



U.S. Carbon Cycle Science Program &
Carbon Cycle Interagency Working Group



*Celebrating over 20 Years of
Interagency Research Partnerships
with the Carbon Cycle Science
Community*

CarbonCycleScience.us



Ocean Carbon Dioxide Removal: Some Interagency Perspectives

Gyami Shrestha, Ph.D.

Director,

U.S. Carbon Cycle Science Program Office at USGCRP & UCAR
Carbon Cycle Interagency Working Group (CCIWG)

Washington, D.C., USA

@USCarbonProgram



**U.S. Carbon Cycle
Science Program**

LAND • OCEAN • ATMOSPHERE • SOCIETY



Co-chair Jim Butler
(NOAA GML)



Co-chair Zhiliang Zhu
(USGS)

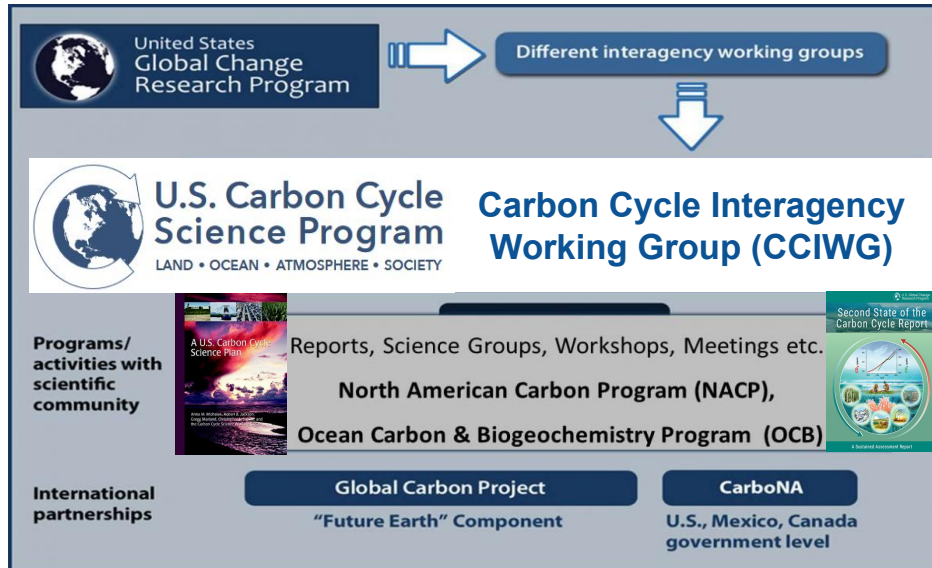


Director,
Gyami Shrestha
(CCSPO/UCAR)

www.carboncyclescience.us

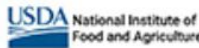


A CCIWG quadri-weekly meeting at the USGCRP, 2019



CCIWG with community science colleagues (First and last joint meeting of the CCIWG, CCSSG and NACP SSG, 2013)

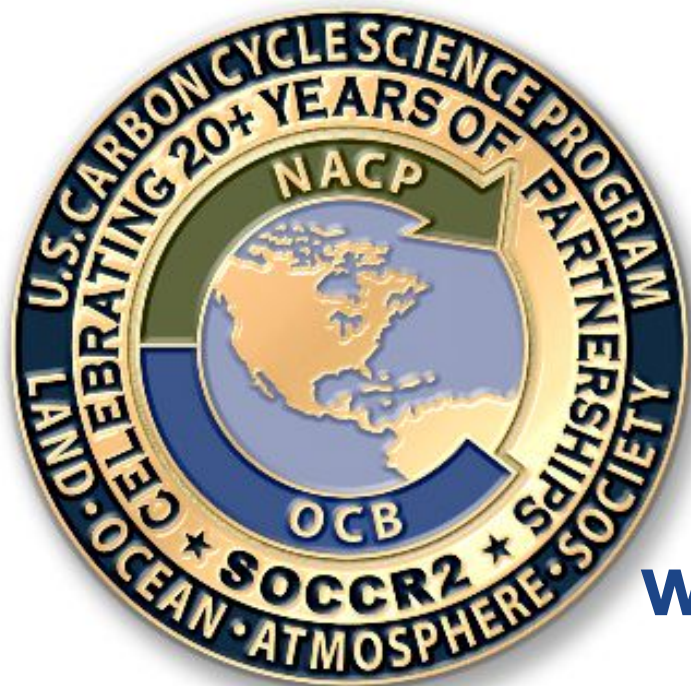




U.S. Carbon Cycle Science Program

LAND • OCEAN • ATMOSPHERE • SOCIETY

An interagency partnership providing a coordinated & focused scientific strategy for conducting federal carbon cycle research



