test, and scale marine CDR technologies. This includes funding pilot projects and field trials to advance methods as well as investing in fit-for-purpose sensors and ocean observing infrastructure to advance MRV solutions.
2. **Clear Guidelines and Best Practices**: Development of standardized procedures and best practices for conducting marine CDR safely and effectively.
3. **Monitoring and Reporting Frameworks**: Robust frameworks to ensure continuous monitoring and reporting of the carbon removal efficacy and environmental impacts of marine CDR activities.
4. **Capacity Building:** Training programs and resources to build expertise within the federal government (regulatory agencies), academic institutions, and the private sector. These are necessary to build the blue economy workforce, who will ultimately be tasked with enabling a potential trillion-dollar market.[3]

1. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-H
2. https://www.federalregister.gov/documents/2021/01/15/2021-00302/credit-for-carbon-oxide-sequestration
3. https://impact.economist.com/ocean/ocean-and-climate/advancing-responsible-deep-blue-carbon-a-business-strategist-perspective

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Question 3

Specific Focus:

Novel MCDR methods offer an opportunity for carbon removal unmatched by terrestrial approaches. Given the scale of the problem, the state of our current understanding, and the general uncertainties associated with MCDR, a decision to limit the support to a small subset of proposed methods is premature. Rather, a marine CDR plan should encompass both the "mainstream" methods as presented in the literature (e.g. National Academies Consensus Study[4]), as well as leave room for supporting novel methods that emerge as the field and knowledgebase matures.

Promising Methods:

While we believe that the government should support a broad range of focus areas regardless of current and predicted market factors, our organization is primarily focused on advancing MRV and deployment infrastructure for biotic methods of carbon sequestration, particularly microalgae cultivation. This method has the potential to safely scale to meet the forecasted carbon sequestration demand due to the low cost of material required and the minimal energy requirement for both material sourcing and deployment. There are unproven potential risks associated with this proposed method, as with other MCDR approaches. Part of our priorities is to appropriately characterize, monitor and mitigate these, including harmful algal blooms and the disruption of nutrient cycles.

4. National Academies of Sciences, Engineering, and Medicine. 2022. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

Question 4

Focus on Public Outreach

The Government's strategy in disseminating information about marine CDR should prioritize transparency, inclusivity, and proactive communication, particularly aimed at non-scientific stakeholders. Gaining widespread public support is essential for two primary reasons:

1. **Public Policy Influence:** Public perception significantly influences policy decisions. A well-informed public can drive the adoption of effective and supportive policies for marine CDR.
2. **Support for both Voluntary and Compliance Markets:** Fostering a positive public perception of marine CDR is crucial as it encourages private companies to enhance their carbon reduction goals and continue to include MCDR-generated removals in their portfolios. Currently, much of the movement in carbon removal is driven by market perceptions and the need for positive environmental marketing. While this has energized the latent removals market and provided a new source of capital for early-stage ventures, neither the voluntary carbon removal market, nor any future compliance carbon market will survive or exist without widespread public acknowledgment and support for these goals, and the carbon removal methodologies that allow private companies to achieve them.

Strategies for Government Engagement

1. **Openness and Transparency:** The government must commit to openness in its communications, learning from challenges seen in other major public initiatives, such as the COVID-19 response. Clear, accurate, and timely information is essential to combat misinformation and build trust in marine CDR as a viable solution to climate change.
2. **Meeting the Public Where They Are**: Communications should be tailored to meet the public through familiar and accessible channels. This includes engaging community representatives, thought leaders, and science communicators who resonate with, and are trusted by the broader public. Utilizing platforms where most Americans receive their information will help ensure the message is received and understood.

Messaging Strategies

1. **Balanced Messaging:** Government messaging should be carefully balanced. While it is important not to downplay any potential risks associated with marine CDR, the focus should be on the urgent need for these technologies and their potential co-benefits. Messaging should remain positive, emphasizing how marine CDR contributes to mitigating climate change and enhancing community resilience.
2. **Highlighting Economic and National Security Benefits:** Communications should highlight the economic opportunities presented by marine CDR projects, including job creation and industry growth. Additionally, the role of these projects in addressing national security concerns related to climate change should be underscored, presenting marine CDR as a strategic component in the broader national response to global warming.

Engagement with Indigenous and Coastal Communities

1. **Respectful and Collaborative Engagement:** Engagement with Indigenous and coastal communities should be respectful and collaborative. The government should prioritize learning from the unique lifeways and rich cultural knowledge of these communities and integrate their insights into project planning and implementation[1].
2. **Inclusion in Rewards of the Work:** It is crucial that these communities are not just consulted, but actively involved in a way that allows them to benefit from local marine CDR projects[5]. This approach fosters genuine partnership and ensures that the projects support local development while advancing global environmental goals.

5. Boettcher, M. (2023). A Code of Conduct for Marine Carbon Dioxide Removal Research. Aspen Institute. https://www.aspeninstitute.org/wp-content/uploads/2023/11/110223_Code-of-Conduct_FINAL2.pdf

Question 6

Special Considerations for Trial Site Access:

As the Federal Government develops a comprehensive Marine Carbon Dioxide Removal Plan, it is crucial to address the significant challenges facing early-stage marine CDR efforts, particularly regarding access to suitable trial sites. Our organization, Oasis, is deeply committed to developing observational infrastructure for trial sites and beyond that would offer state-of-the-art MRV capabilities to a diverse set of MCDR methodologies. As such, we have identified several strategic considerations that we urge the government to incorporate into the Marine CDR Plan, specifically for the creation of trial sites:

Recommendations for Government Action:

1. **Designation of Research Zones:** The government could designate specific areas within U.S. territorial waters as marine CDR research zones. These zones could be carefully selected as to be pre-approved for research and experimentation, significantly reducing the hurdles that currently impede quick setup and execution of pilot projects. By streamlining the approval process within these zones, the government would enable faster deployment, testing, and scaling of innovative marine CDR technologies. While the concept of pre-approved sites carries certain risks, we believe centralized oversight of such zones would reduce the administrative burden, and avoid undesirable consequences of relegating site selection, permitting, and monitoring solely to the entities conducting MCDR research.
2. **International Collaborative Research Areas:** Marine environments and their management are inherently international issues that do not adhere to national boundaries. The U.S. government should lead or participate in international efforts to establish cross-border marine CDR research areas. These areas could serve as global hubs for innovation, sharing infrastructure, data, and best practices, and would be managed through treaties or international agreements.
3. **Funding and Incentives for Site Development:** Create proposals for grants, tax incentives, or other financial support mechanisms to assist research entities in developing and maintaining trial sites. This support would be particularly crucial for non-profit research institutes and small enterprises that might lack the capital to invest in such infrastructure on their own.
4. **Enhanced Stakeholder Engagement:** Develop mechanisms to ensure that all stakeholders, including local communities, Indigenous groups, and environmental organizations, are actively involved in the planning and ongoing operations of trial sites. This targeted, location-specific engagement should include regular consultations, transparent reporting, and opportunities for these groups to benefit from the research activities.
5. **Facilitating Knowledge Sharing:** Establish online platforms or databases to share findings, best practices, and environmental data from these trial sites with the broader marine CDR research community globally. With provisions to protect intellectual property while promoting open collaboration, this approach would accelerate learning across projects and geographies, driving faster innovation and adoption of effective CDR methods.

From: Romany M. Webb (b) (6)
Sent: Thursday, April 18, 2024 5:42 PM
To: Light, Tricia M. EOP/OSTP
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan - Response to RFI from Sabin Center for Climate Change Law
Attachments: Sabin center - Comments on mCDR FTAC RFI (with attachment) - Apr. 2024.pdf

Dear Ms. Light,

Please find attached comments submitted on behalf of the Sabin Center for Climate Change Law in response to the February 23, 2024 request for information to inform the development of a marine carbon dioxide removal implementation plan by the Fast-Track Action Committee on marine carbon dioxide removal.

Sincerely,
Romany Webb

Romany M. Webb (she / her)
Research Scholar, Columbia Law School
Deputy Director, Sabin Center for Climate Change Law
Adjunct Assistant Professor of Climate, Columbia Climate School

Phone: (b) (6)
Email: (b) (6)

Pronouns: she, her, hers

Columbia Law School | COLUMBIA CLIMATE SCHOOL
SABIN CENTER FOR CLIMATE CHANGE LAW

April 18, 2024

Tricia Light
Office of Science & Technology Policy
Executive Office of the President

By email: (b) (6)

Re: National Science Foundation Request for Information on Development of Marine Carbon Dioxide Removal Research Plan

Dear Ms. Light,

Columbia Law School's Sabin Center for Climate Change Law ("Sabin Center") respectfully submits these comments in response to the National Science Foundation's Request for Information ("RFI") to inform the development of a marine carbon dioxide removal ("mCDR") implementation plan by the mCDR Fast-Track Action Committee ("FTAC").[1]

The Sabin Center strongly supports the FTAC's work to advance research into mCDR as a possible climate change mitigation tool and develop legal and policy frameworks to ensure that mCDR research and any subsequent deployment occur in a safe, responsible, and just way. As noted in the RFI, climate change poses serious and growing threats to human and natural systems.[2] The Intergovernmental Panel on Climate Change has made clear that, to avoid climate catastrophe, global greenhouse gas emissions must be rapidly reduced to net zero.[3] The United States has committed to achieving a net-zero emissions economy by 2050, which will require not only widespread decarbonization (e.g., of energy systems, manufacturing, and other industry sectors) but also the removal of carbon dioxide from the atmosphere.[4] A recent U.S. National Academies of Sciences, Engineering, and Medicine ("NASEM") report concluded that "[t]he ocean holds great potential for uptake and longer-term sequestration of" carbon dioxide, but that further research is needed to answer key questions about the efficacy and impacts of different mCDR approaches.[5] As noted in the NASEM report, mCDR research and any subsequent deployment should be pursued in an open and transparent manner, with robust public engagement and effective government oversight.[6] The Sabin Center urges the FTAC to bear these objectives in mind when developing the implementation plan. The Sabin Center also offers more specific comments on the first four questions posed in the RFI.

Question 1: Relevance and Impact of an mCDR Implementation Plan for the Sabin Center

An academic think-and-do tank housed at Columbia Law School, the Sabin Center works to develop innovative legal tools to combat the climate crisis and advance climate justice. Through its initiative on

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[1] Marine Carbon Dioxide Removal Research Plan, 89 Fed. Reg. 13755 (Feb. 23, 2024).
[2] *Id.*
[3] Press Release, IPCC, The evidence is clear: the time for action is now. We can halve emissions by 2030 (April 4, 2022), https://www.ipcc.ch/2022/04/04/ipcc-ar6-wgiii-pressrelease/.
[4] THE LONG TERM STRATEGY OF THE UNITED STATES: PATHWAYS TO NET-ZERO GREENHOUSE GAS EMISSIONS BY 2050 (2021), https://www.whitehouse.gov/wp-content/uploads/2021/10/us-long-term-strategy.pdf
[5] SCOTT DONEY ET AL., A RESEARCH STRATEGY FOR OCEAN-BASED CARBON DIOXIDE REMOVAL AND SEQUESTRATION 2 (National Academies Press, 2022)..
[6] *Id.* at 245.

"carbon management and negative emissions," the Sabin Center has explored legal challenges and opportunities associated with mCDR research and deployment. In 2023, Sabin Center researchers published an edited book—*Ocean Carbon Dioxide Removal for Climate Mitigation: The Legal Framework*—analyzing the laws governing five different mCDR activities at the international level and domestically in the U.S. and six other countries.[7] Research undertaken for the book highlighted key gaps and shortcomings in existing legal frameworks, prompting the Sabin Center to explore possible legal reforms to advance safe, responsible, and just mCDR development. The Sabin Center has published recommendations for new federal legislation on mCDR,[8] as well as executive actions that could be taken under existing law to improve regulation.[9] The Sabin Center also engages with mCDR researchers and others, for example, to provide education and training on the legal issues associated with mCDR activities.

The implementation plan developed by the FTAC will help to inform the Sabin Center's future research and engagement on mCDR. As one example, the Sabin Center is currently planning an mCDR law symposium which will be held in 2025, and bring together diverse stakeholders to discuss legal and policy frameworks for advancing mCDR. To the extent that the FTAC's implementation plan identifies key legal questions or proposes new legal frameworks, they could be a focus of discussions at the symposium.

Question 2: Uncertainties, Gaps, and Shortcomings in the Regulatory Framework for mCDR

Effective federal regulation is essential to advance safe, responsible, and just mCDR research.[10] Currently, the regulatory framework is highly fragmented, with multiple federal agencies potentially involved in overseeing mCDR activities.[11] For example, depending on where they take place and the activities involved, mCDR projects may require permits or other approvals from the Army Corps of Engineers ("ACE"), Bureau of Ocean Energy Management ("BOEM"), and Environmental Protection Agency ("EPA") (among others).[12] Some projects (or aspects of projects) might also be subject to Tribal, state, or local regulation.[13]

This fragmentation results in significant uncertainty for researchers and others seeking to undertake mCDR projects and creates the potential for inefficiencies in the project review process. To address these issues, we recommend that (1) the FTAC explore ways to enhance coordination both among federal agencies and between those agencies and relevant actors at other levels of government, and (2) individual agencies clarify how they will exercise their respective roles and responsibilities. These recommendations are elaborated on below and in a recent Sabin Center white paper, included as Attachment A to this letter.

Enhancing Interagency Coordination on mCDR

Interagency coordination—both among federal bodies and between those bodies and actors at other levels of government—is essential to ensure effective oversight of mCDR projects and avoid duplication and other inefficiencies in the project review process.[14]

Establishment of the FTAC was an important first step in promoting greater coordination amongst federal

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[7] ROMANY M. WEBB ET AL., OCEAN CARBON DIOXIDE REMOVAL FOR CLIMATE MITIGATION: THE LEGAL FRAMEWORK (Edward Elgar Publishing, 2023).
[8] ROMANY M. WEBB & KOREY SILVERMAN-ROATI, DEVELOPING MODEL FEDERAL LEGISLATION TO ADVANCE SAFE AND RESPONSIBLE OCEAN CARBON DIOXIDE REMOVAL RESEARCH IN THE UNITED STATES (2023), https://scholarship.law.columbia.edu/sabin_climate_change/199/.
[9] ROMANY M. WEBB & KOREY SILVERMAN-ROATI, EXECUTIVE ACTIONS TO ENSURE SAFE AND RESPONSIBLE OCEAN CARBON DIOXIDE REMOVAL RESEARCH IN THE UNITED STATES (2023 (updated 2024)), https://scholarship.law.columbia.edu/sabin_climate_change/211/. (Included as Attachment A to this letter.)
[10] *See generally* Doney et al., *supra* note 5, at 54 ("Establishing a robust legal framework for ocean CDR is essential to ensure that research and (if deemed appropriate) deployment is conducted in a safe and responsible manner that minimizes the risk of negative environmental and other outcomes").
[11] *Id*. 52-54.
[12] *Id*.
[13] *Id*. at 52.
[14] Webb & Silverman-Roati, *supra* note 9, at 506.

agencies. The FTAC does not, however, involve relevant bodies at other levels of government. Moreover, the FTAC is intended to be temporary, with its Charter indicating that it "shall terminate no later than 14 months after the date of approval."[15] Developing a more permanent vehicle for interagency coordination is essential to ensure that agency actions are aligned, avoid duplication of effort, and promote efficiency in project reviews.

Federal agencies could formalize their cooperation on mCDR by entering into an Interagency Memorandum of Understanding ("MOU"). Interagency MOUs are used across the federal government to establish the ground rules for agency collaboration and cooperation. Recently, a number of interagency MOUs have been adopted to streamline the review of projects, particularly climate-related infrastructure projects that require approvals from multiple federal agencies.[16] Building on this experience, agencies currently participating in the FTAC, or a subset thereof, could enter into an MOU to coordinate their work on mCDR. The MOU should include mechanisms designed to align agencies' review of mCDR projects, promote information sharing, and reduce duplication and similar inefficiencies in agency processes. For example, agencies might consider implementing a combined pre-application process for mCDR projects and developing a joint schedule for project reviews and authorizations, which provides for parallel (rather than sequential) action by different federal bodies. (See Attachment A for a more detailed discussion of these and other options.)

Federal agencies should also explore ways to enhance coordination with, and otherwise support the work of, Tribal, state, and local government bodies involved in overseeing mCDR activities. Improved information sharing and the provision of technical and other assistance to relevant bodies at other levels of government is likely to be especially useful. (See Attachment A for further information.)

Resolving Key Uncertainties About the Regulation of mCDR

As well as enhancing interagency coordination on mCDR, it will also be important for individual federal agencies to clarify how they will approach permitting and other reviews of mCDR projects. We note that, at the listening session on March 19, 2024, EPA representatives provided useful information about the potential regulation of mCDR projects under the Marine Protection, Research, and Sanctuaries Act ("MPRSA") and the Clean Water Act ("CWA"). EPA also recently published an online guide to permitting mCDR projects under the MPRSA and CWA. While we commend EPA for proactively sharing this information, we urge the agency to go further and address remaining questions about its regulation of mCDR activities. We also encourage other federal agencies to clarify their regulatory approaches.

