The NOAA Ocean Acidification Program 2024 National Oceanographic Partnership Program Marine Carbon Dioxide Removal Meeting Summary Report

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Convened by the NOAA Ocean Acidification Program
February 16-17, 2024

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Acronym List

Phrase	Acronym
Arizona State University	ASU
Atlantic Oceanographic and Meteorological Laboratory	AOML
Clean Water Act	CWA
Department of Energy	DOE
Electrochemical Acid Sequestration to Ease Ocean Acidification	EASE-OA
Environmental Protection Agency	EPA
Fiscal Year	FY
Geophysical Fluid Dynamics Laboratory	GFDL
Global Ocean Monitoring and Observing	GOMO
Inflation Reduction Act	IRA

Locking Away Ocean Carbon in the Northeast Shelf and Slope	LOC-NESS
Marine Carbon Dioxide Removal	mCDR
Marine Protection, Research and Sanctuaries Act	MPRSA
Measurement, Monitoring, Reporting, and Verification	MMRV
National Center for Atmospheric Research	NCAR
National Centers for Environmental Information	NCEI
National Marine Fisheries Service	NMFS
National Oceanographic and Atmospheric Organization	NOAA
National Oceanographic Partnership Program	NOPP
National Pollutant Discharge Elimination System	NPDES
National Science Foundation	NSF
Ocean Acidification Program	OAP
Ocean Carbon & Biogeochemistry	OCB
Ocean Carbon and Acidification Data System	OCADS
Ocean Sciences Meeting	OSM
Oregon State University	OSU
Pacific Marine Environmental Laboratory	PMEL
Pacific Northwest National Laboratory	PNNL
Principal Investigator	PI
Rich Metadata Management System	RMMS
Scientific Data Information System	SDIS
Surface Ocean-Lower Atmosphere Study	SOLAS
University of Maryland Center for Environmental Sciences	UMCES
United States Army Corps of Engineers	USACE
University of Washington-Cooperative Institute for Climate, Oceans, & Ecosystem Studies	UW-CICOES
Woods Hole Oceanographic Institution	WHOI

Acknowledgements

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- The Inflation Reduction Act provided more than $14M in funding for ten of the projects as part of the Investing in Coastal Communities and Climate Resilience provision under NOAA's U.S. Integrated Ocean Observing System Office IRA priorities
- An additional $10M in funding was provided by: NOAA's Ocean Acidification Program and Global Ocean Monitoring and Observing Program, and NOAA's appropriations for NOAA NOPP; the Department of Energy's Office of Fossil Energy and Carbon Management and Water Power Technologies Office; the Office of Naval Research; the U.S. National Science Foundation; and the ClimateWorks Foundation

We thank our panelists for their generous contribution of time:

- Social & Ethical Considerations: Sonja Klinsky, Holly Buck, and Sara Nawaz
- Data Management: Brendan Carter, Tyler Kukla, and Liqing Jiang
- Permitting Panel: Betsy Valente, Martin Mayer, Grace Andrews, Jennie Rheuban, and Nicholas Ward
- Measurement, Monitoring, Reporting, and Verification: Jaime Palter

And we thank the supplementary funding that allowed for their travel to the conference: Inflation Reduction Act funding

We also thank the Hampton Inn & Suites New Orleans - Convention Center for hosting this event and providing audio/visual support.

We also thank ClimateWorks for their hospitality during the event.

Executive Summary

Marine carbon dioxide removal (mCDR) project research groups funded under the fiscal years (FYs) 2022 and 2023 NOAA Ocean Acidification Program (OAP)-managed National Oceanographic Partnership Program (NOPP) funding call gathered from February 16-17, 2024, in New Orleans, LA, USA, to discuss project progress and next steps towards successful completion of their project goals. The first day of the Workshop was closed to only Principal Investigators (PIs) and invited members of their research teams, and included updates from each group on their project progress. All groups reported making meaningful strides towards accomplishing their scientific goals, despite many shared challenges related to administrative burdens and hiring of new personnel.

