

Marine Carbon Dioxide Removal

NOAA Research efforts

Gabby Kitch, PhD

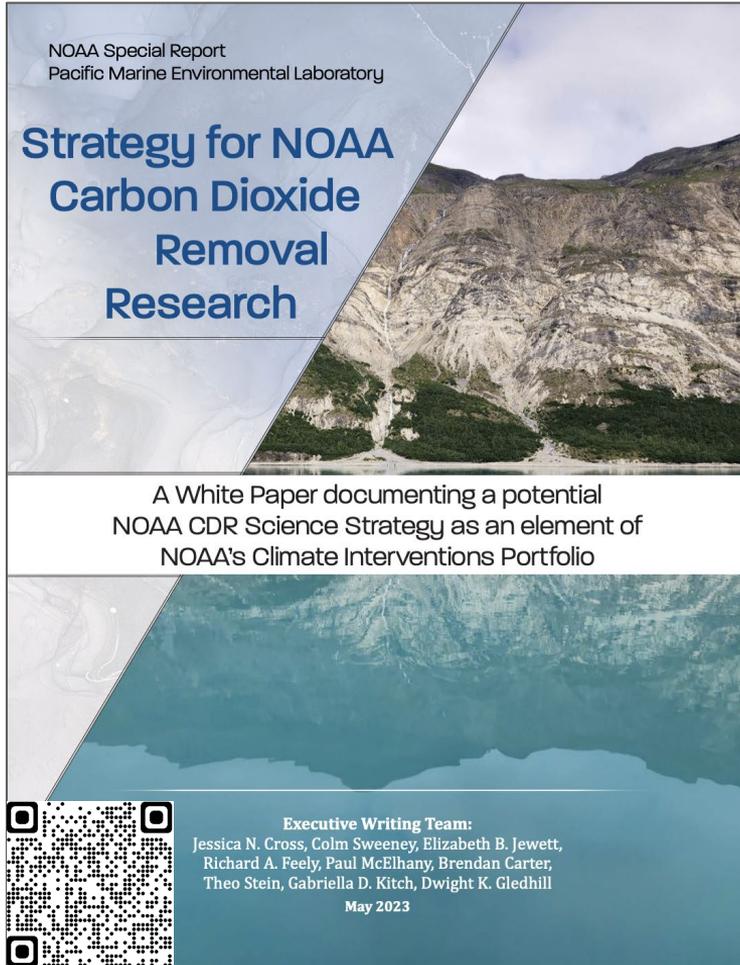
Marine Carbon Dioxide Removal Lead
NOAA Ocean Acidification Program



NOAA OCEAN ACIDIFICATION PROGRAM



What is NOAA's Role?



Key NOAA assets

Observing Networks

Global and local ocean and atmospheric observing; tech development

Modeling, Scaling, and Projection of CDR Pathways

Earth system and process study models can assess impacts of and potential for scale

Evaluating Environmental Impacts

Ecosystem system monitoring and modeling, laboratory research

Decision Support

Data management, marine spatial planning, aquaculture research, collaborative and conservation research

More detailed Table 2 in strategy (scan QR code)