With respect to EPA, the agency has noted that mCDR projects involving the discharge of materials into the ocean may require MPRSA permits.[17] In international discussions under the London Convention and Protocol, U.S. representatives suggested that MPRSA permits would only be required for mCDR projects "if the project sponsor did not intend, anticipate, or prepare to recover the materials from the ocean as part of the project."[18] That approach has not, however, been expressly approved by EPA (e.g., in regulations) and there is significant uncertainty as to how it would be implemented in practice. For example, what will project proponents need to show to demonstrate that they intend to remove materials? Within what timeframe must materials be removed? What are the consequences of materials being lost before removal?

There is also significant uncertainty as to how EPA will approach the permitting of mCDR activities that are found to be subject to the MPRSA. We note that regulations adopted by EPA under the MPRSA provide

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[15] Charter of the Marine Carbon Dioxide Removal Fast Track Action Committee of the Subcommittee on Ocean Science and Technology National Science and Technology Council (Sept. 15, 2023), https://www.noaa.gov/sites/default/files/2023-10/mCDR_FTAC_charter_2023_09_19_approved.pdf.
[16] *See generally* Webb & Silverman-Roati, *supra* note 9, at 506.
[17] Envtl. Prot. Agency, *Permitting for mCDR and mSRM*, OCEAN DUMPING, https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm.
[18] Report of the Forty-Sixth Meeting of the Scientific Group Under the London Convention and the Seventeenth Meeting of the Scientific Group Under the London Convention, IMO Doc. LC/SG 46/16 (March 31, 2023).

for the issuance of research permits.[19] EPA has indicated on its website that "[r]esearch permits are the most relevant MPRSA permit category for mCDR . . . research activities" but has not further elaborated on when an mCDR activity may qualify as research.[20] In a 2023 report outlining recommendations for new federal legislation on mCDR, the Sabin Center offered a possible definition of mCDR research as follows: "Research project means an action or activity undertaken . . . for the primary purpose of advancing scientific understanding of [mCDR] techniques. Research projects may involve the development, testing, evaluation, and demonstration of [mCDR] techniques. Research projects exclude deployment," which we defined to mean "an activity or project that involves the use of an [mCDR] technique to remove a total of 100,000 metric tons or more of carbon dioxide from the atmosphere or such other amount as" the agency may specify.[21] This definition was developed in consultation with a broad range of mCDR stakeholders from across academia, industry, the NGO community, and government. As such, it may provide a useful starting point for EPA as it considers how to define mCDR research for the purposes of the MPRSA.

EPA should also explain whether / how its review of mCDR research activities will be informed by the Assessment Framework for Scientific Research Involving Ocean Fertilization, which was adopted by parties to the London Convention and Protocol in October 2010.[22] The Assessment Framework outlines a set of criteria that projects must meet in order to be considered "legitimate scientific research."[23] Will EPA apply those criteria to determine whether an mCDR project qualifies as a "research activity" that may be permitted via an MPRSA research permit? If not, what criteria will EPA apply?

We encourage EPA to answer these and other key questions regarding the permitting of mCDR research under the MPRSA. EPA should also explain how it will approach the permitting of non-research activities and whether / what different requirements might apply to those activities versus research projects (e.g., in terms of the information required from permit applicants, the criteria for issuing permits, and the permit conditions that might be imposed.). (See Attachment A for more information on actions EPA may take.)

Other agencies that may be involved in regulating mCDR activities, such as BOEM and ACE, should similarly clarify their regulatory approaches. For example, BOEM should specify when mCDR activities may require leases under the Outer Continental Shelf Lands Act, and the limits of its leasing authority. ACE should explain the treatment of mCDR activities under the Rivers and Harbors Act and whether / when those activities may be covered by existing general permits issued under that Act. BOEM, ACE, and other agencies should also clarify the application of the National Environmental Policy Act ("NEPA") and explore options for streamlining NEPA reviews of mCDR projects, including through the use of categorical exclusions and programmatic reviews as appropriate. (See Attachment A for further information.)

Question 3: mCDR Techniques Requiring Research

As explained in the 2022 NASEM report, all mCDR techniques are in the early stages of development, and require significantly more research to verify their efficacy and impacts.[24] Given this, we urge the FTAC to take a technique-neutral approach, and ensure that the implementation plan does not promote or exclude any particular mCDR approach. Specifically, we endorse the recommendation in the 2022 NASEM report that "a research program for [m]CDR should be implemented, in parallel across multiple approaches. . .

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[19] 40 CFR § 220.3.
[20] Envtl. Prot. Agency, *supra* note 17.
[21] Webb & Silverman-Roati, supra note 8, at 2-3. See also id. at 4-5 (explaining why a default, 100,000 ton threshold was applied to mCDR deployments).
[22] Resolution LC-LP.2(2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (adopted 14 Oct. 2010) [hereinafter "2010 Assessment Framework"]. We note that EPA regulations indicate that the agency will "apply the standards and criteria binding upon the United States under the" London Convention "to the extent that application of such standards and criteria do not relax the requirements of the Act." *See* 40 C.F.R. δ 220.1(b). This does not, however, answer the question of whether / how the EPA will apply the 2010 Assessment Framework since that framework is not legally binding on the United States.
[23] 2010 Assessment Framework, *supra* note 22, at 5.
[24] NASEM Report, *supra* note, at 239 & 253-260.

The research program should not advocate for or lock in future [m]CDR deployments but rather provide an improved and unbiased knowledge base for the public, stakeholders, and policymakers."[25]

We further recommend that the implementation plan be designed to support and facilitate the full suite of research needed to assess different mCDR approaches. That will include not only scientific and technical research but also work on the social science aspects of mCDR. As the 2022 NASEM report concluded, any mCDR research strategy must "integrat[e] . . . research on social, legal, regulatory, policy, and economic questions relevant to ocean CDR . . . with the natural science, engineering, and technical aspects" of the research agenda.[26] This is essential to inform future societal decisions about whether, when, where, and how mCDR might be used to combat climate change.

Question 4: Requirements for Information Sharing and Public Engagement

The federal government has an essential role to play in educating the public about mCDR, its potential use to mitigate climate change, and the other co-benefits and risks it might present. We recommend that federal agencies develop and publish fact sheets and host public information sessions on mCDR.

Additionally, federal agencies that authorize, fund, or are otherwise involved in mCDR research should ensure that project proponents effectively engage with local communities and other potentially affected and interested stakeholders and actively involve them in the project design and implementation process. As noted in a recent report published by the Aspen Institute, "[h]aving communities participate from the outset and guide the research can increase the likelihood of mCDR implementations that are compatible with environmental justice . . . 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."[27] The report thus recommended that entities funding mCDR research, including government bodies, ensure project budgets and timelines reflect the need for co-development of research.[28] Government funders should also require mCDR project proponents to develop community engagement plans and make implementation of those plans a condition of federal funding. This is discussed further in Attachment A.

* * * * *

In conclusion, the Sabin Center commends the FTAC for its work to date, and appreciates the opportunity to submit comments to inform its development of the mCDR implementation plan. As noted above, the plan is an important component of the federal government's efforts to advance research into mCDR as a possible climate change mitigation tool and develop complementary legal and policy frameworks to ensure that research and any subsequent deployment occur in a safe, responsible, and just way.

Sincerely,

/s/ Romany Webb

Romany M. Webb
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[25] *Id*. at 240.
[26] *Id*.
[27] Mirand Boettcher et al., A Code of Conduct for Marine Carbon Dioxide Removal Research 25 (2023), https://www.aspeninstitute.org/publications/a-code-of-conduct-for-marine-carbon-dioxide-removal-research/. t
[28] Id. at 26.

Attachment:

(1) Romany M. Webb & Korey Silverman-Roati, Executive Actions to Ensure Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States (November 2023, updated April 2024).

4-2024

Executive Actions to Ensure Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States

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Executive Actions to Ensure Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States

By Romany M. Webb and Korey Silverman-Roati

November 2023

(Revised April 2024)

The Sabin Center for Climate Change Law develops legal techniques to fight climate change, trains law students and lawyers in their use, and provides the legal profession and the public with up-to-date resources on key topics in climate law and regulation. It works closely with the scientists at Columbia University's Climate School and with a wide range of governmental, non-governmental and academic organizations.

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This work was generously supported by Ocean Visions.

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Note: This white paper was first published in November 2023. The white paper was updated in April 2024 to incorporate new information published by the Environmental Protection Agency regarding its regulation of ocean carbon dioxide removal activities and correct typographical and minor other errors in the original manuscript.

Table of Contents

I. Introduction

There is now broad scientific consensus that carbon dioxide removal (CDR) will be needed, alongside deep emissions cuts, to achieve global temperature targets. According to the Intergovernmental Panel on Climate Change (IPCC), we must reach net-zero carbon dioxide emissions in the early 2070s to limit temperature increases to 2ºC above pre-industrial levels, and by the early 2050s to hold temperature increases to 1.5ºC.[1] In almost all modeled scenarios, CDR is needed to achieve net zero emissions, leading the IPCC to conclude that CDR is "unavoidable."[2] The extent of CDR required will depend on how quickly emissions are cut; the longer emissions cuts are delayed, the more CDR will be needed.[3]

Scientists have proposed a number of land- and ocean-based CDR approaches, and recent years have seen increased scientific and policy interest in ocean-based approaches. According to a 2022 report by the U.S. National Academies of Sciences, Engineering, and Medicine (NASEM), the ocean holds "great potential" for additional uptake and longer-term sequestration of carbon dioxide.[4] The 2022 NASEM report explored a range of possible strategies for increasing the ocean's role as a carbon sink, including:

> (1) Ocean fertilization, which involves adding iron, nitrogen, or phosphorous to the surface ocean to stimulate the growth of phytoplankton that uptake carbon dioxide and convert it into organic carbon.[5]
>
> (2) Artificial upwelling, which involves installing vertical pipes in the ocean to transport nutrient-rich water from the deep ocean to the surface, and thereby stimulate the growth of phytoplankton. As in ocean fertilization, the phytoplankton uptake carbon dioxide and convert it into organic carbon, which may end up stored in the deep sea.[6]
>
> (3) Seaweed cultivation and sinking, which involves growing kelp and other macroalgae that take up carbon dioxide as they grow and store it in biomass, which can later be sunk into the deep ocean to sequester the carbon it contains.[7]
>
> (4) Ocean alkalinity enhancement, which involves adding alkalinity to ocean waters, typically by discharging ground silicate or carbonate rock, which then reacts with carbon

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[1] IPCC, *Summary for Policymakers, in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE. CONTRIBUTION OF WORKING GROUP III TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 1, 23 (P.R. Shukla et al. eds, 2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf.
[2] *Id*. at 36.
[3] *Id*.
[4] SCOTT C. DONEY ET AL., A RESEARCH STRATEGY FOR OCEAN-BASED CARBON DIOXIDE REMOVAL AND SEQUESTRATION 2 (National Academy of Sciences, Engineering, and Medicine, 2022), https://nap.nationalacademies.org/read/26278/chapter/1.
[5] For more information about ocean fertilization, see *id*. at 77-102.
[6] For more information about artificial upwelling, see *id*. at 103-126
[7] For more information about seaweed cultivation, see *id*. at 127-180.

dioxide in the water, converting it into other forms of dissolved inorganic carbon and thereby enabling the ocean to absorb additional carbon dioxide from the atmosphere.[8]

(5) Electrochemical ocean CDR, which encompasses a range of techniques that use electricity to drive chemical reactions that result in carbon removal. As an example, electricity may be used to separate ocean water into basic and acidic streams. The basic stream can then be added back into the ocean to increase the alkalinity of the water, enabling it to uptake additional carbon dioxide from the atmosphere. The acidic stream can be treated to strip out carbon dioxide, which can then be sequestered onshore or in sub-seabed geologic formations.[9]

The 2022 NASEM report concluded that "[t]he present state of knowledge on many ocean CDR approaches is inadequate . . . to inform future societal decisions" about whether and how they might be used to address climate change.[10] Key questions remain about the efficacy of different ocean CDR techniques, including the net amount of carbon dioxide that can be removed from the atmosphere using each technique, and how long the removed carbon dioxide will be stored in the ocean. The NASEM report called for "[e]xpanded research including field research" to answer these questions.[11] In addition, according to the NASEM report, "[r]esearch is also needed to identify and qualify environmental impacts, risks, benefits, and co-benefits" associated with different ocean CDR techniques.[12] Initial work, based on laboratory experiments and modeling, suggests that ocean CDR approaches could have a range of non-carbon co-benefits. For example, ocean fertilization could increase fish stocks, seaweed cultivation could help to combat coastal eutrophication, and ocean alkalinity enhancement could mitigate ocean acidification (among other things).[13] However, each approach also presents environmental and other risks, with scientists expressing particular concerns about the potential for changes to surface and deep ocean biology.[14] For example, ocean fertilization in one area could lead to a decline in biological production and oxygen consumption in other regions of the ocean, [15] and sinking seaweed in the deep sea could lead to increases in acidification, hypoxia, and eutrophication in those deep sea areas. [16]

Further research is needed to fully evaluate each ocean-based CDR technique. Many of the remaining scientific questions can only be answered through in-ocean research and, in some cases, relatively large-scale or long-duration field trials may be necessary.[17] This could raise a host of legal issues, since ocean-based activities are governed by a variety of international, national, and

[8] For more information about ocean alkalinity enhancement, see *id*. at 181-208.
[9] For more information about electrochemical ocean capture, see *id*. at 209-238.
[10] *Id*. at 239-240.
[11] *Id*. at 239.
[12] *Id*.
[13] *Id*. at 256
[14] *Id*. at 6.
[15] *Id*. at 89.
[16] *Id*. at 140.
[17] *Id*. at 261-262.

subnational laws.[18] As the 2022 NASEM report noted, "a robust legal framework . . . is essential to ensure that [ocean CDR] research is conducted in a safe and responsible manner that minimizes the risk of negative environmental and other outcomes."[19] At the same time, however, it is "important to avoid imposing inappropriate or overly strict requirements that could unnecessarily hinder ocean CDR research."[20]

A. Challenges in the Existing Legal Framework

The U.S. legal framework for ocean CDR is highly fragmented.[21] A variety of U.S. environmental and other laws could apply to research projects, depending on where they take place and the activities involved. In general, federal environmental law will apply to activities that take place within 200 nautical miles of the U.S. coast, and some federal laws will apply further out into the ocean if U.S. citizens are involved in the project or a U.S.-flagged ship is used.[22] Some projects might also be subject to tribal, state, territory, and/or local laws, but they generally have more limited application. For example, in most of the U.S., coastal states only have jurisdiction over ocean areas within 3 nautical miles of the coast.

At the federal level, ocean CDR activities are regulated under decades-old, general environmental laws that were developed with other activities in mind. Federal agencies have yet to fully explain—either in regulations or other guidance documents—how these existing laws will be applied to ocean CDR activities.

Prior studies have highlighted a number of challenges associated with regulating ocean CDR under existing general environmental laws.[23] In some cases, ocean CDR activities may be subject to multiple overlapping permit and other legal requirements.[24] The time, cost, and complexity associated with navigating those requirements could hinder or entirely prevent needed ocean CDR

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[18] For a detailed discussion of the legal framework for ocean CDR, *see* ROMANY M. WEBB ET AL., OCEAN CARBON DIOXIDE REMOVAL FOR CLIMATE MITIGATION: THE LEGAL FRAMEWORK (Edward Elgar Publishing, 2023).
[19] Doney et al., *supra* note 4, at 54.
[20] *Id*. at 40.
[21] *Id*. at 41.
[22] *See* Romany M. Webb et al., *United States, in* OCEAN CARBON DIOXIDE REMOVAL FOR CLIMATE MITIGATION: THE LEGAL FRAMEWORK 278, 281-284 (Romany M. Webb et al. eds, 2023).
[23] KOREY SILVERMAN-ROATI ET AL., REMOVING CARBON DIOXIDE THROUGH OCEAN FERTILIZATION: LEGAL CHALLENGES AND OPPORTUNITIES (2022), https://scholarship.law.columbia.edu/faculty_scholarship/3637/; ROMANY M. WEBB ET. AL., REMOVING CARBON DIOXIDE THROUGH ARTIFICIAL UPWELLING AND DOWNWELLING: LEGAL CHALLENGES AND OPPORTUNITIES (2022), https://scholarship.law.columbia.edu/faculty_scholarship/3337/; KOREY SILVERMAN-ROATI ET AL., REMOVING CARBON DIOXIDE THROUGH SEAWEED CULTIVATION: LEGAL CHALLENGES AND OPPORTUNITIES (2021), https://scholarship.law.columbia.edu/faculty_scholarship/2980/; ROMANY M. WEBB ET AL. REMOVING CARBON DIOXIDE THROUGH OCEAN ALKALINITY ENHANCEMENT: LEGAL CHALLENGES AND OPPORTUNITIES (2021), https://scholarship.law.columbia.edu/faculty_scholarship/2739/.
[24] *Id*.

research.[25] This may be especially true where permit reviews are not coordinated, requiring sequential agency review, with differing informational requirements and timelines. Conversely, other ocean CDR research may not be adequately regulated under existing law, which could create opportunities for projects that are not scientifically sound and/or present unacceptable risks to the environment or communities.[26] Greater clarity from agencies around how they will evaluate potential risks could help mitigate these outcomes.