Day 2 of the Workshop was open to the public, and consisted of four panels: Social and Ethical Considerations; Data Management; Permitting; and Measurement, Monitoring, Reporting, and Verification (MMRV). Panel topics were selected based on a survey of PIs, and focused on key challenge areas that PIs desired more guidance on for the success of their projects. Guided by expert presentations and lively discussion, PIs expressed (1) a need for increased guidance on social and ethical concerns of mCDR research and how to engage the communities that they work in, (2) that a novel data management system tailored to mCDR work is needed, (3) that the permitting landscape for mCDR work should be clarified with Federal guidance, and (4) that MMRV technologies need further advancement to accurately monitor and verify carbon durably drawdown by mCDR activities.

Event Overview:

The NOAA Ocean Acidification Program (OAP) on behalf of the National Oceanographic Partnership Program (NOPP) hosted a meeting for the principal investigators (PIs) of projects funded through a FY23 marine carbon dioxide removal (mCDR) Multi-agency Funding Opportunity. Funding totaling $24.3M supports research that “expands understanding of various aspects of marine carbon dioxide removal approaches, risks, and co-benefits including ocean acidification mitigation, and science needed to build regulatory frameworks for testing and scaling of marine carbon dioxide removal.” In addition to projects funded through the FY23 NOPP call, the PI group of an mCDR project funded through NOPP in FY22 also participated in the meeting.

The event took place from February 16-17, 2024, in New Orleans, LA, USA in advance of the AGU 2024 Ocean Sciences Meeting. The first day of the meeting focused on PI presentations on the state of their science. The sessions on this day were closed to PIs, co-PIs, and invited guests. In total 88 people attended the meeting in person, and 40 people attended online. The second day was open to the public, and focused on four panels: Social and Ethical Considerations; Data Management; Permitting; and Measurement, Monitoring, Reporting and Verification (MMRV). In addition to the in-person presence of Day 1, approximately 80 people registered to attend the open session online, with a total of approximately 168 participants and audience members on Day 2. The approximate breakdown of time spent on PI presentations, group discussion, and panels throughout the two days is presented in Figure 1. See Appendix 1 for the full participant agenda for both days.

The four panels on Day 2 added a unique element to this workshop. Panel topics reflected feedback from PIs, and therefore addressed specific concerns and areas of interest relevant to the PI group. Panel presentations and subsequent small- and large-group discussions centered on a few key themes. PIs expressed (1) a need for increased guidance on social and ethical concerns of mCDR research and how to engage the communities that they work in, (2) that a novel data management system tailored to mCDR work is needed, (3) that the permitting landscape for mCDR work should be clarified with Federal guidance, and (4) that MMRV technologies need further advancement to produce highly accurate and reliable results for mCDR pathways. Later sections in this report provide details on panel presentations and resulting discussions.

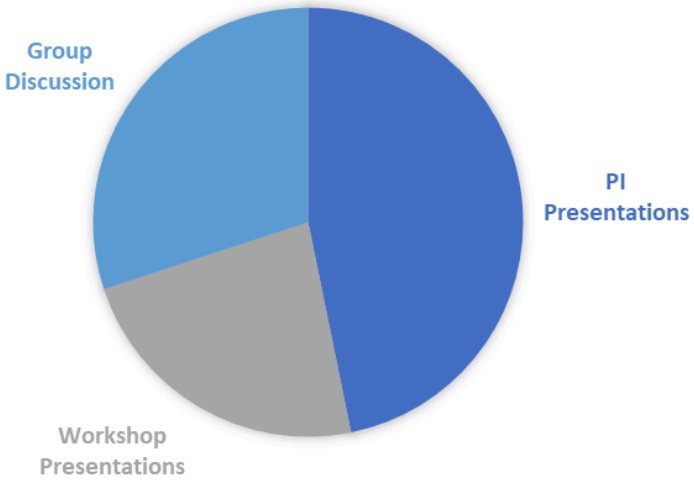

Figure 1: Approximate breakdown of workshop time spent on PI presentations on NOPP-funded projects, workshop presentations (Social and Ethical Considerations, Data Management, Permitting, and MMRV), and group discussions.

Day 1: PI Science Reports

Agenda

A PI or co-PI representative for each of the NOPP projects presented for 15 minutes, allowing ten minutes for an update on science and five minutes for questions and group discussion. Science updates focused on research project descriptions, proposed timelines, and existing and anticipated challenges. In addition to newly funded projects (FY23), the PI of the FY22 NOPP project, EASE-OA, updated the group on their progress one year into their funding period for 30 minutes. See "Project Details" for information on projects and groups involved.