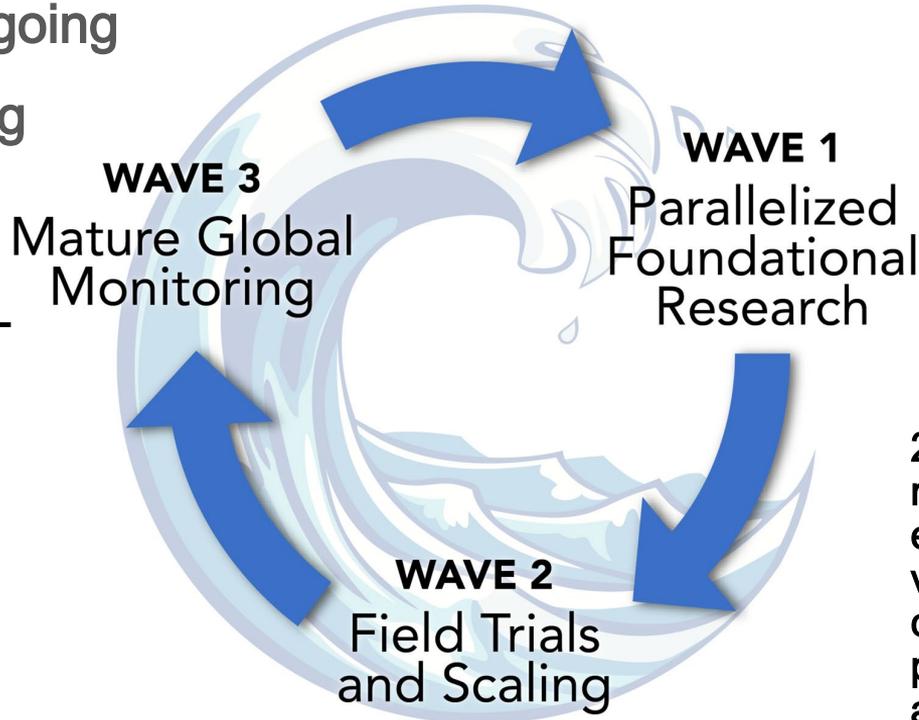
Looking forward: CDR Task Force Vision

3 Waves of NOAA Research:

Underline = ongoing

Italics = budding

GT Scale: Clear expansion of public - private partnerships that enable the monitoring of the mCDR industry, expansion of global observing and modeling to contribute to verification and validation



Active NOW: Conduct laboratory bench studies , design and grow local to regional ocean carbon observations, develop modeling packages, support development of permitting infrastructure , *early stakeholder engagement*

2-5 years: Synthesize research results, process studies on ecosystem impacts, provide verification to large -scale controlled demonstration projects, assess risks of approaches, compare and contrast cost -benefit analysis studies

Relevant policy and permitting landscape



U.S. EPA

- Permitting under Marine Protection, Research, and Sanctuaries Act (MPRSA) and Clean Water Act 402 (NPDES)
- mCDR permitting available on EPA's website
- Reach out to EPAMarineCDR@epa.gov with questions

USACE

- Permitting under Clean Water Act 404 and Rivers and Harbors Act
- Just permitted the first large scale pilot in the US

NOAA authorities related to conservation / management of marine resources

Living Marine Resource Management

- Endangered Species Act (ESA)
- Marine Mammal Protection Act (MMPA)
- Magnuson - Stevens Act (MSA)

Coastal and Ocean Management

- Coastal Zone Management Act (CZMA)
- National Marine Sanctuaries Act (NMSA)

NOAA contributes to the implementation of many of these rules as a consultant on resource management decisions.

- Productive and sustainable fisheries
- Safe sources of seafood
- Recovery and conservation of protected resources
- Healthy ecosystems

NOAA's mCDR research portfolio

Leveraging National Oceanographic Partnership Program (NOPP)

FY2023 portfolio: 17 mCDR projects (\$24.3M)

- Includes \$14M in Inflation Reduction Act Funding
- 47 Institutions and 79 Principal Investigators

FY2022 portfolio: EASE OA (\$1.05M)