B. Executive Actions to Help Overcome the Challenges

Legal reforms are needed to create a framework that balances the need for further research to enhance understanding of ocean CDR techniques against the potential risks of such research. Reforms are also needed to put in place appropriate safeguards to prevent or minimize negative environmental or other outcomes. The needed reforms could be implemented in various ways, including through legislative or executive-level action at the federal, tribal, state, and local levels.

In March 2023, the authors published model federal legislation aimed at advancing ocean CDR research in U.S. ocean waters.[27] The model legislation was designed to achieve the dual goals of facilitating needed research, while also ensuring that it occurs in a scientifically sound, safe, and responsible manner.[28] Enacting new federal legislation would have the advantage of restructuring the legal framework in a top-down, comprehensive way. A new law could spur needed changes by clearly defining agency authority and directing federal agencies to issue resources, guidance, and regulations aimed at facilitating safe and responsible research. However, enacting new legislation can be difficult, requiring the balancing of constituents and interests across the country, and can take a number of years to develop.

Absent new legislation, federal agencies could take a variety of actions under existing law to facilitate safe and responsible ocean CDR research. The Biden Administration has already recognized the need for such action. In March 2023, the Biden Administration released its Ocean Climate Action Plan, which outlines a number of actions the administration could take to help achieve three goals: (1) create a carbon-neutral future, (2) accelerate ocean climate solutions, and (3) enhance community resilience.[29] It recommends, among other things, development of "a robust regulatory framework for research and possible later deployment" of ocean CDR approaches.[30]

In October 2023, the White House Office of Science and Technology Policy announced a Fast-

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[25] Korey Silverman-Roati and Romany M. Webb, *Conclusion*, in OCEAN CARBON DIOXIDE REMOVAL FOR CLIMATE MITIGATION: THE LEGAL FRAMEWORK 310, 317-318 (Romany M. Webb et al. eds, 2023).
[26] Romany M. Webb, *Introduction, in* OCEAN CARBON DIOXIDE REMOVAL FOR CLIMATE MITIGATION: THE LEGAL FRAMEWORK 1, 6-8 (Romany M. Webb et al. eds, 2023).
[27] ROMANY M. WEBB AND KOREY SILVERMAN-ROATI, DEVELOPING MODEL FEDERAL LEGISLATION TO ADVANCE SAFE AND RESPONSIBLE OCEAN CARBON DIOXIDE REMOVAL RESEARCH IN THE UNITED STATES (2023), https://scholarship.law.columbia.edu/sabin_climate_change/199/.
[28] *Id*.
[29] THE WHITE HOUSE, OCEAN CLIMATE ACTION PLAN (2023), https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf.
[30] *Id*. at 41.

Track Action Committee on marine CDR.[31] The committee is made up of experts from 11 federal agencies and three White House offices, and aims to fulfill the Ocean Climate Action Plan's goal of "a substantial ramp up in marine CDR research and development."[32] Among other actions, the committee will draft "[r]ecommendations and guidelines for policy, permitting, and regulatory standards for marine CDR research and implementation"[33] These developments demonstrate that federal officials acknowledge the need for regulatory reforms, and that there is a distinct opportunity to implement such reforms.

This paper presents several recommended actions that federal agencies could take to ensure safe and responsible permitting and regulation of ocean CDR research in U.S. waters. First, the paper recommends actions designed to enhance interagency coordination, which will be critical to ensure the efficient review and permitting of ocean CDR projects. Second, the paper discusses actions to improve environmental review of, and ensure robust stakeholder engagement about, ocean CDR projects. The actions in both of these first two recommendations apply to a broad range of agencies across the federal government. The third section of the paper then recommends actions that individual agencies should take to improve the regulation of ocean CDR, including actions by the Environmental Protection Agency (EPA), the Department of the Interior's Bureau of Ocean Energy Management (BOEM), the Army Corps of Engineers (ACE), the National Oceanic and Atmospheric Administration (NOAA), and the Department of Energy (DOE). All of the recommended actions are intended to achieve the dual goals of facilitating needed ocean CDR research, while ensuring that research occurs in a safe and responsible way that minimizes risks to the environment and communities.

This paper discusses actions that the federal executive can take to improve permitting and regulation. It does not address possible changes at the tribal, state, and local levels. Given the shared nature of authority over the oceans, legal reforms at these levels of government may also be needed to facilitate safe and responsible ocean CDR research. Further research is needed to identify and evaluate possible tribal, state, and local reforms.

II. Recommendations

A. Recommended Actions to Enhance Interagency Coordination

1. **Federal agencies involved in reviewing ocean CDR projects should clarify their respective roles and responsibilities and take steps to avoid duplicative processes and otherwise streamline project reviews.** Depending on where an ocean CDR research project takes place and the activities involved, the project may require permits and other

[31] Scott Doney and Jane Lubchenco, *Marine Carbon Dioxide Removal: Potential Ways to Harness the Ocean to Mitigate Climate Change*, THE WHITE HOUSE OSTP BLOG (Oct. 6, 2023), https://www.whitehouse.gov/ostp/news-updates/2023/10/06/marine-carbon-dioxide-removal-potential-ways-to-harness-the-ocean-to-mitigate-climate-change/.

[32] EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES, CHARTER OF THE MARINE CARBON DIOXIDE REMOVAL FAST TRACK ACTION COMMITTEE OF THE SUBCOMMITTEE ON OCEAN SCIENCE AND TECHNOLOGY NATIONAL SCIENCE AND TECHNOLOGY COUNCIL (2023), https://www.noaa.gov/ocean-science-and-technology-subcommittee/ost-activities-and-products.

[33] *Id*.

approvals from a number of federal agencies, including EPA, BOEM, and ACE. Other agencies, such as NOAA and DOE could also be involved in funding or otherwise supporting ocean research projects. For example, a DOE-funded ocean alkalinity enhancement project sited in federal ocean waters and co-located with renewable energy could require a federal outer continental shelf lease from BOEM, a Rivers and Harbors Act (RHA) permit from ACE, and an ocean dumping permit from EPA.[34]

In stakeholder interviews conducted as part of this project, many identified the lack of coordination across federal agencies as a key barrier to an efficient and effective regulatory regime. Many expressed uncertainty about which federal agencies will be involved in reviewing any particular ocean CDR project and whether and how those agencies will work together, share information, or otherwise coordinate their reviews. Clarifying the respective roles and responsibilities of each federal agency involved in reviewing ocean CDR projects, and better coordinating their review processes, would help to avoid duplication of effort, saving both time and money. It would also increase certainty for project proponents, enabling them to develop more accurate project timelines and budgets, and it could help agencies better anticipate resource needs for project reviews and authorizations.

Federal agencies have a number of options to formalize their coordination on ocean CDR. One option would be to enter into an Interagency Memorandum of Understanding (MOU). Interagency MOUs are used across the federal government to establish the ground rules for agency collaboration and cooperation. In recent years, a number of interagency MOUs have been adopted with the goal of streamlining the review of projects, particularly climate-related infrastructure projects that require approvals from multiple federal agencies. For example, in 2021, the Departments of Agriculture, Defense, Energy, and the Interior and EPA entered into an interagency MOU to "improve public land renewable energy project permitting coordination."[35] In addition, in 2022, the Departments of Energy, Housing and Urban Development, and Transportation and EPA entered into an interagency MOU to establish a blueprint for decarbonizing transportation.[36] The agencies agreed, among other actions, to establish a joint executive-level team to implement the MOU, ensure cross-agency coordination on research, and establish points of contact from each agency for administration of the MOU.[37]

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[34] ROMANY M. WEBB ET AL. REMOVING CARBON DIOXIDE THROUGH OCEAN ALKALINITY ENHANCEMENT: LEGAL CHALLENGES AND OPPORTUNITIES (2021), https://scholarship.law.columbia.edu/faculty_scholarship/2739/.

[35] Memorandum of Understanding between the U.S. Department of the Interior, the U.S. Department of Agriculture, the U.S. Department of Defense, the U.S. Department Of Energy, and the U.S. Environmental Protection Agency to Improve Public Land Renewable Energy Project Permit Coordination (2021), https://www.doi.gov/sites/doi.gov/files/mou-esb46-04208-pub-land-renewable-energy-proj-permit-coord-doi-usda-dod-epa-doe-2022-01-06.pdf.

[36] Memorandum of Understanding between the U.S. Department Of Energy, the U.S. Department of Transportation, the U.S. Environmental Protection Agency, and the U.S. Department Of Housing And Urban Development (2022), https://www.energy.gov/articles/biden-harris-administration-announces-interagency-commitment-lower-transportation.

[37] *Id*.

An interagency MOU on ocean CDR could serve a number of purposes. The MOU could help to clarify the legal framework for ocean CDR, and the role different federal agencies play in implementing that framework. It is common for MOUs to describe the statutory authorities and responsibilities of the participating agencies. For example, prior MOUs dealing with interagency coordination on renewable energy development have listed the statutes pursuant to which each agency reviews renewable energy projects, and described the scope of the agencies' review authority. An MOU on ocean CDR could similarly clarify the roles different federal agencies' play in overseeing projects.

An interagency MOU on ocean CDR should also outline steps that will be taken to improve coordination between federal agencies and reduce duplication and other inefficiencies in project reviews. In this regard, we offer three specific recommendations.

First, as part of the MOU, federal agencies should agree to implement a combined interagency pre-application process. The agencies should publish guidelines on the pre-application process that list the approvals an ocean CDR project proponent may need (based on the activities involved, where they would take place, and their potential impacts) and the agencies responsible for issuing those approvals. The pre-application process should include a system for formalized pre-application meetings, where the applicant can describe the project and agencies can describe authorization informational needs. The agencies should also consider identifying a single person who can serve as the primary point of contact for applicants navigating the pre-application process. This contact could to field informal questions and connect applicants with relevant contacts at the agencies to set up meetings.

The agencies could draw lessons from other permitting regimes that incorporate pre-application processes. For instance, the Bureau of Land Management (BLM) sets procedures for pre-application meetings and screenings for solar and wind energy project applications.[38] These meetings are intended to identify potential environmental and siting constraints for the projects.[39] Another example comes from state aquaculture projects, which often require complex permitting approvals from multiple state agencies. To address this complexity, Alaska,[40] California,[41] and Maine[42] encourage aquaculture project applicants to engage in a pre-application process, which includes pre-application meetings with representatives of the state permitting agencies. These meetings help

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[38] Bureau of Land Management, Initial Screening and Prioritization for Solar and Wind Energy Applications and Nominations/Expressions of Interests, IM 2022-027, https://www.blm.gov/policy/im-2022-027.
[39] *Id*.
[40] Alaska Aquatic Farm Program, *Joint Agency Application – Part I*, https://www.adfg.alaska.gov/static/license/aquaticfarming/pdfs/aquatic_farming_application_form_and_instructions_part1.pdf.
[41] California Department of Fish & Wildlife Office of Aquaculture, *Permit Guide to Aquaculture in California*, https://archive.org/details/perma_cc_H5BP-P5JW.
[42] Maine Department of Marine Resources, *Standard Aquaculture Lease Process*, https://www.maine.gov/dmr/aquaculture/applications-and-forms/standard-lease-applications-and-forms.

applicants get a sense for informational requirements and timelines, and notify agencies of potential incoming applications.[43]

Second, the federal agencies entering into an interagency MOU should develop a standard schedule for project reviews and authorizations. The schedule should identify the steps generally needed to complete decisions on all federal reviews and authorizations with recommended timing for each. The schedule should provide for parallel (rather than sequential) action by multiple federal agencies wherever possible.

Standard schedules would provide more temporal certainty to both applicants and fellow agencies. They would also advance goals similar to those outlined in the Biden-Harris Permitting Action Plan, which aims to "strengthen and accelerate Federal permitting and environmental reviews" for infrastructure and clean energy projects.[44] That plan directs agencies to "create permitting schedules with clear timeline goals" and to make that information available to the public.[45] Providing standard schedules for ocean CDR project reviews and authorizations would advance these same priorities in the context of developing climate solutions, another administration priority, as explained above. Setting standard timelines for review would not impede agency flexibility because agencies could deviate from the timelines where necessary to fulfil their statutory obligations.

Third, each federal agency should identify a primary point of contact for other agencies and for project proponents. The designated contacts at each agency should have regular meetings to (among other things) assess the status of projects under review and jointly develop plans to address any issues, delays, or obstacles to completing the review process in accordance with the agreed schedule (see above). Both while projects are under review and subsequently, agencies should share information and data to the maximum extent possible. This would address a concern among stakeholders that federal agencies in the ocean CDR space often operate in silos and do not coordinate their project reviews and other functions. Designating a point of contact and establishing a regular schedule of meetings would help to formalize coordination. It should be noted that agency resources are limited and proposals like this may require additional funding from Congress. Absent such funding, clear directives from the White House through executive actions could be helpful to ensure that agencies prioritize coordination work, and allocate existing resources to it.

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[43] KOREY SILVERMAN-ROATI ET AL., PERMITTING SEAWEED CULTIVATION FOR CARBON SEQUESTRATION IN CALIFORNIA: BARRIERS AND RECOMMENDATIONS (2022), https://scholarship.law.columbia.edu/faculty_scholarship/3523.

[44] The White House, *The Biden-Harris Permitting Action Plan to Rebuild America's Infrastructure, Accelerate the Clean Energy Transition, Revitalize Communities, and Create Jobs*, THE WHITE HOUSE BRIEFING ROOM (May 11, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/11/fact-sheet-biden-harris-administration-releases-permitting-action-plan-to-accelerate-and-deliver-infrastructure-projects-on-time-on-task-and-on-budget/ .

[45] *Id*.

2. **Funding agencies should consult with permitting agencies on ocean CDR funding decisions. Permitting agencies should provide guidance to funding agencies on whether projects they propose to fund are likely to meet permitting requirements.** During 2022 and 2023, federal agencies announced significant funding for ocean CDR research. In November 2022, NOAA's National Oceanographic Partnership Program (NOPP) announced a call for proposals focused on understanding ocean CDR, co-benefits and risks, and the science needed to build regulatory frameworks.[46] Then, in September 2023, NOAA's NOPP announced $24.3 million in funding to advance these research goals in 17 individual projects.[47] The Department of Energy (DOE) has similarly invested millions in ocean CDR research.[48] In October 2023, DOE announced it would provide $36 million for 11 projects aimed at improving measurement, reporting, and validation of ocean CDR approaches.[49]

   This sort of federal funding is important to enable research to advance scientific understanding of ocean CDR approaches. However, where that research is to occur in the field, the project will still need to comply with all applicable permitting and other requirements. It is critical, therefore, that permitting agencies are engaged in funding agency processes early on and throughout funding agency decisions and oversight. This can ensure that the projects are able to secure necessary permits within the time-limited parameters of the funding, and that funding agencies do not support projects that are unlikely to receive permits. Developing stronger ties between permitting and funding agencies can also help build coordination infrastructure for future funding agency decisions, in that agencies will develop better communication, identify helpful contacts, and develop better expectations around how other agencies work on ocean CDR project decisions. The more the agencies are coordinating early on, the more likely the funding agencies will avoid unnecessary delays in their sponsored projects.

B. Recommended Actions to Improve Environmental Review and Stakeholder Engagement

1. **Federal agencies should explore options for streamlining environmental review of ocean CDR projects, including through the use of categorical exclusions for projects that pose minimal environmental risks.** Under the National Environmental Policy Act

[46] NOAA Ocean Acidification Program, Announcing Funding Opportunity in Marine Carbon Dioxide Removal (Mcdr)- Opportunity Closed, https://oceanacidification.noaa.gov/announcing-funding-opportunity-in-marine-carbon-dioxide-removal-mcdr/ (last updated Nov. 24, 2022).
[47] NOAA Ocean Acidification Program, Announcing $24.3M Investment Advancing Marine Carbon Dioxide Removal Research, https://oceanacidification.noaa.gov/fy23-nopp-mcdr-awards/ (last updated Sept. 7, 2023).
[48] ARPA-E, U.S. Department of Energy Announces $45 Million to Validate Marine Carbon Dioxide Removal Techniques, https://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-45-million-validate-marine-carbon (last updated Feb. 16, 2023).
[49] Department of Energy, DOE Announces $36 Million To Advance Marine Carbon Dioxide Removal Techniques and Slash Harmful Greenhouse Gas Pollution, https://www.energy.gov/articles/doe-announces-36-million-advance-marine-carbon-dioxide-removal-techniques-and-slash (last updated Oct. 23, 2023).

(NEPA), federal agencies must prepare an environmental impact statement (EIS) for any "major federal action[] significantly affecting the quality of the human environment."[50] Preparation of an EIS is important to inform agency decision-makers and the broader public about the environmental risks posed by a proposed action and possible options for preventing, mitigating, and managing those risks. However, the process of preparing an EIS is often highly complex, can take several years and cost millions of dollars, and lead to litigation that can add further complexity, time, and cost. Given the urgency of addressing the climate crisis, it is important that agencies look at ways to simplify and streamline environmental review of climate-beneficial projects, while still fully complying with their obligations under NEPA. They have several options to do just that.