Major Takeaways

Projects are all progressing well, with each group reporting distinct achieved milestones. However, there are specific current and anticipated challenges that are shared among many groups discussed in the "Next Steps" section.

Next Steps

Outside of project-specific science questions, many projects overlapped with current and anticipated challenges including permitting, administrative delays, and hiring delays, both due to finding the right candidate and bureaucratic slowdowns. A discussion topic, particularly for *in situ* projects, was the concept of additionality and discerning between natural system background variability and experiment-driven changes. For modeling-based projects, an area of focus was how groups decide on optimal model calibration and resolution. In addition to meeting the milestones laid out in their proposals, next steps for PIs will focus on working through these stated and anticipated challenges.

Project Details

The FY23 and FY22 NOPP projects are detailed below. Projects are listed in the order that they were presented during the PI Science Reports (further details below).
Table 1: Details for all NOPP projects are presented, with more information hyperlinked.

Project Title	Lead PI	Co-PIs	Funding Source
Developing a coupled benthic-pelagic biogeochemical model to evaluate the effectiveness of mCDR interventions	Cristina Schultz, Northeastern University	Jessica Luo, NOAA Geophysical Fluid Dynamics Laboratory (GFDL) Damien Brady, University of Maine, Walpole	NOAA Inflation Reduction Act (IRA)

		Enrique Curchister, Rutgers University Samantha Siedlecki, University of Connecticut Charles Stock, NOAA GFDL Jeremy Testa, University of Maryland Center for Environmental Sciences (UMCES)	
Carbon capture and ocean acidification mitigation potential by seaweed farms in tropical and subtropical coastal environments	Andreas Andersson, Scripps Institution of Oceanography	Satoshi Mitarai, Okinawa Institute of Science and Technology Loretta Roberson, University of Chicago Marine Biological Laboratory Reggie Spaulding, Sunburst Sensors Adrienne Sutton, NOAA Pacific Marine Environmental Laboratory (PMEL)	NOPP, NOAA Ocean Acidification Program (OAP)
Multiscale observing system simulation experiments for iron fertilization in the Southern Ocean, Equatorial Pacific, and Northeast Pacific	Dennis McGillicuddy, Woods Hole Oceanographic Institution (WHOI)	Ken Buesseler, WHOI John Dunne, NOAA GFDL Kristen Krumhardt, National Center For Atmospheric Research (NCAR) Matthew Long, NCAR Charles Stock, NOAA GFDL Weifeng (Gordon) Zhang, WHOI	NOAA Global Ocean Monitoring and Observing (GOMO), NOAA OAP, National Science Foundation (NSF)
Data requirements for quantifying natural variability and the background ocean carbon sink in mCDR models	Galen McKinley, Columbia University	Thea Hatlen Heimdal, Columbia University Adrienne Sutton, NOAA PMEL	NOAA OAP, NSF
Biotic calcification impacts on marine carbon dioxide removal additionality	Kelly Kearney, University of Washington Cooperative Institute for Climate, Ocean, &	Brendan Carter, NOAA PMEL Kristen Krumhardt, NCAR Darren Pilcher, UW-CICOES[2]	NOAA IRA

[2] As of July 2024, Darren Pilcher is no longer with UW-CICOES. He remains a co-PI on the project, now representing NOAA Northwest Fisheries Science Center.

	Ecosystem Studies (UW-CICOES)[1]		
Tidal wetlands as a low pH environment for accelerated and scalable olivine dissolution	Kevin Kroeger, United States Geological Survey (USGS)	Grace Andrews, Vesta Corporation[3] Sophia Fox, National Park Service (NPS) Shannon Meseck, NOAA National Marine Fisheries Service (NMFS) Timothy Smith, NPS Robert Sohn, WHOI Nathaniel Walworth, Vesta Corporation Aleck Wang, WHOI	NOAA IRA
Engaging U.S. commercial fishing community to develop recommendation for fishery-sensitive mCDR governance, collaborative research and monitoring, and outreach to fishing communities	Fiona Hogan, Responsible Offshore Development Alliance	Roger Griffis, NOAA Office of Science and Technology Sarah Schumann, Shining Sea Fisheries Consulting, LLC	Office of Naval Research, ClimateWorks Foundation
Coupling desalination with novel mCDR membranes	Katherine Hornbostel, University of Pittsburgh[4]	Matthew Green, Arizona State University Mou Paul, National Renewable Energy Laboratory Jennifer Yang, University of California, Irvine	Office of Naval Research
Electrolysis-driven weathering of basic minerals for long-term ocean buffering and CO2 reduction	Burke Hales, Oregon State University (OSU)	Yvette Spitz, OSU Kelsey Stoerzinger, OSU George Waldbusser, OSU Simone Alin, NOAA PMEL Richard Feely, NOAA PMEL	DOE Office of Fossil Energy and Carbon Management (FECM), DOE Water Power