MISSION

To coordinate and facilitate federally-funded carbon cycle research and provide leadership to the U.S. Global Change Research Program (USGCRP) on carbon cycle science priorities

www.carboncyclescience.us

CCIWG membership

Zhiliang	Zhu	USGS, CCIWG co-chair	Libby	Jewett	NOAA OA
Carolyn	Olson	USGS Emeritus	Kathy	Tedesco	NOAA GOMO
Brad	Reed	USGS	Jim	Butler	NOAA GML, CCIWG co-chair
Meg	Walsh	USDA OCE	Monika	Kopacz	NOAA AC4
Louie	Tupas	USDA NRCS	Anna	Karion	NIST
Eric	Norland	USDA NIFA	James	Whetstone	NIST
Anne	Marsh	USDA FS	Libby	Larson	NASA / NACP
Toral	Patel-Weynand	USDA FS	Hank	Margolis	NASA
Marlen	Eve	USDA ARS	Kathy	Hibbard	NASA
Sarah	Beebout	USDA ARS	Laura	Lorenzoni	NASA
Nancy	Cavallaro	USGS Volunteer (former co-chair)	Mike	Falkowski	NASA
Juliann	Aukema	USAID	Chris	Clark	EPA
Noel	Gurwick	USAID	Tom	Wirth	EPA
Gyami	Shrestha	US Carbon Cycle Science Program Office Director	Brian	Benscoter	DOE Office of Science
Dwight	Gledhill	NOAA OA	Dan	Stover	DOE Office of Science
Erica	Ombres	NOAA OA	David	Bason	DOE ARPA-E



U.S. Carbon Cycle Science Program
LAND • OCEAN • ATMOSPHERE • SOCIETY

- Multidisciplinary portfolio of federal research and science funding on carbon cycling in interconnected earth systems - land, ocean, atmosphere, society and interfaces
- Coastal carbon research/ observations covered by most of these research programs on carbon cycle science



CCIWG during Oct 16, 2020 quadri-weekly meeting

Major CCIWG/CCSPO Activities and Accomplishments

[Youtube Channel 'From Science to Solutions: The State of the Carbon Cycle'](#)

[State of the Carbon Cycle Report \(SOCCR2\)](#)

[Joint Workshops and Publications](#)

[Joint Research Funding Solicitations](#)



**U.S. Carbon Cycle
Science Program**

LAND • OCEAN • ATMOSPHERE • SOCIETY

[Science Group activities](#)

[A U.S. Carbon Cycle Science Plan](#)

[International Activities/Collaborations](#)

[North American Carbon Program](#)

[Ocean Carbon and Biogeochemistry Program](#)

[Joint NACP-OCB Focus](#)

<https://www.carboncyclescience.us>

Sponsored by



Strengthening the Observational Basis for Carbon Science, Policy

Sustained Observations for Carbon Cycle Science and Decision Support Workshop; Boulder, Colorado, 13–14 April 2016

MEETINGS

Examining Uncertainties in Representations of the Carbon Cycle in Earth System Models

Key Uncertainties in the Global Carbon-Cycle: Perspectives Across Terrestrial and Ocean Ecosystems;

An interactive open-access journal of the European Geosciences Union

| EGU.eu | EGU Publications | EGU Highlight Articles |

Special issue | REgional Carbon Cycle Assessment and Processes (RECCAP)

Improving Carbon Cycle Projections for Better Carbon Management

Workshop on Development of Predictive Carbon Cycle Science; College Park, Maryland, 7–9 March 2016

BIOGEOSCIENCES

Opinion

Managing the Carbon Cycle Requires Strong Science

For future climate change mitigation strategies to be effective, carbon cycle science must receive a major boost.

Global Science and Data Network for Coastal Blue Carbon Workshop completed

January 14, 2016
Menlo Park, California



U.S. Carbon Cycle
Science Program
LAND • OCEAN • ATMOSPHERE • SOCIETY



Commission for
Environmental
Cooperation



2018 Update: Following this workshop, the **Coastal Carbon Research Coordination Network (CCRCN)** was established, with support from the National Science Foundation. The new CCRCN 'builds on work by the Blue

Coastal Carbon Research Coordination Network



Coastal Carbon Data Clearinghouse

Coastal Carbon ATLAS



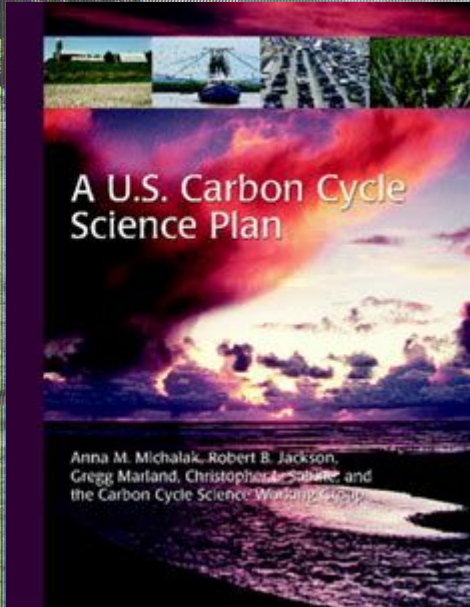
<https://serc.si.edu/coastalCarbon>

Some Products, Focus areas (2011-2019)