As noted above, NEPA only applies to "federal actions," which "projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by Federal agencies" (subject to limited exceptions).[51] This would encompass ocean CDR projects that are undertaken directly by federal agencies or by private parties with funding from, or the approval of, a federal agency. Thus, for example, an ocean CDR project that requires a federal permit may be considered a "federal action" under NEPA.[52] Notably however, as a result of amendments made to NEPA in the 2023 Fiscal Responsibility Act, actions "with effects located entirely outside the jurisdiction of the United States" do not qualify as "federal actions" for the purposes of NEPA.[53] As such, in determining whether NEPA applies to a particular ocean CDR project, it is necessary to consider where the project's effects will be felt. Projects that take place in, and only affect, areas outside U.S. jurisdiction (e.g., the high seas) will not be subject to NEPA.

Where NEPA does apply, the agency undertaking, funding, or authorizing an ocean CDR project will need to prepare an EIS if it determines that the project will "significantly affect[] the quality of the human environment." This must be assessed on a case-by-case basis, taking into account "the potentially affected environment and degree of the effects of the" project.[54] If project effects are unknown or uncertain, the agency may need to complete an environmental assessment (EA) to determine whether an EIS is required.[55] EAs must include a brief discussion of the proposed project, possible alternatives, and their respective environmental impacts. If the agency concludes, based on the EA, that no EIS is required, it may issue a finding of no significant impact (FONSI). However, if the EA shows that a project may have significant impacts, a full EIS must be prepared. This

[50] 42 U.S.C. § 4332(2)(C).
[51] 40 CFR § 1508.1(q).
[52] It should be noted that some federally-permitted ocean CDR projects may not be subject to NEPA. For example, NEPA will generally not apply to ocean CDR projects that only require a permit from EPA under the MPRSA, and do not have any other federal connection (e.g., do not receive federal funding or other support). The courts have held that EPA is not required to prepare an EIS when permitting projects under the MPRSA because that Act includes requirements for assessment of the environmental impacts of the permitted activity that are equivalent to the requirements imposed by NEPA. *See* Maryland v. Train, 415 F.Supp. 116.
[53] 42 U.S.C. § 4336e(10)(B).
[54] 40 CFR § 1501.3(b).
[55] 42 U.S.C. § 4336; 40 CFR § 1501.5.

can be a highly complex, time consuming, and costly process.

Ocean CDR projects may require an EA and, in some cases, that EA may show that a full EIS is required. However, for certain small-scale research and other projects, it may be clear from the outset that there will be no or only very minor environmental impacts. Where that is the case, agencies should consider issuing categorical exclusions (CEs) for the projects.

CEs may be issued for categories of actions that agencies determine, in advance, do not normally have significant environmental effects.[56] Agencies typically do not need to prepare an EA or EIS for actions covered by a CE and can, instead, make a determination that further environmental review is unnecessary. However, if extraordinary circumstances exist that suggest an action normally covered by a CE could have significant impacts, the agency must undertake further review to determine if an EIS is required.[57] In this way, CEs can help to streamline the environmental review process for low-risk activities while still maintaining flexibility for agencies to undertake a full review where necessary to comply with NEPA.

The use of CEs has been endorsed by the Council on Environmental Quality (CEQ)–the federal entity charged with overseeing implementation of NEPA–which recently described CEs as "an important mechanism to promote efficiency in the NEPA process."[58] CEQ has suggested that, where a class of activity is typically overseen by multiple federal agencies, those agencies "may find value in establishing a CE jointly."[59] According to CEQ, joint development of CEs "may save administrative time," and increase "efficiency in project implementation."[60] The various agencies involved in overseeing ocean CDR activities should, thus, jointly consider whether and when CEs may be appropriate therefor. Agencies should, in particular, consider whether there are categories of ocean CDR research that pose minimal environmental risks and thus may be eligible for a CE.

2. **Federal agencies should, where appropriate, conduct programmatic environmental reviews for ocean CDR activities.** CEQ has encouraged federal agencies to take a programmatic approach to environmental review where possible.[61] According to CEQ, the programmatic approach reflects "best practice" for assessing the environmental impacts of "broad actions, such as programs, policies, rulemakings, series of projects, and larger or multi-phase projects."[62] Federal agencies are encouraged to issue programmatic

[56] 40 CFR § 1501.4(a).
[57] *Id*. § 1501.4(b).
[58] National Environmental Policy Act Implementing Regulations Revisions Phase 2, 88 Fed. Reg. 49924, 49937 (July 31, 2023).
[59] *Id*.
[60] *Id*.
[61] 40 CFR § 1502.4(b); Memorandum for Heads for Federal Departments and Agencies from Michael Boots, Council on Environmental Quality, on Effective Use of Programmatic NEPA Reviews (Dec. 18, 2014) [hereinafter "Boots Memo"].
[62] National Environmental Policy Act Implementing Regulations Revisions Phase 2, 88 Fed. Reg. 49924, 49943 (July 31, 2023).

EAs and EISs, which assess the environmental impacts of a class of activities or multiple, related projects in a single document. Once a programmatic EA / EIS has been developed, subsequent project-specific reviews can tier to, or incorporate analysis from, the programmatic document.[63] As CEQ has noted, this "avoids repetitive . . . analyses in subsequent tiered NEPA reviews," and allows agencies to "narrow the consideration of alternatives and impact[s]."[64] The programmatic approach can, therefore, "provide a better defined and more expeditious path toward decisions on proposed action."[65]

Federal agencies should consider using programmatic approaches to streamline the environmental review process for ocean CDR activities. In doing so, agencies can learn from prior experience with the use of programmatic reviews for other climate-beneficial activities, such as renewable energy development. During the Obama Administration, the Department of the Interior's Bureau of Land Management (BLM) sought to expedite renewable energy development on federal lands by, among other things, streamlining the environmental review process. BLM prepared a programmatic EIS that examined the impacts of solar energy development on federal lands in six southwestern states.[66] BLM relied on that programmatic EIS when deciding whether to approve individual solar projects on land in the covered states. As a result, individual projects did not require their own EISs, and could be approved more quickly than would have otherwise been possible.[67]

3. **Federal agencies should require those seeking federal funding for, or federal approval of, ocean CDR projects to develop and implement robust public engagement programs.** Ocean CDR activities could have impacts–both positive and negative–on a wide range of stakeholders. For example, where ocean CDR activities require the construction of new coastal facilities, local communities in the vicinity of those facilities might experience both benefits (e.g., job creation) and harms (e.g., environmental disturbance) as a result. Ocean CDR activities could also affect communities' access to coastal and marine resources and interact with other ocean uses (e.g., fishing, shipping, energy development, recreation, etc.) in various positive and negative ways. The impacts may be felt especially keenly by Native American Tribes and

[63] 40 CFR § 1501.11. The Fiscal Responsibility Act of 2023 inserted a new section 108 into NEPA, declaring that agencies may use the analysis in a programmatic EA / EIS in subsequent environmental documents "[w]ithin 5 years and without additional review of the analysis in the programmatic environmental document, unless there are substantial new circumstances or information about the significance of adverse effects that bear on the analysis." The new section 108 further provides that the analysis in the programmatic EA / EIS may be relied upon "[a]fter 5 years, so long as the agency reevaluates the analysis in the programmatic environmental document and any underlying assumptions to ensure reliance on the analysis remains valid." *See* 42 U.S.C. § 4336b.
[64] Boots Memo, *supra* note 61, at 10-11.
[65] *Id*. at 7.
[66] BUREAU OF LAND MANAGEMENT, FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (PEIS) FOR SOLAR ENERGY DEVELOPMENT IN SIX SOUTHWESTERN STATES, FES 12-24 (2012), https://solareis.anl.gov/documents/fpeis/.
[67] For a more detailed discussion of BLM's approach, *see* Michael B. Gerrard, *Legal Pathways for a Massive Increase in Utility-Scale Renewable Generation Capacity*, 47 ENVTL. L. REP. 10591, 10594-10597 (2017).

other indigenous communities, which have spiritual and cultural connections to the ocean and have long relied on it for substance.

The 2022 NASEM report on ocean CDR concluded:

> [I]t is critical that research and development activities incorporate equity, diversity, and inclusion with a particular focus on coastal communities, especially Indigenous communities . . .
>
> Having communities participate from the outset and guide research can increase the likelihood of ocean CDR implementations that are compatible with environmental justice, and avoid ocean CDR implementations that would exacerbate environmental injustice. Engagement with stakeholders from local government, business, NGOs, and other stakeholders as identified through stakeholder assessment will also be important.[68]

Robust engagement can improve projects by, among other things, ensuring they are designed with local environmental conditions and local community needs in mind. Community concerns and other problems can be addressed early on, thus lessening or avoiding local opposition, which has proved to be a major barrier to advancing other climate-beneficial projects (e.g., renewable energy development).[69] Despite these benefits, however, some ocean CDR researchers and developers may be hesitant to undertake community engagement due to concerns about the time and cost it might add to the project design process.

Federal agencies can and should take steps to ensure robust engagement on all ocean CDR projects. To this end, agencies could require applicants for federal funding or authorization of a project to submit an engagement plan with their application, and make implementation of that plan a condition of the funding or authorization. There are precedents for this. For example, DOE now requires all applicants for funding under programs established by the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act to submit a community benefits plan, including details of any community engagement that has been undertaken or is planned (among other things).[70] If DOE approves funding, compliance with the community benefits plan becomes "part of the contractual obligation of the funding recipient."[71]

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[68] Doney et al., *supra* note 4, at 65 & 244.
[69] *See generally*, MATTHEW EISENSON, OPPOSITION TO RENEWABLE ENERGY FACILITIES IN THE UNITED STATES, SABIN CENTER FOR CLIMATE CHANGE LAW 2-3 (May 2023 ed.), https://scholarship.law.columbia.edu/sabin_climate_change/200/; MATTHEW EISENSON & ROMANY M. WEBB, EXPERT INSIGHTS ON BEST PRACTICES FOR COMMUNITY BENEFITS AGREEMENTS 2-4 (2023), https://scholarship.law.columbia.edu/sabin_climate_change/206/.
[70] Department of Energy, *About Community Benefits Plans*, CLEAN ENERGY INFRASTRUCTURE, https://www.energy.gov/infrastructure/about-community-benefits-plans.
[71] *Id*.

4. **Federal agencies should coordinate with, and provide assistance and resources to, other government bodies involved in reviewing ocean CDR projects.** In addition to federal approvals, some ocean CDR projects may also require permits or other approvals from state, territory, and/or local governments. Coastal states and territories generally have primary jurisdiction over ocean waters and the underlying submerged land within three nautical miles of the coast.[72] Some offshore land, underlying state ocean waters, is under municipal ownership. As a result, states, territories, and sometimes municipalities may need to approve near-shore ocean CDR projects. Additionally, where those projects require onshore activities (e.g., the construction of new infrastructure), those activities may also fall under state, territory, and/or municipal control. Some states, territories, and municipalities have their own environmental review laws similar to NEPA.[73] Where these "little NEPAs" exist, the state, territorial, or municipal government may need to evaluate the environmental impacts of ocean CDR projects and undertake public consultation thereon, before issuing any permits or approvals. Additionally, where ocean CDR projects implicate Native American tribal rights, additional consultation and other requirements might also apply.[74]

   Federal agencies reviewing ocean CDR projects should coordinate closely with any reviews occurring at the tribal, state, territory, and/or local levels. This is important to avoid duplication of effort across different levels of government, and would help to streamline the review process, making it easier, quicker, and cheaper for applicants to navigate.

   Environmental review is one area where coordination between agencies at different levels of government would be particularly beneficial. As noted above, the environmental review process can be highly complex and time consuming, particularly where multiple government bodies are involved. There are examples, from outside the ocean CDR space, of poorly coordinated reviews that have delayed projects or created other issues. For example, large infrastructure project approvals often proceed in a linear fashion, with one federal agency completing its permitting responsibilities before handing it off to the next agency, leading to long delays and added costs.[75] To avoid this outcome, where an ocean CDR project is subject to environmental review requirements at multiple levels of government, the reviews should be conducted jointly or otherwise coordinated to the maximum extent possible. This is consistent with the direction in the NEPA implementing regulations that federal agencies "shall cooperate with State, Tribal, and local agencies to reduce duplication between NEPA and State, Tribal, or local requirements," including by

[72] State / territorial jurisdiction extends more than 3 nautical miles from the coast in some areas. For example, in parts of the Gulf of Mexico, the jurisdiction of Texas and Florida extends 9 nautical miles from the coast. Puerto Rico's jurisdiction also extends 9 nautical miles from the coast. *See* 43 U.S.C. §§ 1301 & 1312; 48 U.S.C. §§ 749 & 1705; U.S. v. Louisiana, 100 S. Ct. 1618 (1980), 420 U.S. 529 (1975), 394 U.S. 11 (1969), 389 U.S. 155 (1967), 363 U.S. 1 (1960), 339 U.S. 699 (1950).
[73] NEPA.gov, *States and Local Jurisdictions with NEPA-like Environmental Planning Requirements*, https://ceq.doe.gov/laws-regulations/states.html.
[74] *See generally*, Webb et al., *supra* note 22, at 301-203.
[75] David J. Hayes, *Leaning on NEPA to Improve the Federal Permitting Process*, 45 ENVTL. L. REP. 10018 (2015).

conducting "[j]oint planning processes," "[j]oint environmental research and studies," and "[j]oint public hearings," and preparing joint environmental assessments and EISs.[76] The NEPA implementing regulations further provide: "Where State or Tribal laws, or local ordinances have [EIS] or similar requirements in addition to but not in conflict with those in NEPA, federal agencies may cooperate in fulfilling these requirements, as well as those of Federal laws, so that one document will comply with all laws."[77]

Reviewing bodies at all levels of government should also share information and resources to the maximum extent possible. Where appropriate, federal agencies should make use of studies and analysis developed by tribal, state, territorial, and local agencies rather than duplicating the work themselves.[78] Federal agencies should similarly ensure that tribal, state, territorial, and local bodies have access to reports and other information they prepare. Additionally, where those bodies lack relevant expertise or resources, federal agencies should offer to provide technical and/or other assistance as appropriate.

C. Agency Specific Recommendations

Environmental Protection Agency

1. **EPA should clarify when the Marine Protection, Research, and Sanctuaries Act (MPRSA) will apply to ocean CDR activities.** The MPRSA authorizes EPA to "regulate the dumping of all types of materials into ocean waters."[79] There is currently significant uncertainty as to whether and when different ocean CDR activities will qualify as "dumping" for the purposes of the MPRSA.

   The term "dumping" is defined in the MPRSA to mean "a disposition of material."[80] In ordinary parlance, "disposition" means "the act or power of disposing" of something,[81] perhaps suggesting that the MPRSA was only intended to apply where materials are discharged into the ocean for the purpose of disposal. Supporting this interpretation is the fact that the MPRSA is intended to implement the U.S.'s obligations under the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) which defines "dumping" to mean "the *disposal* at sea of wastes or other matter" (emphasis added).[82]

   On the other hand, the definition of "dumping" in the MPRSA expressly excludes "the construction of any fixed structure or artificial island []or the intentional placement of any

[76] 40 CFR § 1506.2(b)-(c).
[77] *Id*. § 1506.2(c).
[78] This is, again, encouraged by the NEPA implementing regulations which state that federal agencies should "use… studies, analysis, and decisions developed by State, Tribal, or local agencies" to the fullest extent practicable. See *id*. § 1506.2(c).
[79] 33 U.S.C. § 1401(b).
[80] *Id*. § 1402(f).
[81] Merriam-Webster Dictionary, *Disposition*, https://www.merriam-webster.com/dictionary/disposition.
[82] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Art. III(1)(a).

device in ocean waters or on or in the submerged land beneath such waters, for a purpose other than disposal, when such construction or such placement is otherwise regulated by Federal or State law or occurs pursuant to an authorized Federal or State program" (the "placement exception").[83] This might be taken to suggest that the MPRSA does not apply solely to disposal at sea but also covers the discharge of materials for other purposes. This is because, if the MPRSA did not apply to the latter category of discharges, the exception for the installation of structures and devices would be unnecessary.

Regulations adopted by EPA under the MPRSA incorporate the statutory definition of "dumping" but do not further elaborate on the meaning of that term. EPA did recently update the "ocean dumping" section of its website to include the following statement: "An MPRSA permit may be needed for field research, large-scale field trials, and field deployment of [ocean]CDR . . . activities if the activities involve the disposition of material into the ocean environment."[84] EPA subsequently published a new webpage on "permitting for mCDR," which states that the definition of dumping in the MPRSA "encompasses the disposition of material both for the purpose of disposal and purposes other than disposal," and thus MPRSA permits may be required for certain ocean CDR activities that involve "transporting . . . and releasing . . . materials into [ocean] waters."[85] The website identifies activities involving the transportation or discharge of iron or alkaline materials and the sinking of biomass as possibly subject to regulation under the MPRSA.[86] This still leaves key questions unanswered. For example, when might ocean CDR activities qualify for the "placement exception" noted above? Would pipes installed in the ocean in connection with artificial upwelling / downwelling qualify as "devices" and thus fall within the exception? This is uncertain since the term "device" is not defined in either the MPRSA or EPA regulations under the Act.