[1] As of January 2024, Kelly Kearney is no longer with UW-CICOES. She remains the project PI, now representing NOAA Alaska Fisheries Science Center. Evan Howard has joined the project as the co-PI representing UW-CICOES.
[3] Grace Andrews is no longer with Vesta Corporation, as of February 2024. She remains a co-PI on the project, now representing Hourglass Climate.
[4] As of fall 2024, Katherine Hornbostel is no longer with the University of Pittsburgh. She remains the project PI, now representing Duquesne University.

			Technologies Office (WPTO)
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	Andrew Dickson, Scripps Institution of Oceanography	Robert Richardson, Pacific Rim Design & Development Nina Bednaršek, OSU Cooperative Institute for Marine Resources Studies Richard Feely, NOAA PMEL	NOAA IRA
Determining the Influence of Ocean Alkalinity Enhancement on Foraminifera Calcification, Distribution, and CaCO3 Production	Laura Haynes, Vassar College	Jennifer Fehrenbacher, OSU Emily Osborne, NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML)	NOAA IRA
Assessing the laboratory and field responses of diatoms and coccolithophores to ocean alkalinity enhancement	Adam Subhas, WHOI	Kay Bidle, Rutgers University Kimberlee Thamatrakoln, Rutgers University	NOAA IRA
Assessing carbon dioxide removal and ecosystem response for an ocean alkalinity enhancement field trial	David Nicholson, WHOI	Adam Subhas, WHOI Yui Takeshita, Monterey Bay Aquarium Research Institute (MBARI) Robert Todd, WHOI Katherine Zaba, MRV Systems, LLC	NOAA IRA
An opportunity to study ocean alkalinity enhancement, CDR, and ecosystem impacts through coastal liming	Jaime Palter, University of Rhode Island (URI)	Jason Grear, Environmental Protection Agency (EPA) David Ho, University of Hawai'i, Manoa (UH Manoa) Robert Pockalny, URI Rebecca Robinson, URI Samantha Siedlecki, University of Connecticut Hongjie Wang, URI	NOAA IRA

Quantifying the efficacy of wastewater alkalinity enhancement on mCDR and acidification mitigation in a large estuary	Jeremy Testa, UMCES	Wei-Jun Cai, University of Delaware Ming Li, UMCES Will Burt, Planetary Technologies, Inc.[5]	NOAA IRA
Assessing efficacy of electrochemical ocean alkalinity enhancement at an existing outfall using tracer release experiments and oceanographic models	David Ho, UH Manoa[6]	Danielle Bianchi, University of California Los Angeles (UCLA) Matthew Eisaman, Ebb Carbon, Inc. Alicia Karspeck, Convergent Research, LLC Matthew Long, Convergent Research, LLC James McWilliams, UCLA Sara Nawaz, American University Mallory Ringham, Ebb Carbon, Inc.	NOAA IRA, ClimateWorks Foundation
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	Melissa Meléndez, UH Manoa	Keisha Bahr, Texas A&M, Corpus Christi Hannah Barkley, NOAA Pacific Islands Fisheries Science Center Nick Hawco, UH Manoa Conall McNicholl, UH Manoa Lisa McManus, UH Manoa Christopher Sabine, UH Manoa	DOE FECM
Electrochemical acid sequestration to ease ocean acidification (EASE-OA)	Brendan Carter, NOAA PMEL	Tarang Khangaonkar, DOE PNNL Lakshitha Premathilake, DOE PNNL Matthew Eisaman, Ebb Carbon Richard Feely, NOAA PMEL Nicholas Ward, DOE PNNL Chinmayee Subban, DOE PNNL Lenaig Hemery, DOE PNNL	NOAA OAP, DOE WPTO, ClimateWorks Foundation

[5] Yuanyuan Xu, the original co-PI from Planetary Technologies, Inc., is no longer affiliated with the project. Will Burt is now the lead collaborator representing Planetary Technologies, Inc.