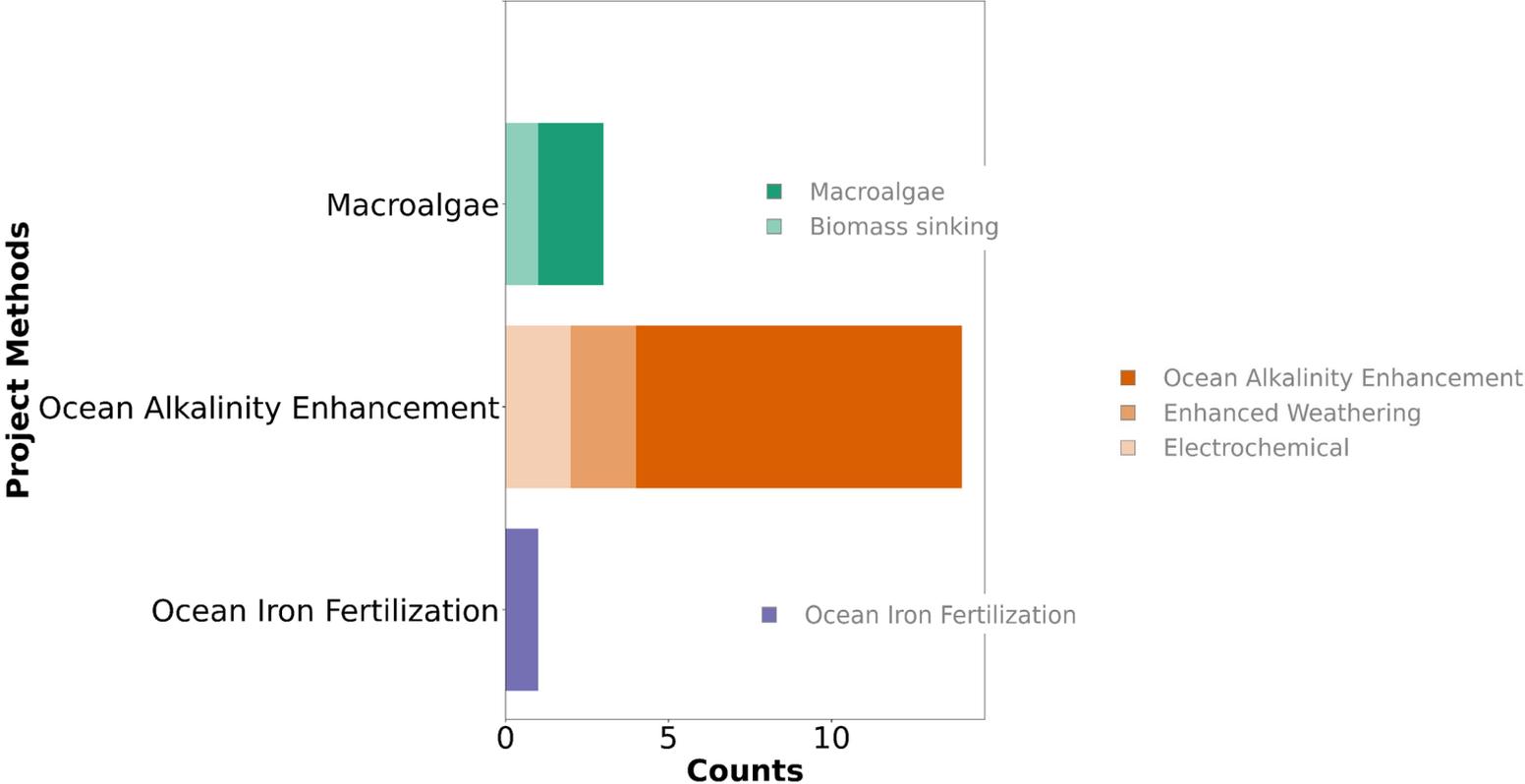
- Electrochemical Acid Sequestration to Ease Ocean Acidification
- Partnership between PNNL, University of Washington, PMEL, and Ebb Carbon