Some additional information regarding the potential application of the MPRSA to ocean CDR activities can be found in a report published by the International Maritime Organization (IMO), summarizing discussions at a meeting of the scientific group established under the London Convention in March 2023.[87] According to the report, at the meeting, "the delegation of the United States informed" attendees that "[t]he United States considered the disposition of material in the ocean to be "dumping" subject to [the MPRSA] if the project sponsor did not intend, anticipate, or prepare to recover the material from the ocean as part of the project."[88] The IMO report does not specify who made this statement or provide any other detail. As such, it is unclear whether the statement reflects official EPA policy and, if it does, how that policy will be implemented in practice. For

[83] 33 U.S.C. § 1402(f).
[84] Envtl. Prot. Agency, *Ocean Dumping Permits*, OCEAN DUMPING, https://www.epa.gov/ocean-dumping/ocean-dumping-permits.
[85] Envtl. Prot. Agency, *Permitting for mCDR and mSRM*, OCEAN DUMPING, https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm.
[86] *Id*.
[87] Report of the Forty-Sixth Meeting of the Scientific Group Under the London Convention and the Seventeenth Meeting of the Scientific Group Under the London Convention, IMO Doc. LC/SG 46/16 (March 31, 2023).
[88] *Id*. at 12.

example, what will ocean CDR project developers need to show to satisfy EPA that they intend to remove materials from the ocean? Within what timeframe must the materials be removed? What, if any, recourse will EPA have if a project developer says it intends to remove materials but in fact does not? How will EPA deal with situations in which materials are accidentally lost before they can be removed?

In order to provide more certainty for project developers, EPA should clarify when and how it will regulate ocean CDR activities under the MRPSA. To this end, EPA should issue an official guidance document on the regulation of ocean CDR activities and update the MPRSA implementing regulations, where necessary and appropriate.

2. **EPA should clarify when MPRSA research permits may be issued for ocean CDR activities.** Under the MPRSA, an EPA permit is required to dump materials into ocean waters within 12 nautical miles of the United States coast and outside that area, if the materials are transported from the United States or using a vessel or aircraft registered in the United States.[89] The MPRSA authorizes EPA to "establish and issue various categories of permits."[90] Regulations issued by EPA under the MPRSA identify four permit categories – (1) general, (2) special, (3) emergency, and (4) research – and outline the criteria for issuance of each category of permit.[91]

   EPA has indicated that ocean CDR projects may be permitted under "research, special, or general permits."[92] It recommends that anyone proposing to undertake an ocean CDR project "contact the . . . Ocean Dumping Program at EPA Headquarters to discuss . . . what type of MPRSA permit . . . would be most appropriate" for the project.[93] This makes sense as EPA will need to consider the specifics of each project to determine the appropriate category of permit. Project proponents would, however, benefit from greater clarity regarding how EPA will make its determination.

   Many of the stakeholders interviewed for this project were especially confused about whether and when ocean CDR projects might qualify for research permits. EPA regulations indicate that "[r]esearch permits may be issued for the dumping of materials . . . into the ocean as part of a research project" if certain criteria are met.[94] The term "research project" is not defined in the regulations and EPA has not provided any guidance on the factors it will consider in determining whether a particular activity involves research. This has prompted a range of questions including: What counts as research? Are

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[89] 33 U.S.C. § 1411.
[90] *Id*. § 1412(b)
[91] 40 CFR § 220.3.
[92] Environmental Protection Agency, *Ocean Dumping Permits*, OCEAN DUMPING, https://www.epa.gov/ocean-dumping/ocean-dumping-permits. See also Envtl. Prot. Agency, *Permitting for mCDR and mSRM*, OCEAN DUMPING, https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm (stating that "[r]esearch permits are the most relevant MPRSA permit category for [ocean]CDR . . . research activities. However, MPRSA general or special permits may be appropriate in some situations").
[93] Environmental Protection Agency, *Ocean Dumping Permits*, OCEAN DUMPING, https://www.epa.gov/ocean-dumping/ocean-dumping-permits.
[94] 40 CFR § 220.3(e).

there restrictions on who can undertake research projects (e.g., only academic or government scientists)? Could an activity undertaken by a commercial entity qualify as a research project? How will a project that has both research and commercial elements be treated? For instance, if a project is designed to answer scientific questions about the impacts of ocean CDR, but is funded through the sale of carbon credits, would it still be treated as a research project? Guidance adopted at the international level, under the London Convention and Protocol, suggests that research activities should not result in any "economic gain" but EPA has not indicated whether or how it will apply the international guidance.[95]

In addition to the confusion regarding what constitutes a "research project," there is also significant uncertainty about how EPA will determine whether to issue a research permit for such a project. EPA regulations state that research permits may be issued "when it is determined that the scientific merit of the proposed [research] project outweighs the potential environmental or other damage that may result from the dumping."[96] This standard may be particularly difficult to apply to ocean CDR research projects that are intended to deliver global benefits but could result in localized harms.

EPA should provide additional guidance on when research permits may be available for ocean CDR activities. In particular, EPA should clarify the factors it will consider in determining whether an ocean CDR activity qualifies as a research project, how it will evaluate the scientific merit of any such project, and how it will weigh the potential for global benefits against possible local harms.

3. **EPA should further define its timeline for processing MPRSA permit applications and establish an application tracking system.** Some statutory permitting regimes specify a deadline by which the permitting agency must make a decision on applications (e.g., within 90 days of receiving a complete application).[97] No such deadline is specified in the MPRSA but regulations issued by EPA under the Act state that "[f]inal action on any application for a permit will, to the extent practicable, be taken within 180 days from the date a complete application is filed.**"**[98] This provides useful guidance to permit applicants on the likely duration of EPA's review process. To further assist applicants in planning, EPA should clarify the various stages of its permitting process, and provide an estimate of the likely timing of each. EPA has previously done this for other permitting programs. For instance, in the context of permitting Class VI (carbon sequestration) wells under the Safe Drinking Water Act, EPA has indicated that it "aims to review complete Class VI applications and issue permits when appropriate within 24 months,"[99] and provided a useful breakdown of the different stages of the 24 month review as follows: (1) "Completeness Review (est. 30 days)," (2) "Technical Review (est. 18 months)," (3)

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[95] Resolution LC-LP.1(2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization (adopted Oct. 14, 20210).
[96] *Id*. § 220.3(e).
[97] *See e.g.,* 42 U.S.C. § 4370m-7.
[98] 40 CFR § 220.1.
[99] Environmental Protection Agency, *Current Class VI Projects under Review at EPA*, UNDERGROUND INJECTION CONTROL (UIC), https://www.epa.gov/uic/current-class-vi-projects-under-review-epa.

"Prepare Draft Permit (est. 60 days)," (4) "Public Comment Period (est. 30-45 days), and (5) "Prepare Final Permit Decision (est. 90 days)." EPA should publish a similar timeline for its review of MPRSA permit applications.

EPA should also take steps to enhance the transparency of its review process to enable applicants to better plan for any potential delays in the issuance of their permit. This could be achieved by, for example, establishing a permit tracking system that applicants can use to determine where in the review process their application currently sits and what further steps are needed before a permit can be issued.

4. **EPA should create a database of MPRSA permits for ocean CDR projects.** To further increase transparency, EPA should establish a publicly-accessible, searchable database of MPRSA permit records for ocean CDR projects. The database should include information about permit applications (e.g., date of application, name of applicant, and ocean CDR activity to be permitted) and issued permits (e.g., date of issuance and details of the permitted activity). Information collected by EPA from permittees (e.g., reports on permitted activities) should also be made publicly available in the database where possible.

   There are a number of examples EPA could draw from in developing the database. For instance, EPA already has an online "permit search" tool that allows users to access records relating to certain categories of general permits issued under the National Pollutant Discharge Elimination System established in the Clean Water Act.[100] The tool can, for example, be used to generate a list of all aquaculture operations covered by general permits and access information submitted to EPA by the operators. A similar tool could be created for MPRSA permit records relating to ocean CDR projects. Over time, as the number of records in the database grows, this would help to shed light on how the MPRSA is being used to regulate ocean CDR activities. The information would be useful to individuals and entities looking to develop ocean CDR projects – e.g., to assess whether and how the MPRSA might apply – as well as other stakeholders. It might, for example, be used by coastal communities to identify and track nearby projects. It could also enable community and other groups to evaluate the adequacy of existing regulatory frameworks for ocean CDR and the need for additional controls to mitigate environmental or other risks.

Department of the Interior, Bureau of Ocean Energy Management

5. **BOEM should clarify when ocean CDR projects on the outer continental shelf require a lease or right-of-way under the Outer Continental Shelf Lands Act (OCSLA).** Under international law, coastal countries (i.e., those bordering the ocean) typically have jurisdiction over ocean areas within 200 nautical miles of their coasts. In the United States, authority over the 200 nautical mile zone is shared among the different levels of government. Coastal states and territories have primarily authority over the water

[100] Environmental Protection Agency, *Permit Search*, RESOURCES, https://permitsearch.epa.gov/epermit-search/ui/search.

and submerged lands in most near-shore areas, typically within three nautical miles of shore, while the federal government controls areas further offshore. The submerged lands under federal control – typically extending 3 to 200 nautical miles from shore – are known as the outer continental shelf. In the OCSLA, Congress declared that "the subsoil and seabed of the outer continental shelf appertain to the United States and are subject to its jurisdiction, control, and power of disposition."[101] Consistent with this declaration, the courts have held that the U.S. federal government has "paramount rights" to the outer continental shelf and, as such, use of it by others must be federally authorized.[102]

Under the OCSLA, BOEM may issue leases and rights-of-way authorizing specific uses of the outer continental shelf (e.g., for oil and gas exploration and renewable energy development).[103] The Army Corps of Engineers (ACE) can also issue permits authorizing the installation of structures on the outer continental shelf under the RHA (as amended by the OCSLA).[104] There is currently some uncertainty regarding the interaction of these two statutory frameworks and how they might apply to ocean CDR projects.[105] In particular, it is unclear whether an ocean CDR project that makes use of the outer continental shelf (e.g., to moor equipment) would require both a lease / right-of-way from BOEM and a permit from ACE, or only one of the two.

In *Alliance to Protect Nantucket Sound, Inc. v. U.S. Department of the Army,* the First Circuit Court of Appeals held that only an ACE-issued permit (and no BOEM-issued lease / right-of-way) was required to temporarily install a data tower on the outer continental shelf.[106] The data tower was to be installed for five years as part of a research project aimed at assessing offshore wind energy potential. The court held that "erect[ing] a single, temporary scientific device . . . which gives the federal government information it requires" to assess the feasibility of offshore wind energy development would not "be an infringement on any federal property ownership interest" in the outer continental shelf.[107] The court thus held that the tower could be authorized through an ACE-issued permit and did not require additional authorization from BOEM.[108]

Applying the above reasoning to ocean CDR, it could be argued that the installation of facilities on the outer continental shelf in connection with an ocean CDR research project does not require a BOEM-issued lease / right-of-way, provided the facilities are relatively small and will only remain in place temporarily.[109] BOEM has not, however, taken an official position on this. To provide additional certainty to researchers, BOEM should clarify whether and when a lease / right-of-way will be required for ocean CDR research

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[101] 43 U.S.C. § 1332(1).
[102] U.S. v. California, 332 U.S. 19 (1947). *See also* ADAM VANN, WIND ENERGY: OFFSHORE PERMITTING 3 (2012), https://perma.cc/36W3-3E66.
[103] 43 U.S.C. § 1337.
[104] 33 U.S.C. § 403; 43 U.S.C. 1333.
[105] *See generally,* Webb et al., *supra* note 74.
[106] Alliance to Protect Nantucket Sound, Inc. v. US Dept. of the Army [2005] 398 F.3d 105.
[107] *Id*. at 114.
[108] *Id*.
[109] Webb et al., *supra* note 22, at 297.

projects. If, consistent with the court's decision in *Alliance to Protect Nantucket Sound*, BOEM determines that a lease / right-of-way is not required for projects involving only small and temporary installations on the outer continental shelf, it should provide guidance on when it will consider an installation to be "small" and "temporary."

6. **BOEM should confirm that it has authority to issue leases for ocean CDR projects that are integrated with renewable energy facilities.** BOEM's authority to issue leases / rights-of-way over the outer continental shelf is somewhat limited. Under the OCSLA, BOEM can only issue leases / rights-of-way for certain activities that involve mineral or energy development, or sub-seabed carbon storage. Activities relating to ocean CDR are not expressly mentioned in the OCSLA. There is, however, a good argument that BOEM has authority to issue leases / rights of way for ocean CDR installations that are integrated with renewable energy facilities. BOEM should confirm this and clarify the limits to its authority.

   Under the OCSLA, BOEM has authority to issue leases / rights-of-way over the outer continental shelf for activities that "produce or support production, transportation, or transmission of energy from sources other than oil and gas."[110] Relying on that authority, BOEM has issued leases for renewable energy facilities (e.g., offshore wind turbines) on the outer continental shelf.[111] BOEM regulations state that facilities installed on the outer continental shelf under renewable energy leases must be used for either (1) "commercial activities . . . associated with the generation, storage, or transmission of electricity or other energy product . . . intended for distribution, sale, or other commercial use," or (2) other activities "that support, result from, or relate to the production of energy from a renewable energy source."[112] Category (2) is very broad and would appear to allow for the installation of ocean CDR equipment that is powered by offshore renewable energy facilities. In this regard, one recent study concluded:

   > [I]n artificial upwelling projects, pipes and pumps may be deployed with, and powered by, [offshore] wind turbines or solar panels. Where this occurs, it could be argued that the pipes and pumps are "relate[d] to the production of energy from a renewable" source (i.e., because they use energy produced by the wind turbines or solar panels).[113]

   To provide additional certainty to CDR project proponents, BOEM should issue guidance, clarifying the ocean CDR facilities that may be installed on the outer continental shelf pursuant to a renewable energy lease.

[110] 43 U.S.C. § 1337(p)(1)(C).
[111] 30 CFR §§ 585,104 & 585.112.
[112] *Id*. § 585.200.
[113] Webb et al., *supra* note 22, at 295.

Army Corps of Engineers

7. **ACE should consider issuing general permits for ocean CDR activities that present minimal environmental risks.** Under the RHA, a permit from ACE is required to install structures in, excavate, fill, or otherwise alter navigable waters of the United States.[114] For the purposes of the RHA, navigable waters of the U.S. include ocean waters, extending up to three nautical miles from shore.[115] While ocean areas further offshore do not qualify as "navigable waters" under the RHA, in the OCSLA, Congress extended ACE's authority "to prevent obstruction of navigation" to "artificial islands, installations, and other devices" attached to seabed the outer continental shelf.[116] An ACE-issued permit will, therefore, be required for any ocean CDR project involving the installation of fixed structures in ocean areas under U.S. jurisdiction (typically within 200 nautical miles of shore).

   ACE issues two classes of permits: (1) general, and (2) individual. General permits are issued for categories of activities that "are substantially similar in nature and only cause minimal individual and cumulative environmental impacts."[117] Activities covered by general permits do not need to be specifically authorized by ACE. In some cases, the person undertaking the activity may need to notify ACE in advance, but that is not always required.[118] Even where advance notice is required, operating under a general permit is far easier than securing an individual permit from ACE, which involves submission of a detailed permit application, a public notice and comment process, and thorough review by ACE.[119] Indeed, ACE has described general permits as being "designed to regulate with little, if any delay or paperwork certain activities having minimal impacts."[120]

   Certain research activities are already covered by general permits issued by ACE. Specifically, Nationwide General Permit 5 (Scientific Measurement Devices) covers the installation of "devices whose purpose is to measure and record scientific data, such as staff gages, tide and current gages, meteorological stations, water recording and biological observation devices, water quality testing and improvement devices, and similar structures."[121] This would encompass equipment installed to collect baseline data needed to inform decisions about when and where to pursue ocean CDR. It is, however, unlikely to cover the installation of other equipment used in ocean CDR research. For example, according to one recent study, the installation of pipes and pumps to test the efficacy of

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[114] 33 U.S.C § 403.
[115] 33 CFR §§ 322.2 & 329.12(a).
[116] 43 U.S.C. § 1333. *See also* Army Corps of Engineers, Regulatory Guideline Letter 88-08: Regulation of Artificial Islands, Installations, and Structures on the U.S. Outer Continental Shelf (1998), https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll9/id/1345.
[117] 33 CFR § 322.2(f)(1).
[118] *Id*. §§ 330.1(e) & 330.6.
[119] *See generally, id*. Pt. 325.
[120] *Id*. § 330.1(b).
[121] ARMY CORPS OF ENGINEERS, 2021 NATIONWIDE PERMIT 6 (2021), https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/20099.

artificial upwelling and downwelling is unlikely to be covered by General Permit 5.[122] ACE should consider issuing a new general permit(s) dealing with the installation of this and other equipment in connection with ocean CDR research projects. This would help to simplify and streamline the approvals process for ocean CDR research.