[6] As of December 31, 2023, this award has been terminated by consent. It was re-awarded, with the same scope, budget, and PI group, to lead PI Matthew Long, Convergent Research, LLC.

Day 2: Panels

Social & Ethical Considerations Panel

What Happened

The following panel held and facilitated a workshop on social and ethical considerations of mCDR: Sonja Klinsky (presenter and moderator; Arizona State University), Holly Buck (in-person moderator; University at Buffalo), and Sara Nawaz (online moderator; American University). A recording of the panel is available here. This panel centered around the complex context that mCDR research might happen in and politicized dynamics around the research, personal values that PI's might wish to to carry through their research, and ways to ethically interact with stakeholders throughout the entire research process. These topics of conversation were introduced through presentations, and then participants were given time for discussion. Discussions ranged from small tables (~4 - 8 people, or small virtual breakout rooms) to the entire in-person and online meeting group. Participants were pointed to the Aspen Institute "Code of Conduct for Marine Carbon Dioxide Removal Research (2023)", the Ocean Visions Principles, and the American Geophysical Union Ethical Framework Principles for Climate Intervention as resources for best practices in social and ethical considerations for climate solution research. In addition, participants were provided with a social and ethical guidance workbook from Sonja Klinsky.

Panel and Discussion Takeaways

- End goal: *Carry out research with explicitly defined values that the researchers hold for themselves, which are revisited iteratively throughout the life cycle of a research project.*
    - This helps orient researchers when facing novel decisions, strengthens their ability to align work with their values and deepen their own thinking about them, allows for collaborators and stakeholders to hold them accountable
- End goal: *Carry out research with a firm understanding of what a researcher's community is, how their research is connected to their community, and what their obligations to their community are*
    - Researchers must go into communities knowing that they're part of a much bigger context than themselves, and there are unique histories within each community with regards to scientific research; we may see ourselves as trying to do good but actually causing harm in the communities that we try to enter

    - Many people don't consider climate action as the most important need. Many under-resourced communities view climate action as secondary to meeting their basic needs and researchers have a responsibility to learn the interpersonal skills necessary to navigate this
- End goal: *Recognize and respond to the fact that marine carbon dioxide removal research is happening in a delicate context*
    - The research field is changing extremely rapidly, and within the context of immense regional and global inequalities
    - It is inherently political and economical, and researchers must navigate globally diverse worldviews
    - Researchers must recognize and carefully navigate the perception that research into a particular technology can be perceived as an endorsement of that technology

Data Management Panel

What Happened

The following panel held and facilitated a workshop on data management in mCDR research: Brendan Carter (NOAA PMEL; University of Washington), Tyler Kukla (CarbonPlan), and Liqing Jiang (NOAA NCEI; University of Maryland). A recording of the panel is available here. Brendan Carter's presentation focused on his experience with data management for the EASE-OA project, and his perspective as a PI submitting mCDR-related data to databases. Tyler Kukla shared CarbonPlan's data management approach for carbon dioxide removal data and how PIs could interact with this. Liqing Jiang presented on the NOAA NCEI data management approach for carbon data and how PIs could interact with it. The group then asked questions of the panel and discussed perspectives on and wishes for an idealized data management system for marine carbon dioxide removal research.

Presentation Key Points

- Liqing Jiang; NOAA National Centers for Environmental Information (NCEI) data management primer
    - Ocean Carbon and Acidification Data System (OCADS)
        - See Jiang et al. (2023a) for a best practice document on mCDR data management
        - OCADS is an international data repository with the current scope being ocean carbon and acidification data, along with accompanying data, but plans to cover both ocean acidification and mCDR data; infrastructure is capable of managing all types of oceanographic data