<https://oceanacidification.noaa.gov/project-search>

<https://oceanacidification.noaa.gov/fy23-nopp-mcdr-awards/>

NOPP portfolio mCDR method types



OAE: Biology Focused

<p>PI</p>	<p>Laura Haynes</p> 	<p>Adam Subhas</p> 	<p>Kelley Kearney</p> 	<p>Melissa Melendez</p> 
<p>Project Title</p>	<p>Determining the Influence of Ocean Alkalinity Enhancement on Foraminifera Calcification, Distribution, and CaCO₃ Production</p>	<p>Assessing the laboratory and field responses of diatoms and coccolithophores to ocean alkalinity enhancement</p>	<p>Biotic calcification impacts on marine carbon dioxide removal additionality</p>	<p>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</p>
<p>Institution</p>		 <p>WOODS HOLE OCEANOGRAPHIC INSTITUTION <i>Our Ocean. Our Planet. Our Future.®</i></p>	 <p>Cooperative Institute for CLIMATE, OCEAN & ECOSYSTEM STUDIES</p>	

OAE: Field Focused

<p>PI</p>	<p>Jaime Palter</p> 	<p>Jeremy Testa</p> 	<p>Kevin Kroeger</p> 	<p>David Ho</p> 	<p>David Nicholson</p> 
<p>Project Title</p>	<p>An opportunity to study Ocean Alkalinity Enhancement, CDR, and ecosystem impacts through coastal liming</p>	<p>Quantifying the Efficacy of Wastewater Alkalinity Enhancement on mCDR and Acidification Mitigation in a Large Estuary</p>	<p>Tidal wetlands as a low pH environment for accelerated and scalable olivine dissolution</p>	<p>Assessing efficacy of electrochemical ocean alkalinity enhancement at an existing outfall using tracer release experiments and oceanographic models</p>	<p>Assessing Carbon Dioxide Removal and Ecosystem Response for an Ocean Alkalinity Enhancement Field Trial</p>
<p>Institution</p>					<p>WOODS HOLE OCEANOGRAPHIC INSTITUTE <i>Our Ocean. Our Planet. Our Future.®</i></p>

OAE: Lab and model focused

<p>PI</p>	<p>Andrew Dickson</p> 	<p>Katherine Hornbostel</p> 	<p>Burke Hales</p> 	<p>Brendan Carter (FY22)</p> 
<p>Project Title</p>	<p>Assessing chemical and biological implications of OAE using carbonate salts obtained from captured CO₂ to mitigate negative effects of OA and enable mCDR</p>	<p>Coupling Desalination with Novel mCDR Membranes</p>	<p>Electrolysis-driven weathering of basic minerals for long-term ocean buffering and CO₂ reduction</p>	<p>Electrochemical Acid Sequestration to Ease Ocean Acidification (EASE-OA)</p>
<p>Institution</p>	 <p>SCRIPPS INSTITUTION OF OCEANOGRAPHY UC San Diego</p>		 <p>Oregon State University</p>	 <p>Cooperative Institute for CLIMATE, OCEAN & ECOSYSTEM STUDIES</p>

Biotic methods

<p>PI</p>	<p>Cristina Schultz & Jessica Lou</p>  	<p>Dennis McGillicuddy</p> 	<p>Andreas Andersson</p> 
<p>Project Title</p>	<p>Developing a coupled benthic-pelagic biogeochemical model to evaluate the effectiveness of mCDR interventions</p>	<p>Multiscale observing system simulation experiments for iron fertilization in the Southern Ocean, Equatorial Pacific, and Northeast Pacific</p>	<p>Carbon capture and ocean acidification mitigation potential by seaweed farms in tropical and subtropical coastal environments</p>
<p>Institution</p>	 	 <p>WOODS HOLE OCEANOGRAPHIC INSTITUTION <small>Our Ocean. Our Planet. Our Future.®</small></p>	 <p>SCRIPPS INSTITUTION OF OCEANOGRAPHY <u>UC San Diego</u></p>

Method agnostic

PI	Galen McKinley 	Fiona Hogan 
Project Title	Data requirements for quantifying natural variability and the background ocean carbon sink in mCDR models	Engaging U.S. Commercial Fishing Community to Develop Recommendations for Fishery-Sensitive mCDR Governance, Collaborative Research and Monitoring, and Outreach to Fishing Communities
Institution		