Before issuing a general permit for ocean CDR research, ACE would need to assess the risks posed by different research activities since, as noted above, only activities that have "minimal impacts" can be authorized via a general permit. To inform its assessment, ACE may need to consult with other agencies with greater experience and expertise with respect to ocean CDR, such as NOAA, DOE, and the National Labs. ACE would also need to provide an opportunity for public comment and consider any comments received before adopting any new general permit.[123] A NEPA review and other environmental assessments may also be required.[124]

National Oceanic and Atmospheric Administration

8. **NOAA should share relevant data with permitting agencies to enable them to evaluate project impacts.** NOAA has a valuable role to play in providing data to permitting agencies, like those described above, to use in evaluating whether to accept or reject permit applications for ocean CDR projects. NOAA is widely considered an authority on data both about climate change and about ocean environments. NOAA hosts a large suite of data products on its website, called U.S. climate normals, that provide information about typical climate conditions for locations around the U.S.[125] Similarly NOAA studies ocean ecosystems to improve understanding and help manage living marine resources.[126]

   Although the data NOAA collects is often publicly available, NOAA guidance on how to use the data could help permitting agencies in their decisions. In order to determine whether individual projects will be effective at storing carbon dioxide, permitting agencies will need a good understanding of baseline ocean biology and chemistry in a given marine environment. Similarly, in order to understand ecosystem impacts of ocean CDR projects, permitting agencies will need to understand baseline ecosystem conditions, and how those conditions might be expected to change due to climate change. NOAA should devote resources towards sharing data relevant to these questions with permitting agencies and provide advice to the agencies on how to locate and use the data.

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[122] ROMANY M. WEBB ET AL., REMOVING CARBON DIOXIDE THROUGH ARTIFICIAL UPWELLING AND DOWNWELLING: LEGAL CHALLENGES AND OPPORTUNITIES 36 (2022), https://scholarship.law.columbia.edu/faculty_scholarship/3337/.
[123] 33 CFR § 330.5
[124] *Id*.
[125] NOAA National Centers for Environmental Information, *U.S. Climate Normals*, https://www.ncei.noaa.gov/products/land-based-station/us-climate-normals (last visited April 11, 2024).
[126] NOAA, Ecosystems & Fisheries-Oceanography Coordinated Investigations, https://www.ecofoci.noaa.gov/ (last visited April 11, 2024).

9. **NOAA should provide technical assistance to permitting agencies for the evaluation of project impacts.** Similar to the recommendation above, NOAA's expertise on ocean and atmospheric dynamics can aid permitting agencies in making their permitting decisions. In addition to sharing data, NOAA could also provide technical assistance, and even directly share employees, to help agencies like EPA and ACE evaluate project impacts. NOAA's expertise in using environmental data towards management of fisheries might be especially instructive. Under the Magnuson-Stevens Fishery Conservation and Management Act, NOAA assesses and predicts the status of fish stocks, sets catch limits, and ensures compliance with fisheries regulations.[127] The expertise required to do this well, by evaluating ecosystem impacts of fishery and other ocean uses, could aid permitting agencies in making decisions about projects with potential impacts on marine ecosystems.

   One way to formalize the provision of technical assistance is through a secondment program. Federal employees can work on a temporary basis at other federal agencies through an "external detail."[128] These details may require compliance with existing or new interagency agreements, approval from the sending and receiving agencies, and approval by the General Services Administration.[129] By formalizing a secondment program, NOAA could facilitate smooth processing of external details. This could lead to, for example, NOAA experts working for a number of months at EPA, ACE, or BOEM to train their staff and offer other assistance to the agencies to help with their review and regulation of ocean CDR projects

Department of Energy

10. **DOE should share relevant data and provide technical assistance to permitting agencies on ocean CDR projects.** This recommendation should be read in conjunction with the two recommendations directed at NOAA above, as the general thrust of the recommendation is the same. Similar to NOAA, DOE should be proactive in sharing relevant data and should consider providing technical assistance to permitting agencies, including, for example, through a secondment program. DOE has specific expertise on ocean CDR that would be relevant to permitting agencies, and they should share that expertise with them. Since 2017, DOE's Advance Programs Research-Energy (ARPA-E) office has been funding research into seaweed cultivation as part of its Macroalgae Research Inspiring Novel Energy Resources (MARINER) program.[130] Data and lessons learned from this project could aid in permitting decisions around seaweed cultivation for ocean CDR. In addition, as mentioned above, DOE has committed $36 million in funding

[127] NOAA Fisheries, *Our Mission*, https://www.fisheries.noaa.gov/about-us (last visited April 11, 2024).
[128] Government Services Administration, *Details with Other Agencies*, TTS HANDBOOK, https://handbook.tts.gsa.gov/hiring-staying-or-changing-jobs/external-details/ (last visited April 11, 2024).
[129] *Id*.
[130] ARPA-E, *Macroalgae Research Inspiring Novel Energy Resources*, https://arpa-e.energy.gov/technologies/programs/mariner (last visited April 11, 2024).

for 11 projects focused on monitoring, reporting, and verification of ocean CDR.[131] The lessons learned from those projects might answer critical questions permitting agencies have about the viability of ocean CDR approaches and environmental impacts. Further, DOE's national labs, like the Pacific Northwest National Laboratory, appear likely to conduct early in-ocean experiments.[132] DOE should proactively share information and learnings from those experiments.

[131] Department of Energy, *DOE Announces $36 Million to Advance Marine Carbon Dioxide Removal Techniques and Slash Harmful Greenhouse Gas Pollution*, https://www.energy.gov/articles/doe-announces-36-million-advance-marine-carbon-dioxide-removal-techniques-and-slash (last updated Oct. 26, 2023).
[132] *Id*.

From: Brendan Carter - NOAA Affiliate <brendan.carter@noaa.gov>
Sent: Tuesday, April 23, 2024 11:58 AM
To: Light, Tricia M. EOP/OSTP
Subject: Marine Carbon Dioxide Removal Research Plan

1. How would a Marine CDR Plan affect you, your organization, or your community?

It would help. I am a mCDR researcher currently grappling with many of the questions that the mCDR research program would address. It feels like we are in a crowded room full of shouting, and a more coordinated research strategy would be immensely helpful to avoid duplication of efforts, help identify a sensible path forward, and coordinate research with community outreach and permitting agencies.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

I am concerned about monitoring resources and personnel being diverted from ongoing ocean carbon monitoring efforts, which are already underfunded and providing a critical service to society. As a personal anecdote, my lab has lost 20% (and counting) of its staff to mCDR startups in the last 2 years.

Many other respondents will undoubtedly list some of the other important needs for mCDR research, so I will instead focus on one related need that might otherwise be overlooked: today is the baseline from which future mCDR efforts will be assessed. We need to invest in sustained ocean carbon monitoring today because, in the future, we won't be able to go back in time to measure how things were before we started field trials. Most mCDR approaches are 10-20 years of engineering from being economically viable and require a carbon tax that doesn't yet exist to provide a net good for society. It will also likely be at least that long before the techniques can be scaled up to an extent that a field trial would have a quantifiable impact on the ocean carbon cycle (read: detectable above natural variability and measurement noise and able to inform permanence in a meaningful way). The best thing we can do today to prepare for the future is to try to accurately monitor the ~2.3 GtC/yr that is already going into the ocean. This is an endeavor that is ready today, needs funding today, could provide value today, and could prepare us for a future where mCDR is a part of our portfolio of climate solutions.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Ocean alkalinity enhancement (OAE) seems the most promising for long term mitigation and potentially (though seemingly unlikely) local OA mitigation, but it is unclear whether OAE could be meaningfully scaled without electrochemical approaches and it is doubtful that electrochemical approaches could be meaningfully scaled until we have a vast excess of green energy production (~10x our production today). OIF could be affordable and may or may not help us kick the can down the road, but decades of research into OIF have revealed the chances of a robust MMRV for OIF with a ton-year time horizon of longer than a year or two are nearly negligible (i.e., we'll never really know if it works... we'll just have to hope, and we'll be praying that we don't cause an ecological catastrophe with our efforts).

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

We need to make it clear that scalable mCDR is urgently needed in the same sense that fusion power is urgently needed... I.e., with the recognition that having an urgent need for something doesn't put it within reach. As someone who would personally benefit from mCDR research investments, I will confidently say that, today, the bulk of the research dollars need to be focused as a society on decarbonizing our energy production and not on mCDR. We should invest in mCDR as a part of our portfolio of investments, but we need to have a clear eyed view of the quite low likelihood of success.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

>https://oceanvisions.org/mcdr-field-trials/<

We need to make it clear that partnership in assessing a technology is not an endorsement of the technology. In our lab we routinely assess novel sensors from industry partners, and many of the sensors do not produce useful information. This is usually not a problem and we are glad that the companies are trying to innovate even when things don't work, but in the mCDR space we've had CEOs stating in speeches that "partnership with NOAA gives us legitimacy," (and heard similar comments from others) and that is somewhat problematic.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Good luck, and thank you for taking this on.

From: Niffenegger, James (b) (6)
Sent: Tuesday, April 23, 2024 7:07 PM
To: Light, Tricia M. EOP/OSTP
Cc: Lawson, Michael; Thresher, Robert; Schaidle, Joshua; Deutsch, Todd; Grantham, Kerry; Rippy, Kerry; Laurens, Lieve; Yu, Jianping; Chen, Yian; Chen, Xiaowen
Subject: Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan RFI Responses.pdf

Hi Tricia,

I have attached our organization's (the National Renewable Energy Laboratory) responses to the RFI. Thank you for the opportunity to provide our insights on this topic.

Best,
James Niffenegger
Researcher II – Water Power R&D
National Renewable Energy Laboratory

Marine Carbon Dioxide Removal Research Plan RFI Responses

Organization Filing Response:

The National Renewable Energy Laboratory

People Filing Response:

James Niffenegger, Michael Lawson, Kerry Grantham, Jianping Yu, and Kerry Rippy

Responses to Questions:

1. How would a Marine CDR Plan affect you, your organization, or your community?

NREL aims to support the development, validation, deployment, and environmentally and socially responsible scaling of marine CDR. A Marine CDR Plan will enhance our efforts by providing clarity on the direction of future R&D needs that will allow us to invest in the right capabilities and staff to meet national R&D and technology development goals.

2. What questions or concerns do you have about the regulation of marine CDR, including marine CDR research? What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists, and what additional knowledge is needed to inform the safe and effective regulation of marine CDR research? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?

Depending on the project type, scale, and location, a number of federal[1] and state agencies[2] may be involved in authorizing marine CDR RD&D activities.

Since there are many different forms of marine CDR, each comes with its unique anticipated risks and requirements for verifying CO_2 removal. For instance methods that electrochemically capture CO_2 from the ocean will primarily need to monitor changes in pH, alkalinity, partial pressure of CO_2, and concentrations of dissolved inorganic carbon in the surface ocean while methods that sink biomass to the deep ocean will need to monitor the water column and deep ocean to assess how much of that sunk carbon is remaining in the deep sea and what the environmental impacts of it are (Niffenegger, et al. 2023). Therefore, it is important to consider the risks of the different methods, the environments and key parameters needed to be monitored, and what the acceptable levels for these parameters are for capturing and storing carbon and the subsequent environmental impacts. Developing these requirements will require consultation from experts along with additional research and data gathering that will enable the Federal Government to understand how best to regulate marine CDR R&D activities.

Currently, there is not a comprehensive regulatory framework to address the various marine CDR forms. A streamlined framework with simplified permits could reduce barriers to advancing

[1] https://www.epa.gov/ocean-dumping/permitting-mcdr-and-msrm

[2] https://clearpath.org/tech-101/ocean-cdr-permitting-and-regulations-101/

marine CDR RD&D by defining a clear consultation process for researchers, developers, regulators, and stakeholders.

Consultation with federal, state, and where applicable, local agencies along with stakeholders is critical to analyzing a proposed project to determine the potential effects. Early consultation ensures that all affected stakeholders are identified and engaged, all issues are adequately addressed, and the environmental documentation contains sufficient information to support all the necessary permit authorizations.

We recommend that priority permitting should be given to marine CDR methods with well understood monitoring requirements that can be adequately assessed with existing technologies, while funding is necessary to determine the monitoring requirements and develop the monitoring technologies for the other marine CDR methods. For instance, recently NASA has started to release to the public satellite imaging data that can be used to evaluate algae (including microalgae and seaweed) growth in the ocean, and algae-related CDR technologies, however more research and funding is needed to further develop monitoring standards for these methods.

3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Generally, the marine CDR techniques that we recommend should be prioritized are those with high scalability and low cost, energy, and negative environmental impacts, in addition to clear and measurable parameters to evaluate environmental effects and CO_2 removal. Note that it is important to weigh these factors together since some techniques could be cheap but environmentally hazardous at scale. Therefore, it is essential to fund studies investigating these factors for the different techniques, and especially those on the environmental risks and efficacy of CO_2 removal. A prior literature review done by our organization found that electrochemical based marine CDR methods have high scalability, energy needs similar to that of onshore direct air capture and sequestration, and minimal anticipated environmental impacts (Niffenegger, et al. 2023). These methods include those that capture pure CO_2 from the ocean and inject it into undersea reservoirs, add base to the ocean, and convert dissolved CO_2 into solid carbonates. Note that more studies are necessary to evaluate the environmental impacts of these methods, however the environmental impacts of biological based methods, like seaweed sinking and artificial upwelling, are anticipated to be very hazardous at large scales and will likely significantly disrupt global ecosystems and food chains (Niffenegger, et al. 2023). However at small local scales artificial upwelling can improve aquaculture yields and seaweed sinking could mitigate negative environmental and societal impacts of the large seaweed bloom in the Caribbean, which is affecting tourism and health in the region, which includes Puerto Rico, the US Virgin Islands, and Florida (Niffenegger, et al. 2023).

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

It will be essential to develop educational materials about the different marine CDR techniques that can be shared with communities. This informational resource should contain details on the co-benefits, environmental risks, and state of development of the different options and could include information on the relevant companies or organizations pursuing these techniques that the community could engage with if they are interested in enabling a field trial or deployment in their region. It could be beneficial to have a neutral representative present this information to the communities before any particular company is engaged so that the communities could decide on what technique of marine CDR, if any, they would like to collaborate with.

5. What are the most significant marine CDR efforts being undertaken by academia, industry, philanthropy, non-governmental organizations, and other governments that the Federal Government should be aware of? What factors should the Federal Government take into account when considering potential partnerships between these entities and the Federal Government? What are the biggest challenges that the Federal Government and potential partners may face in collaborating, and how could the Federal Government help overcome these challenges? What examples of partnerships are most relevant to potential marine CDR partnerships?

Among electrochemical marine CDR techniques, the largest companies our organization is familiar with include Captura, which captures CO_2 from seawater, Ebb Carbon, which adds alkalinity to ocean water, and Equatic, which converts dissolved inorganic carbon into solid carbonate. Among National Labs, the Pacific Northwest National Laboratory is collaborating with Ebb Carbon to evaluate their technology and assist with field testing and the National Renewable Energy Laboratory is collaborating with Captura to model the potential performance of their technology when powered by a hybrid renewable energy based microgrid. Additionally, researchers at the Naval Research Lab are developing electrochemical marine CO_2 capture systems that can extract CO_2 from seawater and convert it into fuels for offshore Naval activities. Among philanthropic efforts, the National Renewable Energy Laboratory has also worked with Carbon to Sea, who are looking to advance scalable pathways to ocean CDR.

Overall, more funding is needed to support more collaborations in marine CDR, especially in assessing environmental impacts, deployments, advancing the efficiency of the CDR technologies, integration with offshore energy sources like offshore wind and marine energy, and co-integration strategies like integrating electrochemical marine CDR technologies with desalination plants.

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

It is also important to provide support for research investigating the integration of offshore renewable energy, such as offshore wind and marine energy, into marine CDR. There is a significant amount of energy in US waters that could be harvested by existing technologies. For instance, about 10 $GtCO_2$/yr of electrochemical marine CDR could be powered by US offshore wind and marine energy while still meeting US coastal energy demand (Niffenegger, et al. 2023). Offshore renewable energy sources will be critical to scaling these marine CDR technologies offshore in the future and could be used in the near-term to power the multitude of monitoring devices required during field trials and long-term deployments. This represents an opportunity for offshore renewable energy to co-develop and scale with marine CDR, which could benefit both fields.

References:

Niffenegger, J.S., D. Greene, R. Thresher, and M. Lawson. 2023. *Mission Analysis for Marine Renewable Energy To Provide Power for Marine Carbon Dioxide Removal.* Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy23osti/87165.pdf.

From: Whitt, Daniel B. (ARC-SGE) <daniel.b.whitt@nasa.gov>
Sent: Tuesday, April 23, 2024 11:27 PM
To: Light, Tricia M. EOP/OSTP
Subject: Marine Carbon Dioxide Removal Research Plan: response to RFI
Attachments: Marine Carbon Dioxide Removal Plan - response to RFI by whitt et al .pdf

Dear Tricia,

Please see the attached response to the RFI entitled Marine Carbon Dioxide Removal Plan due Apr 23, with document citation 89 FR 13755 and document number 2024-03758.

Best,
Dan Whitt

Marine Carbon Dioxide Removal Plan: Response to RFI Submitted April 23, 2024 By:
Dan Whitt (NASA/Ames), Dustin Carroll (Moss Landing Marine Laboratories, San José State University), Laura Iraci (NASA/Ames), Emma Yates (Bay Area Environmental Research Institute), Kay Suselj (Jet Propulsion Laboratory, California Institute of Technology), Matthew Johnson (NASA/Ames), Liane Guild (NASA/Ames), Juan Torres-Perez (NASA/Ames)

How would a Marine CDR Plan affect you, your organization, or your community?