        - Works as a Rich Metadata Management System (RMMS), where data providers submit data through a Scientific Data Information System (SDIS), and data users retrieve is through the OCADS Portal
        - OCADS adopts a customer-centric approach, prioritizing the alignment of all its facets with the needs and preferences of the research community.
        - All data published at OCADS are backed with a long-term archive. Each historical version of the data is preserved on a perpetual basis.
        - OCADS offers stable data citations with DOIs.
        - For more information about OCADS, refer to Jiang et al. (2023b)
- Brendan Carter; Questions about data management from Electrochemical Acid Sequestration to Ease Ocean Acidification (EASE-OA)
    - Brendan Carter shared a scientist's perspective on data management challenges and areas of opportunity for further guidance, based on his experience as the lead PI for the EASE-OA program
    - Main questions for data management: (1) "Herding data," how do we get the data in one place? (2) "Hoarding data," when do we share data? (3) "Housing data," how do we share data?
        - Herding data: throughout a project, data comes in from a number of sources and goes through a number of iterations of quality control; this usually relies on many people, computers, and versions which can become complicated and time consuming
        - Hoarding data: what is the difference between radical transparency and rational transparency? When is our data ready to share, what is the ideal iteration of the data or data product to make public,, and do we have an obligation to the community to share data about what *doesn't* work?
        - Housing data: where do we put data, and how much data do we share? Do we share model output in its entirety or simply the model code and key model outputs?
    - See "Panel Discussion Takeaways" section below for discussion about these points
- Tyler Kukla; presentation about CarbonPlan
    - A nonprofit that conducts data-based analysis of climate solutions
    - Spoke about a vision for solving the "radical versus rational transparency" question Brendan Carter brought up
        - We need guardrails for navigating financial interests and building knowledge in industries that might fail. Improved transparency should be one of these guardrails.
        - These dynamics point to the need for a modified preprint server where data and information can be shared that would otherwise usually be shared only in peer-reviewed publications, or not at all; this will expedite the data

sharing process and allow for increased transparency across academic and industry actors.

Panel and Discussion Takeaways

- End goal: *Establish boundaries of rational transparency versus radical transparency*
    - It is unclear how researchers should talk about and present what *doesn't* work; conventionally, science only focuses on presenting data that "works," but there is validity in this field to sharing what does not work as a public good
    - It is an added challenge to navigate the unusual interest in marine carbon dioxide removal, and eagerness on the part of some stakeholders to prove a certain viewpoint
    - There is no strong consensus on how much quality control for data is necessary and responsible (i.e., a balance between making reliable data available in a reasonable timeframe)
    - The quantity of data that many programs produce is vast (e.g., modeling projects); there is uncertainty about what exactly of this data needs to be shared, and how it should be stored
    - There is a difference between public and proprietary data sharing, and many projects now have a proprietary component, only to increase in the future with increasing commercialization of mCDR
    - There is no strong consensus on how uncertainty and error is assessed
- End goal: *Establish a protocol for flagging data from perturbed systems*
    - There is a worry that data from environments with mCDR will be used by scientists who think they are looking at an unperturbed system, and incorrect scientific conclusions will therefore be drawn
    - There is uncertainty about how or if mCDR research will be welcome in areas where there are long-standing time series and strong programs observing background oceanographic systems data, and it is unclear what recourse measurement programs have to prevent abuse of ongoing time series
- End goal: *Effectively use data sharing systems*
    - Scientists often wait until the last minute to upload data
    - There is not consensus on standard metrics to measure and share, and there are often not consistent quality assessments and flagging conventions
    - Grants don't allow you to put aside funding preemptively for data storage

Permitting Panel

What Happened

This panel focused on the permitting process for marine carbon dioxide removal projects, with presentations by Betsy Valente (U.S. Environmental Protection Agency) and Martin Mayer (U.S. Army Corps of Engineers). Both presenters focused on the permitting programs under statutes administered by their respective agencies that are applicable to mCDR activities. After the presentation from the regulatory agency representatives, Grace Andrews (Hourglass Climate, formerly Vesta Corp), Jennie Rheuban (Woods Hole Oceanographic Institution; LOC-NESS Project), and Nicholas Ward (DOE Pacific Northwest National Laboratory; EASE-OA Project) spoke about their projects' permitting processes. Sharing these experiences helped spur and facilitate group discussion. A recording of the Permitting Panel can be found here.