Visit <https://ocean.acidification.noaa.gov/project-search> for more details

FY24-26 OAP investment in OAE ecosystem impact research



Marine CDR impacts: The effect of elevated pH and alkalinity on the survival, growth and physiology of Dungeness crab and Pacific oyster

- Oyster exposures
- Dungeness crab zoea exposures
- Synthesis product: produce report for regulators



NOAA-DOE MOA

- **5 year agreement** between all of NOAA and DOE's Office of Science, FECM and WPTO
- **Purpose:** to enhance coordination, research, and technology development to advance mCDR
- **Planned activities:** provide technical support for products (e.g. FOAs), accelerate the development of R&D infrastructure, and coordinate on MMRV related activities



NOAA, DOE sign agreement to advance marine carbon dioxide removal

Focus areas: Ocean & Coasts, Research Topics: carbon dioxide, marine

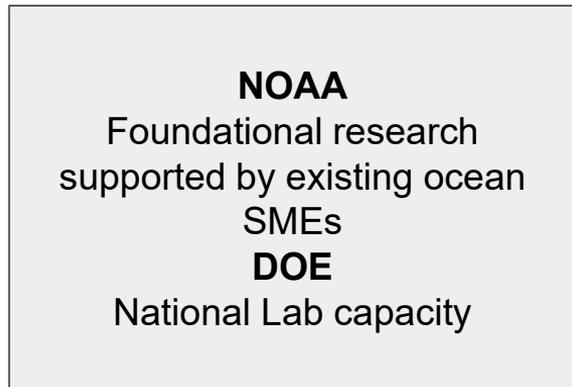
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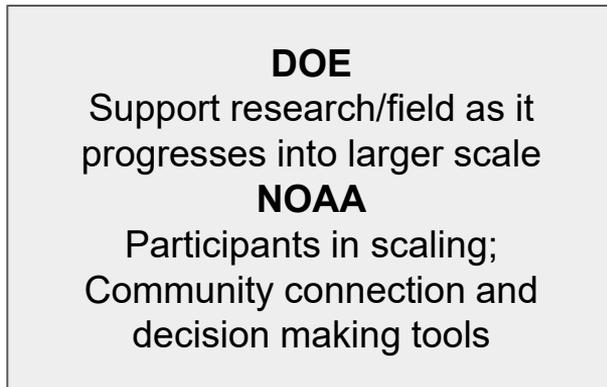


NOAA-DOE MOA

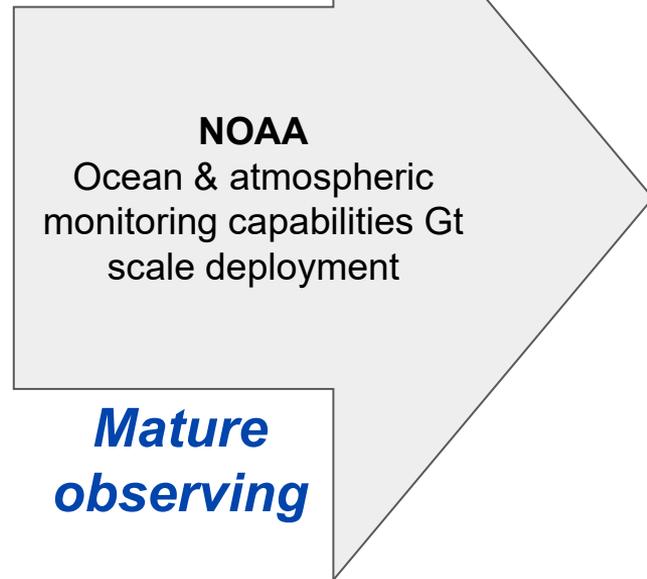
The agencies' roles in the research and scaling



Foundational research



Scaling and demonstrations



Mature observing