In our institutions/communities, an mCDR Plan could incentivize the redeployment of some existing resources, such as sensors/instruments, platforms, supercomputers, and personnel and possibly investment in new resources to advance analysis modeling and data acquisition and assimilation capabilities to address the questions identified by the FTAC. These investments will likely include the modification and application of existing numerical ocean and Earth System Modeling (ESM) and assimilation tools to advance understanding of the climate-mitigation potential, co-benefits, and adverse impacts of mCDR, as well as questions related to monitoring, measurement, reporting, and verification (MRV). An mCDR Plan may also trigger investments to assess the capabilities and needs of existing or potential observing systems, especially the potential contributions of airborne (including remotely-piloted drones) and satellite platforms and their synergies with in-situ observing systems, at scales ranging from local field trials to global. Finally, personnel may invest time coordinating mCDR related activities with a wide range of stakeholders across government, industry, and academia.

What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders?

The government should prioritize basic scientific research about mCDR and applied work related to regulation, monitoring, and verification, including both the natural and social sciences. The government has a tremendous legacy in relevant basic and applied research, including expert personnel, relevant data (observations and model output), and capabilities to observe and simulate the ocean and its carbon in the coupled Earth system. A priority is to efficiently apply these resources to guide and advance mCDR research and investment. The government should also prioritize integrating and coordinating the diverse strengths and capabilities of all relevant agencies. To facilitate safe and effective mCDR research, the Federal Government should provide transparent and open-source observations, including data as well as platforms and sensors, and models, including diagnostic output of various relevant ocean and Earth system variables as well as software and computer systems. The government should support ocean and

Earth system scientists to adapt and guide the application of existing and potential future observational and modeling resources for mCDR research. In addition, the government should support social scientists (policy, governance, and economics) to integrate with natural scientists to facilitate the development of an effective mCDR industry and the safe regulation of mCDR research in field trials.

In this response, we highlight for the FTAC committee a small subset of government tools and resources that we feel should be prioritized in mCDR investments together with other tools and resources: data-constrained models and airborne observations.

Models. Among other things, government resources, tools, and information should include a hierarchy of observationally-constrained numerical ocean circulation and biogeochemistry models and ESMs, including global models, regional/process models, and simpler models adapted for mCDR.

Global models. If successful, scaled-up mCDR efforts to reach net zero will have an impact on the global atmospheric and oceanic carbon budgets. Thus, global ocean models and ESMs are required to advance understanding of potential or real future impacts of mCDR. To plan and guide field trials, we require a first-order understanding of where, when, and why mCDR would be most effective in various ocean basins and regions. These questions could be addressed in virtual pre-field mCDR experiments in data-constrained ocean (e.g., Carroll et al. 2022) and atmospheric state estimates (e.g., Ott et al. 2015, Peiro et al. 2022) as well as ESMs in global warming scenarios (e.g., Lerner et al. 2021). Ultimately, multiple different models in each category should be used to assess uncertainties associated with model biases, and the models should be operationalized so they can be used in tandem with mCDR field trials and/or operational deployment to facilitate prediction and monitoring. It may ultimately be necessary to develop more advanced coupled global ESMs tailored for short-term monitoring and prediction, rather than their usual application of seasonal-to-centennial climate prediction.

*Regional/process models***.** At best, global models resolve variability down to 20–200 km scales and most global-ocean biogeochemical models and/or ESMs resolve only the coarsest end of that range. However, some mCDR field trials, which occur at scales as small as a few square meters (Cyronak et al. 2023), may be too small to be adequately resolved by global models. In addition, many stakeholders have local and regional interests at scales that are not adequately resolved by the global models. Many of the relevant physical stirring and mixing processes in the ocean also occur at scales from meters to 10s of km. Furthermore, in some mCDR approaches, e.g., iron or ocean alkalinity injection, it is necessary to conduct process simulations of the physical, chemical, and biological dynamics in the near-field region around the injection site, e.g., physical/biogeochemical turbulence simulations. And in virtually all cases, many processes underpinning mCDR occur at the microscale, such as particle dissolution or aggregation and iron uptake in phytoplankton, among others. Therefore, it is necessary to conduct downscaled regional modeling and process modeling, e.g., biogeochemical large eddy simulations as in Whitt et al. (2019), in support of field trials and operational deployments (in pre-field, during deployment, and after deployment) to refine our quantitative understanding of the small-scale to regional-scale impacts of mCDR that are relevant to stakeholders (e.g., Fennel et al. 2023). From a scientific perspective, a compelling and state-of-the-art downscaling of the coastal ocean probably requires a data-constrained regional ocean model implementation. Coastal systems are complex and varied, and the dynamics are relatively poorly constrained by global high-resolution remote sensing data, especially in nearly-enclosed estuaries and deltas, where some field trials and deployments may occur. These models can assimilate data to help us better quantify the ocean state and enable counterfactual experiments to quantify impact. Model experiments can also quantify the e-folding time of various biogeochemical perturbations and assess uncertainty.

*Simpler/parameterized models***.** It is not reasonable to develop realistic high-resolution regional ocean biogeochemical models for every patch of coastline to prepare for small field trials. In addition, it is not efficient to run global models with all possible mCDR perturbations along the coastal periphery or at all possible open-ocean locations. It is therefore necessary to leverage a hierarchical modeling approach. First, it is necessary to develop or use existing state-of-the-art global models and regional models and apply them to a few mCDR examples. Then, research is needed to guide the development and evaluation of simpler models or parameterizations (Suselj et al. 2024, *in review*, unpublished preprint available at https://doi.org/10.5281/zenodo.10632054), both for downscaling more efficiently and for considering a wider range of mCDR perturbations. These may take a variety of forms and combine dynamical and empirical/statistical approaches tuned for various applications in the mCDR context.

Observations. The government should also provide relevant observations and observing systems, as well as software to synthesize the data in models. Research should be invested into acquisition and assimilation of observations relevant to mCDR field trials or deployment. Observing the impacts of mCDR in the ocean and atmosphere is challenging due to the complex turbulent movement of the fluids and challenges observing the relevant variables. Hence, the best ocean and atmospheric state estimates are typically made by integrating observations of multiple variables from different platforms and sensors in a model to develop the most complete perspective on the state of the system and its uncertainty.

Variables of interest include those defining the ocean carbon chemistry and composition of the seawater (e.g., total alkalinity and carbon, temperature, salinity), variables defining the movement and mixing of the seawater such as current velocities, turbulence, passive dye tracers of ocean mixing and dispersal, and any variable artificially added to trigger mCDR (such as iron, alkaline minerals, or other substances). In addition, measurements are needed of air-sea exchange, such as the atmospheric carbon dioxide concentration, meteorological variables, and direct measures of the air-sea fluxes. Numerous measures of the marine ecosystem, especially those relevant to carbon cycling but also including others for monitoring the indirect impacts of mCDR on marine ecosystems, are also necessary. A short and general discussion of some variables of interest is available in Cyronak et al. (2023).

Numerous in-situ observations are needed including water samples and samples from buoys, moorings, gliders and other autonomous robotic platforms, but our response focuses on airborne remote sensing observations, which could provide spatiotemporal coverage of the ocean surface that is not obtainable from in-situ observations, the existing satellite fleet, and models alone. Recent U.S. Federal Government investments in research from NOAA/NOPP (https://oceanacidification.noaa.gov/fy23-nopp-mcdr-awards/) and DOE/ARPA-E (https://arpa-e.energy.gov/technologies/programs/sea-co2) have not focused on airborne and suborbital remote sensing capabilities in general. Nevertheless, many prior NASA field programs such as S-MODE (https://espo.nasa.gov/s-mode/content/S-MODE), NAAMES (https://science.larc.nasa.gov/naames/), OMG (https://sealevel.nasa.gov/missions/omg), DeltaX (https://deltax.jpl.nasa.gov/), CORAL (https://science.nasa.gov/mission/coral/), etc. have demonstrated the capability to measure ocean surface winds, currents, temperature, waves, color, and relevant marine ecosystem properties such as particulate organic carbon from the air. It is also feasible to use airborne platforms to map the three-dimensional structure of passive tracers, such as the dispersion of fluorescent dye (Sundermeyer et al. 2014). Additionally, numerous prior airborne campaigns have measured atmospheric carbon dioxide over the ocean (e.g., Long et al. 2021). Although the direct measurement of the air-sea carbon dioxide flux is challenging from the air, artificial reductions to the ocean carbon dioxide concentration may yield measurable air-sea fluxes in the coastal or open ocean from airborne platforms in the context of mCDR (e.g., Hannun et al. 2020). Further investment in research is needed to determine how to leverage government airborne measurement capabilities and related ocean biogeochemistry and Earth system state estimation in support of mCDR. Such research may also lead to better use of satellite remote sensing in support of mCDR.

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From: Brynn Esterly [redacted] >
Sent: Thursday, April 25, 2024 4:31 PM
To: Light, Tricia M. EOP/OSTP
Subject: Re: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan
Attachments: Climate Vault_Marine Carbon Dioxide Removal Research Plan_4.25.24.pdf

Dear Tricia,

I hope you are doing well.

Climate Vault has made updates to the RFI response that I submitted to you on Tuesday (4/23). Would it be possible to replace our prior submission with the updated version (see attached PDF)?

If this is not possible, I completely understand. However, I wanted to inquire in case there was any flexibility. I apologize in advance for the inconvenience and appreciate your time and consideration of my request.

Sincerely,
Brynn

On Tue, Apr 23, 2024 at 4:39 PM Light, Tricia M. EOP/OSTP [redacted] wrote:

> Hello Brynn,
>
> Thank you for your feedback. Your input will be shared with the mCDR Fast Track Action Committee and taken into consideration.
>
> Best,
>
> Tricia
>
> **Tricia Light**, PhD (she/her/hers)
>
> Knauss Ocean Policy Fellow
>
> Office of Science and Technology Policy
>
> [redacted] / [redacted] *(calls only)*

From: Brynn Esterly (b) (6) [redacted] >
Sent: Tuesday, April 23, 2024 4:16 PM
To: Light, Tricia M. EOP/OSTP (b) (6) [redacted]
Subject: [EXTERNAL] Marine Carbon Dioxide Removal Research Plan

Dear Tricia,

I hope this email finds you well.

Climate Vault is pleased to formally submit our response to the Request for Information (RFI) for the Marine Carbon Dioxide Removal Research Plan. Please find our response document attached. Can you kindly confirm receipt?

We applaud the NSF and the MCDR-FTAC in their efforts to implement an impactful Marine CDR Plan and appreciate the opportunity to contribute our insight and feedback. We look forward to continuing the conversation as the Marine CDR Plan evolves.

Thank you for your time and consideration. If you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,

Brynn Esterly

CDR Projects Manager

Climate Vault

CLIMATE VAULT

Submitted via electronic mail on April 23, 2024

Esteemed Members of the National Science Foundation,

Climate Vault applauds the National Science Foundation (NSF) and the White House National Science and Technology Council Marine Carbon Dioxide Removal Fast-Track Action Committee (MCDR-FTAC) in their efforts to implement an impactful Marine CDR Plan ("mCDR Plan") to advance the goals of the Ocean Climate Action Plan. We appreciate the opportunity to submit a response to this RFI and look forward to continuing to engage with the NSF and MCDR-FTAC as this work evolves.

Introduction to Climate Vault

Climate Vault, Inc. ("Climate Vault") is a 501(c)(3) non-profit organization founded at the University of Chicago with the mission to simultaneously reduce carbon emissions and support innovation in carbon dioxide removal (CDR) technologies. Our founder, Dr. Michael Greenstone, is a renowned economist who co-led the development of the United States social cost of carbon under President Obama. At Climate Vault, we believe in the power of markets to solve complex challenges.

Our CDR solutions are vetted by our world-class Technology Experts Chamber ("Tech Chamber"), which includes science and policy experts from Harvard, MIT, Princeton, and UC San Diego (Scripps). The Tech Chamber is chaired by former US Energy Secretary, Ernest Moniz.

Our Tech Chamber assesses CDR technologies across three pathways: Terrestrial, Technological, and Oceanic. Given the ocean's size and natural capacity as a carbon sink, we believe mCDR solutions are imperative to helping the U.S. achieve net-zero by 2050 and collective global efforts to limit warming to 1.5°C above pre-industrial levels. However, we acknowledge that mCDR solutions are currently immature and that a dedicated, coordinated research effort to answer critical questions and overcome roadblocks to growth and expansion is needed to advance these solutions.

Climate Vault's Response to Select RFI Questions

1. How would a Marine CDR Plan affect you, your organization, or your community?

Climate Vault is a 501(c)(3) non-profit organization with the mission to simultaneously reduce carbon emissions and support innovation in carbon dioxide removal (CDR) technologies. Through our annual RFP process, we seek to identify innovative CDR technologies to receive grant funding, and thereby support the growth and development of the carbon removal ecosystem. In Climate Vault's recent RFP round, mCDR solutions comprised 15% of applications received. However, while Climate Vault and the Tech Chamber agree that these mCDR solutions show promise, most lack technical maturity and face common challenges to scaling their solutions. Some examples include: demonstrating the technical feasibility and scalability of their technologies; implementing clear monitoring, reporting and verification (MRV) processes; obtaining permits to implement pilot facilities; and identifying and addressing project impacts on local communities and ecosystems. Therefore, Climate Vault maintains that any guidelines that help to move mCDR solutions forward are worth pursuing.

There are two key ways that the mCDR Plan would support our mission to accelerate mCDR innovation:

- **Address critical barriers to adoption and scaling:** The mCDR Plan would bring clarity and certainty to the common challenges cited above. It could help to reduce the inherent and perceived risks related to these projects, ultimately encouraging greater adoption of mCDR technologies. This clarity, supporting data, and risk reduction could also lead to greater success for project developers applying for funding and investment opportunities, such as through Climate Vault's grant program.

- **Amplify the climate impact of each grant dollar awarded:** The mCDR Plan would help to alleviate costs for internal research, development and deployment efforts for mCDR project developers, thereby lowering the all-in cost to remove 1 tCO2 and enabling Climate Vault to make a bigger impact per grant dollar awarded to successful applicants.

More broadly, the mCDR Plan can have positive impacts for local communities and economies:

- **Quantification of socioeconomic benefits:** The mCDR Plan could help to identify and quantify the socioeconomic benefits of mCDR solutions in local communities. In doing so, the mCDR Plan will equip project developers, advocates and key decision-makers with the data-backed insights necessary to facilitate further adoption and implementation of these technologies.

- **Creation of new jobs and scaling of the green economy:** Following the further adoption and expansion of mCDR solutions, the mCDR Plan will help to foster and scale a new industry of green jobs with positive local economic impacts.

2. **What tools or resources should the Federal Government provide to support the safety and effectiveness of marine CDR research, including testing at scale in the field? What knowledge exists and what additional knowledge will be needed to inform decisions about the readiness of any marine CDR approach for full-scale deployment or commercial application?**

Engage with the International Scientific Community

There is significant work to be done to move the mCDR space forward in a manner and time frame that meets the challenge of the global climate crisis. Therefore, Climate Vault encourages the Federal Government to prioritize engagement with the organizations and institutions that are already conducting valuable mCDR research (e.g. Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, Ocean Visions), in order to accelerate the collective rate of progress. This outreach should be conducted as part of a comprehensive stakeholder engagement exercise, discussed in further detail in our response to Question 4.

Establish Standards for Research Practices

Climate Vault also encourages the Federal Government to develop standards to guide collective research practices under the mCDR Plan to support safety, effectiveness, accountability, and collaboration across all research activities, including field testing. These standards should:

- Seek to identify and mitigate potential ecological and socioeconomic risks resulting from research activities and field experiments.
- Include regular, independent assessments of program performance in order to maintain accountability, while not placing unnecessary burdens on research efforts and hampering progress.
- Promote the standardization and sharing of data across disciplines and via public forums to foster transparency and collaboration.
- Build in flexibility so that research needs and approaches can be adjusted to account for the latest scientific evidence, as it comes available.
- Identify what length of sequestration will be deemed acceptable for the research. For example, some researchers have argued that 100-year sequestration should be acceptable because it will provide relief from near-term impacts of CO2 (e.g., warming, acidification in some regions, etc.) while providing insight into the scalability of mCDR techniques and their environmental impacts.

Additionally, the Federal Government could consider developing standards that are aligned with existing international agreements, such as the United Nations (U.N.) Convention on the Law of the Sea (UNCLOS); the London Protocol; and the U.N. Convention on Biological Diversity (CBD). Doing so could help to reduce any potential future friction in research activities, should the U.S. ratify these agreements or if the mCDR Plan requires collaboration with international bodies for research and field experiments.

Prioritize Critical Needs and Common Hurdles

Based on Climate Vault's research, engagement with the CDR community, and learnings from our RFP process, we suggest that the mCDR Plan focus research efforts in the following areas to advance mCDR initiatives and scale impactful solutions:

Monitoring, Reporting and Verification (MRV)

Given the nacency of the CDR space and the complexity of the ocean, developing MRV standards and regulations is crucial to developing confidence in mCDR solutions. While a few mCDR protocols have been developed by various standards bodies to date, there is no industry-wide consensus for implementation and management. Moreover, there is little consensus at the federal level regarding what mCDR MRV approach(es) are acceptable, how carbon sequestration should be demonstrated, and where research should be allowed to take place. Therefore, Climate Vault encourages the Federal Government to host large-scale workshops with the scientific community to advance discussions and align disparate perspectives on these topics at a national, and potentially international, level.