Presentation Key Points

- Betsy Valente; Permitting of marine carbon dioxide removal activities through statutes administered by the U.S. Environmental Protection Agency
    - In the United States, the Marine Protection, Research and Sanctuaries Act (MPRSA) implements the requirements of the London Convention.
        - For more information on the work of the London Convention and London Protocol related to ocean-based climate change mitigation, visit here.
    - Depending on specifics of the proposed mCDR activity, a permit may be required under the MPRSA or Clean Water Act (CWA)—National Pollutant Discharge Elimination System (NPDES).
    - MPRSA research permits are the most relevant permit category for mCDR research activities subject to the MPRSA. MPRSA general or special permits may be appropriate in some situations.
        - MPRSA research permit: For the disposition of materials into ocean waters as part of a research project when the EPA determines that "the scientific merit of the proposed project outweighs the potential environmental or other damages that may result…"
    - More information about permitting of mCDR activities under the MPRSA and NPDES is available here.
    - The EPA is available to assist potential permit applicants in determining the applicable permitting regime for their proposed activities: *email EPAmarineCDR@epa.gov*
- Martin Mayer; U.S. Army Corps of Engineers marine carbon dioxide removal permitting and considerations
    - USACE is a decentralized organization; 8 divisions, and 38 districts
        - District engineers are the "decision-makers," effecting the national goal to render balanced, transparent, well-reasoned, and timely permit decisions
        - Applicable authorities: Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act
    - Permits fall into two categories
        - General Permits: Abbreviated review process for activities determined to have minimal individual/cumulative impacts
        - Individual Permits: Individual authorization for activities exceeding the "minimal effects" threshold

Panel and Discussion Takeaways

- End goal: *Proactive communication with permitting bodies in order to facilitate a timely and responsible permitting decision*
    - Talk with permitting agency early and often (e.g., pre-application meetings)
    - Permitting bodies would rather a prospective permit applicant meet with them before they submit their permit application, to allow for a more well-informed and smooth permitting process
- End goal: *Valuing worker safety post-permitting through every step of the research process*
    - Obtaining a permit is only the first step. Permitting bodies need to see plans for holding worker safety as critical throughout the research process
    - Contingency plans are key, and receiving a permit does not automatically greenlight all activities within your research plan; researchers must continue to respect safety and the environment throughout the different iterations of the research process
- End goal: *Permitting bodies should be educated about mCDR – both the potential risks and benefits*
    - Researchers should be prepared to explain their research methods and benefits of their work to regulatory authorities
    - This is a challenge that permit applicants need to be ready to address and communicate in their permit application
    - Permitting Agencies have a responsibility to ensure that there are permit reviewers who are familiar with mCDR work

Measurement, Reporting, and Verification Presentation

What Happened

In this presentation, Jaime Palter (University of Rhode Island) presented a review of the Ocean Carbon & Biogeochemistry (OCB) "Essential Science and Problem Solving for Measurement, Reporting, and Verification Workshop." A video of the recording can be found here. This workshop, which occurred in Sept. 2022, aimed to inform and engage the mCDR community, highlight major open questions regarding measurement, monitoring, reporting, and verification (MMRV), and build networks to answer these questions. At the workshop, participants clearly agreed that MMRV requires the evaluation of additionality and durability. Additionality is the question of how much extra carbon the ocean took up relative to a counterfactual in which the intervention never happened. Durability is the question of how long extra carbon dioxide is kept out of the atmosphere after removal. In order to continue the network building and active engagement of the scientific community with partners in government, community organizations, and private industry, OCB is launching Regional Nodes (Northeast, Southeast, Gulf Coast, West

Coast, and Northwest). These mCDR nodes are intentionally place-based, to help consider how field trials influence particular locales and communities.

The first in-person regional node meeting of the Gulf Coast group happened at the New Orleans Aquarium during the Ocean Sciences Meeting (OSM). OCB has identified co-leads for each of the nodes (listed here), with activities spinning up in 2024. Based on this regional node model, the SOLAS Climate Intervention Team is now building a global network to develop standards for mCDR work. A North American node will be represented in the SOLAS teams, with representation from the OCB network.

Final Meeting Takeaways

This meeting gathered together a wide array of the marine carbon dioxide removal community. Day 1 provided a forum for researchers funded by the FY22 and FY23 NOPP mCDR calls to present research progress. Sharing progress as a group, and the networking and collaboration that these discussions fostered, were extremely valuable for participants. This is reflected in the Figure 2 responses to the question "What was the best part of this workshop" (n = 61). Day 2 fostered in-depth learning and discussions about big questions in mCDR research. Robust crowd participation, and a large online presence, affirmed the importance of the four panels.

Overall, this workshop was highly successful and garnered positive feedback from participants. The workshop highlighted the need for communication across emerging scientists in the field in terms of execution of experimental design, data reporting and management, as well as communication strategies. As a result of the clear demonstration in the value of community collaboration, the PI's will continue to leverage one another to become a research cohort. A subsequent PI meeting will occur in 2026.

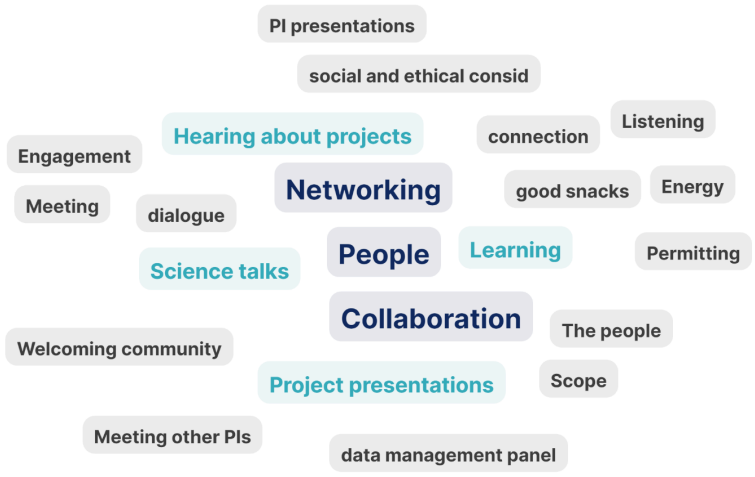

Figure 2: Slido responses to the question "What was the best part of the workshop?" from 61 responses.

Appendix 1: NOPP mCDR PI Meeting Final Agenda

Day 1: Friday, February 16 (Closed to PIs, Co-PIs, and Invited Guests)

- 9-9:15 - Opening and welcome
- 9:15-10:45 - Session 1: 6 presentations
- 10:45-11:00 - Coffee Break
- 11:00-12:15 - Session 2: 5 presentations
- 12:15-1:45 - Lunch
- 1:45-3:15 - Session 3: 6 presentations
- 3:15-3:30 - Coffee Break
- 3:30-4:00 - Session 4: 1 presentation (EASE OA)
- 4:00-4:45 - Wrap up discussion
- 4:45-5:00 - Closing

Day 2: Saturday, February 17 (Recorded open day for viewers)

- 9-9:30 - Opening and welcome
    - Agenda for the day and OSM overview of mCDR events
- 9:30-11:00 - Social and Ethical Considerations Workshop
    - Workshop, facilitated by Sonja Klinsky with assistance from Sara Nawaz and Holly Buck
    - PI Breakout Rooms (Closed to external viewers)
- 11:00-11:15 - Coffee Break
- 11:15-12:15 - Data Management Panel with opening presentations
    - Panelist include Brendan Carter (Cooperative Institute for Climate, Ocean and Ecosystem Studies, University of Washington, NOAA PMEL), Tyler Kukla (CarbonPlan), Liqing Jiang (Cooperative Institute for Satellite Earth System Studies, University of Maryland, NOAA NCEI)
- 12:15-1:45 - Lunch
- 1:45-3:00 Permitting Panels
    - 1:45-2:15 - 10 min presentations from regulators
        - Speakers include Sena McCrory (EPA), Martin Mayer (USACE)
        - Moderated Q&A
    - 2:15-3:00 - Panel discussions with PIs that have applied for or received permits

        - Panel members include Grace Andrews (Vesta), Jennie Rheuban (WHOI), Nicholas Ward (PNNL)
- 3:00-3:30 - Coffee Break
- 3:30-3:45 - MMRV Overview
    - Overview of MMRV (follow up to OCB workshop), Jaime Palter
- 3:45-4:30 - Working time for PIs (closed to external viewers)
    - Discussion for PIs
- 4:30-5:00 - Closing