First and foremost, the Federal Government should determine which mCDR MRV approach(es) it will require or deem acceptable under the mCDR Plan. Given the predominant schools of thought on this topic, this means clarifying whether mCDR projects and research should: demonstrate carbon sequestration potential and environmental impacts (often referred to as "eMRV") collectively; demonstrate carbon sequestration potential first, after which environmental impacts can be researched and factored into decision-making; or whether both approaches are acceptable. In each case, there is also the question of whether carbon sequestration is best demonstrated by directly measuring sequestered CO2, measuring ocean oxygen levels, or whether modeled results will be accepted for some parameters. All three approaches have been discussed by the scientific community, but there is no consensus on what should be required to demonstrate sequestration. The Federal Government should make clear what standards of demonstration will be acceptable.

Additionally, community discussions must address where research can take place. While there are a few instances of very small-scale projects taking place in territorial waters, the Federal Government must determine whether mCDR projects will be allowed to take place in the economic exclusion zone (EEZ) and should develop a framework for identifying optimal test sites. Moreover, if projects are permitted to take place in the EEZ, the Federal Government should clarify whether it plans to indemnify federally-funded project developers and research initiatives operating in the EEZ, should any direct or indirect negative impacts result from the tests, in order to bolster confidence in and support the scaling of thoughtful mCDR projects. Finally, it is important to note that some techniques could not be tested adequately in the EEZ because the conditions necessary for the techniques do not exist in the EEZ. If there is a stipulation that projects only be conducted in the EEZ, this will eliminate some techniques from research consideration.

The government's requirements (or range of acceptable approaches) for mCDR MRV should be clearly outlined. Climate Vault also encourages the government to host community workshops to provide guidance on the requirements to ensure understanding and compliance among relevant stakeholders.

Environmental, Ecological and Community Impacts

Potential mCDR impacts on ocean chemistry, local ecosystems and shoreline communities is an important research area. The climate crisis calls for scaling mCDR solutions quickly, but the urgency to sequester carbon must be balanced with reasonable efforts to avoid causing undue harm. Understanding upstream and downstream impacts of mCDR projects will help address key stakeholder concerns and enable the scaling of thoughtful, well-managed mCDR projects.

Permitting

Navigating the permitting system is time-consuming and resource-intensive for mCDR project developers. The system is complex and fragmented with many local, regional, national, and international regulations and institutions that govern activities within maritime zones. These regulations were not designed specifically for CDR projects, which leaves many questions regarding how mCDR project developers should comply. The mCDR Plan can provide clarity on the types of permits required for different CDR projects, the processes and requirements for obtaining the permits, and where necessary, working with regulators to resolve key information gaps and streamline compliance.

Finally, each of the above research areas can be best supported through the development of advanced oceans systems modeling tools. For example, tools that model ocean system interactions can be used to develop baselines for MRV activities and predict the range of potential outcomes or direct impacts to the ocean resulting from different mCDR approaches. Additionally, ocean modeling systems can be used to develop sophisticated planning tools, which can be used to help regulatory bodies and project developers identify optimal site locations to implement test pilots or expand existing facilities.

3. Which marine CDR techniques do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits?

Climate Vault does not believe that research efforts and field trials have progressed far enough to conclude which mCDR approach(es) are most promising. Climate Vault maintains that researching and developing a variety of mCDR solutions simultaneously is critical to identifying which solution(s) are most effective and scalable. However, Climate Vault encourages dedicated research efforts on the following solutions:

Blue Carbon

Blue carbon projects face significant challenges to scaling and permanence; however, they have significant carbon sequestration capacity and are essential to coastal resilience, supporting wildlife habitats and biodiversity, and bolstering local economies, such as fisheries. Climate Vault views blue carbon projects as a key component of the mCDR landscape and suggests dedicated research on:

- Modeling and quantifying sequestration rates and capacity based on variability in environmental settings and hydrological conditions (e.g., soil and sediment depth, proximity to open water, water circulation, and wave activity).
- Identifying and quantifying climate change impacts on sequestration potential and permanence (e.g., sea level rise, rising temperatures), as well as using this data to predict and better manage future blue carbon projects.
- Opportunities to use soil additions or plant cultivars to enhance sequestration and quantify the impacts of these methods.
- Framework development for identifying preferred site locations for new or expanded blue carbon projects, including opportunities to restore degraded coastal areas, incorporate wetlands into adaptation projects, and convert hardened shorelines to natural shorelines.
- Comprehensive mapping and data sets for blue carbon stocks.
- Quantifying resilience benefits of blue carbon projects for coastline communities.

Moreover, given the impacts that climate change can have on coastal communities, such as damage caused from more frequent and intense storms and sea level rise, Climate Vault encourages the Federal Government to identify collaborative opportunities among blue carbon project developers, local governments, and federal agencies (such as FEMA) for identifying optimal sites for blue carbon projects and tracking and quantifying impacts.

Macroalgae

Macroalgae projects are unique because they do not compete with arable land or require fresh water, and some of the infrastructure and operations are already in place and could be used for future expansion. However, much remains unknown about the effectiveness and impacts of sinking significant quantities of macroalgae to the deep ocean. Therefore, Climate Vault suggests dedicated research on:

- Ecological and biological impacts resulting from the growth, collection, harvesting, and sinking of various amounts of macroalgae in different marine environments and sea depths.

- Ocean modeling systems to quantify the amount of CO2 sequestered through macroalgae growth and harvesting activities.
- Tracking systems to determine the amount of biomass that reaches the ocean floor and is effectively sequestered.
- Opportunities to use plant cultivars to increase embodied carbon and yields.
- Framework development for identifying preferred site locations for macroalgae projects.
- More efficient, cost-effective technologies for harvesting and sinking macroalgae at sea.

Ocean Alkalinity Enhancement

While the chemistry behind Ocean Alkalinity Enhancement (OAE) is well-understood, most OAE research to date has been confined to modeling and lab studies. Field trials are needed in order to better observe and quantify the upstream and downstream impacts of this mCDR approach and to develop more precise accounting for carbon sequestration capacity. Therefore, Climate Vault suggests dedicated research on:

- Quantifying the upstream environmental impacts from mining, grinding and transporting alkaline materials to application sites.
- Identifying and addressing the downstream environmental and socioeconomic impacts from alkaline material application, including effects on ocean chemistry, local ecosystems and shoreline communities.
- Establishing strict purity standards for alkaline materials, with the goal to minimize the presence of trace metals or other pollutants introduced into seawater through OAE applications.
- Framework development for identifying preferred site locations for OAE projects, including projects taking place in the open ocean, on beaches, or in on-shore facilities using coastal outfalls.
- Advancing models and tools used to monitor and verify the amount of CO2 sequestered.

Direct Ocean Capture

Direct Ocean Capture (DOC) has significant potential as a mCDR approach; however, these projects remain in earlier stages of development and implementation. Therefore, Climate Vault suggests dedicated research on:

- Identifying low-cost, energy-efficient DOC methods; in particular, the mCDR Plan should consider aligning with existing research efforts through the DOE/ARPA-E Direct Ocean CO2 Capture Program.
- Ecological and biological impacts resulting from the intake and processing of large quantities of seawater.
- Framework development for identifying preferred site locations for DOC facilities and opportunities to potentially co-locate with existing infrastructure.
- Advancing models and tools used to monitor and verify the amount of CO2 sequestered.

4. How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

Stakeholder engagement is a critical component of the project planning process. For mCDR projects in particular, public acceptance is also a roadblock to advancing further research and testing. Engaging in intentional and continuous dialogue that prioritizes equity, with relevant stakeholders, and implementing feedback accordingly, is important to advancing mCDR solutions. Climate Vault encourages the NSF to incorporate the following into their process:

1. **Identify stakeholder groups**: Conduct an in-depth review of relevant stakeholder groups, including communities that may be adversely impacted by the mCDR Plan.

2. **Establish robust communication**: Engage in transparent and balanced communications with identified stakeholders groups. This includes hosting regular community education and discussion forums regarding the benefits, challenges and risks involved with mCDR technologies and related research initiatives. Additionally, a formal feedback mechanism should be created to ensure all stakeholder perspectives are represented.

3. **Implement targeted research efforts and programs**: Based on stakeholder feedback, devise targeted research efforts and programs that address the most pressing or impactful environmental, social, and economic considerations. In particular, the NSF may consider organizing small-scale pilots where co-benefits can be demonstrated and realized in local communities. Quantifying outcomes and potential co-benefits will also provide project developers and advocates with the data they need to gain acceptance and enable the scaling of their technologies.

4. **Track and measure progress**: Implement robust data collection and monitoring systems to track progress and inform evidence-based action. Data and results should be shared transparently across stakeholder groups to build trust, accountability, and facilitate collaboration.

5. **Conduct regular reviews**: Regularly evaluate progress and community feedback to inform potential program revisions. As outlined above, program assessments should be conducted by an independent body and the results be made available to all stakeholders.

Finally, Climate Vault encourages the NSF to create a “Stakeholder Roadmap” for mCDR project developers. The Stakeholder Roadmap would help to educate project developers on the best practices for stakeholder identification and engagement, including many of the same steps outlined above, and provide them with the tools to successfully identify and engage with stakeholders at different stages of their technological maturity, including implementing test and pilot facilities or expanding their operations to new locations.

Thank you for the opportunity to provide feedback on the development of this important initiative. We appreciate your time and consideration and look forward to continuing the conversation as the mCDR Plan evolves.

Sincerely,

Brynn Esterly
CDR Projects Manager
Climate Vault

Climate Vault referenced the following sources in developing its RFI response:

Aspen Institute, Energy & Environment Program. “A Code of Conduct for Marine Carbon Dioxide Removal Research”. November 2023.

Energy Futures Initiative. “Uncharted Waters: Expanding the Options for Carbon Dioxide Removal in Coastal and Ocean Environments.” December 2020.

Energy Futures Initiative. “Clearing the Air: A Federal RD&D Initiative and Management Plan for Carbon Dioxide Removal Technologies.” September 2019.

Ocean Visions and Monterey Bay Aquarium Research Institute (2022). Answering Critical Questions About Sinking Macroalgae for Carbon Dioxide Removal: A Research Framework to Investigate Sequestration Efficacy and Environmental Impacts. Available online at: oceanvisions.org/ seaweedresearch

Romany M. Webb & Korey Silverman-Roati, *Executive Actions to Ensure Safe and Responsible Ocean Carbon Dioxide Removal Research in the United States*, Sabin Center for Climate Change Law, Columbia Law School, November 2023. Available at: https://scholarship.law.columbia.edu/sabin_climate_change/211

From: Rowena Mamea (b) (6)
Sent: Tuesday, April 23, 2024 3:14 PM
To: Light, Tricia M. EOP/OSTP
Subject: Re: Marine Carbon Dioxide Removal Research Plan
Attachments: Marine Carbon Dioxide Removal Research Plan.pdf

Talofa Tricia,

Please see the attached letter of the above subject for your reference...

Blessed day!

Respectfully,
Rowena Mamea
Office of the Governor
American Samoa Government

OFFICE OF THE GOVERNOR
AMERICAN SAMOA GOVERNMENT

Serial No.: 375 – 24

April 23, 2024

To: Tricia Light
Office of Science & Technology Policy
(b) (6)

From: Governor of American Samoa

Subject: Marine Carbon Dioxide Removal Research Plan

As the Governor of a small island territory, I am well aware of the impacts of climate change. Our small island community suffers the consequences of extreme weather and rising sea levels, impacting both our culture and our economy. Marine Carbon Dioxide Removal (mCDR) might be a promising option for reducing GHG's in our atmosphere, but as the Samoan proverb warns "Seu le Manu ae taga'i i le Galu" or "Proceed with caution."

1. How would a Marine CDR Plan affect you, your organization, or your community?

mCDR methods have their own considerations, benefits, and potential drawbacks. A specific legal framework should be included in any mCDR plan for in-ocean CDR research at the federal and local/jurisdictional/territorial levels.

4. What kinds of information about marine CDR would be most helpful for the Federal Government to make available to the public, research community, and other stakeholders? How should the government engage marine CDR stakeholders and the public, including Indigenous communities and communities that may be affected by marine CDR?

The ocean has played a major role in the every-day lives of the people of American Samoa for thousands of years. Continuing to engage territory leaders and the Pacific Island community is the key to ensuring that our indigenous and underserved community does not bear the consequences of mCDR. Engagement includes hosting virtual webinars and on-site outreach events to ensure that our community is aware and understands potential harms. Including our local experts in the conversation ensures that our voices are heard. Multiple stakeholders, including governmental agencies, research institutions, NGOs, private sectors, and local communities, must be considered when conducting research, testing, regulating, and designing mCDR initiatives.

Support should also be required to assist territories, states, and jurisdictions in establishing legal frameworks or codes of conduct for research for mCDR projects, ensuring that they adhere to best practices and prioritize environmental sustainability and social equity.

A.P. Lutali Executive Office Building · Pago Pago, American Samoa 96799 · Telephone: (684) 633-4121 · www.americansamoa.gov

6. What else would you like the Federal Government to consider as it develops a Marine CDR Plan?

Addressing atmospheric carbon removal is crucial for mitigating the impacts of climate change, but it is imperative to recognize that it is not a standalone solution. While efforts to remove carbon from the atmosphere are essential, they must be complemented by simultaneous actions to reduce carbon emissions at their source. It is essential to avoid a one-size-fits-all approach. Solutions must be tailored to specific ecosystems, cultural/community needs, and capacity to maximize effectiveness and minimize unintended consequences.

Further research and small-scale, contained trials are needed to better understand the efficacy and potential impacts of various mCDR methods.

Sincerely,

Lemanu P. S. Mauga
Governor

From: Schmerfeld, John <john_schmerfeld@fws.gov>
Sent: Thursday, April 25, 2024 2:44 PM
To: Light, Tricia M. EOP/OSTP
Cc: Fink, Wendy R; Leary, Pete; Kroeger, Kevin D; Ward, Sara; Eng, Chris; Sawabini, Anna (Annie)
Subject: USFWS comments to the "Marine Carbon Dioxide Removal Research Plan"

Hey Tricia,
Below, I've included two general comments from the U.S. Fish and Wildlife Service (USFWS) that indicate general support for the mCDR Research plan.

Question 1. How would a Marine CDR Plan affect you, your organization, or your community?

USFWS manages:
- 181 Coastal National Wildlife Refuges
- More than 114 million acres of habitat on coastal refuges
- 5 Marine National Monuments
- More than 760 million acres of marine habitat

Further, USFWS guides and funds management on substantial, additional private and state-owned coastal lands and wetlands.

New DOI and USFWS policies encourage consideration of Nature-based Solutions in ecosystem management decisions.

Additional USFWS policy currently in development is anticipated to enable and guide engagement in carbon offset activities in ways that support the habitat provision mission of the bureau.

mCDR and Ocean Alkalinity Enhancement technologies, deployed safely and responsibly, hold potential to benefit habitats managed by the bureau, and to advance progress toward a number of objectives, including:
- Local mitigation of ocean acidification and associated benefits to shellfish and coral habitats.
- Carbon capture to achieve climate change mitigation goals.
- Enhanced investment in ecosystem conservation and restoration, as co-benefits from carbon capture projects.

Thus, there is tremendous potential for experimentation and potentially for implementation of mCDR within the context of ongoing and accelerating ecosystem management actions on USFWS lands and waters, and in collaboration with partners.

Question 3. Which marine CDR techniques or what aspects of marine CDR do you believe the Federal Government should prioritize for research? Are there particular marine CDR approaches that you believe are especially promising with regard to climate change mitigation, ocean acidification, or other benefits? Are there particular marine CDR approaches that you believe are particularly more or less risky with regard to the environment, public health and communities, or other uses of the sea?

Of particular relevance to USFWS thus far are enhanced mineral weathering approaches to ocean alkalinity enhancement. As an acceleration of a natural process and using widespread, naturally occurring minerals, there may be relatively low risk. But we would like to assess those risks as appropriate. Substantial research is needed to evaluate risk for increased exposure to metals from certain mineral resources, and to identify approaches and minerals that reduce or eliminate metals released to the environment.

Sediment additions to tidal wetland soils are an important approach deployed by the USFWS and others to increase elevation and resilience to sea level rise, thereby conserving habitat. USGS and NPS research is currently testing safety and effectiveness of alkaline mineral addition as a component of such “thin layer placement” or “beneficial use of dredge spoil” projects, to generate carbon capture and mitigation of acidity as co-benefits in these ecosystem conservation or restoration projects.

FWS has expertise on thin layer placement, and could participate in partnerships that are interested in accelerating technology, development, and implementation.
Thank you for your consideration.
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John Schmerfeld
Senior Advisor - Climate Change
U.S. Fish and Wildlife Service/HQ
National Wildlife Refuge System and Science Applications Program
(b) (6) mobile)

One of the most important actions people can take to address global warming is to talk about it.
Dr. Katharine Hayhoe