U.S. Carbon Cycle
Science Program
LAND • OCEAN • ATMOSPHERE • SOCIETY

A 2011 Carbon Science Plan

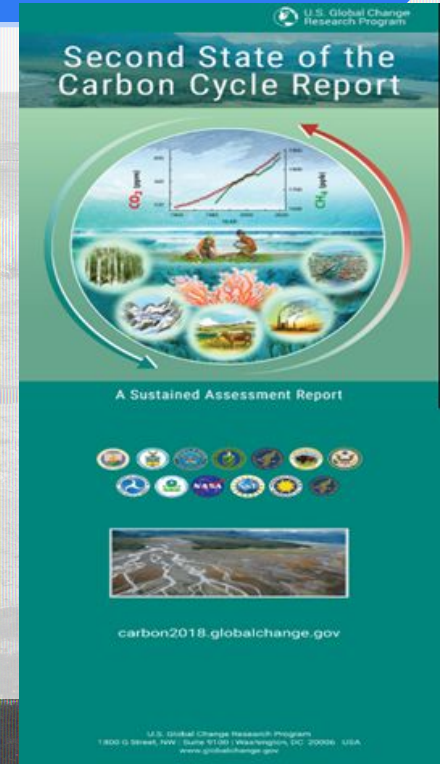


Next Big Ideas 2012-2019

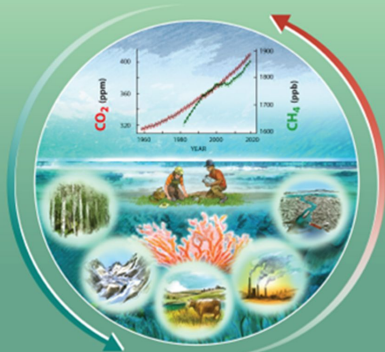
1. Urban
2. Human Dimensions
3. Coastal/Blue Carbon
4. Wetlands
5. Predictive carbon cycle
6. Observation Networks
7. ESM Carbon Uncertainties
8. Soil Carbon Vulnerability and Resilience
9. Regional Carbon Cycle Assessment
10. Carbon Management
11. Many more..

workshops, publications, networks, joint research calls, individual agency calls

SOCCR2 (2015-2019)



Second State of the Carbon Cycle Report



A Sustained Assessment Report



carbon2018.globalchange.gov

SOCCR2: carbon2018.globalchange.gov

The full **decadal assessment** contains **878** pages.

4 sections:

Synthesis,
Human Dimensions of the Carbon Cycle,
State of Air, Land & Water,
Consequences & Ways Forward

19 chapters, 7 appendices

3764 publications cited/assessed

200+ diverse cross-sectoral experts from U.S., Mexico, Canada, Australia, Cyprus, Hong Kong

33 Chapter Leads

5 Science (cross-chapter section) Leads

11 Review Editors

>3 years formulation & production (2015-18)

>6 Drafts reviewed over 6 times incl. by **Public, U.S. National Academy of Sciences**,
expert external reviewers,

21 Federal Steering Committee members.

Final clearance by 13 U.S. Government Agencies and Departments

Citation: USGCRP, 2018: Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, D.C., USA, 878 pp., <https://doi.org/10.7930/SOCCR2.2018>.

Front Matter

Highlights

Preface

Executive Summary

Synthesis ?

1. Overview of the Global Carbon Cycle

2. The North American Carbon Budget

Human Dimensions of the Carbon Cycle ?

3. Energy Systems

4. Understanding Urban Carbon Fluxes

5. Agriculture

6. Social Science Perspectives on Carbon

7. Tribal Lands

State of Air, Land and Water ?

8. Observations of Atmospheric CO₂ and

Methane

9. Forests

10. Grasslands

11. Arctic and Boreal Carbon

12. Soils

13. Terrestrial Wetlands

14. Inland Waters

15. Tidal Wetlands and Estuaries

16. Coastal Ocean and Continental Shelves

Consequences and Ways Forward ?

17. Biogeochemical Effects of Rising Atmospheric
CO₂

18. Carbon Cycle Science in Support of Decision
Making

19. Future of the North American Carbon Cycle

Appendices

A. Report Development Process

B. Information Quality in the Assessment

C. Selected Carbon Cycle Research Observations
and Measurement Programs

D. Carbon Measurement Approaches and
Accounting Frameworks

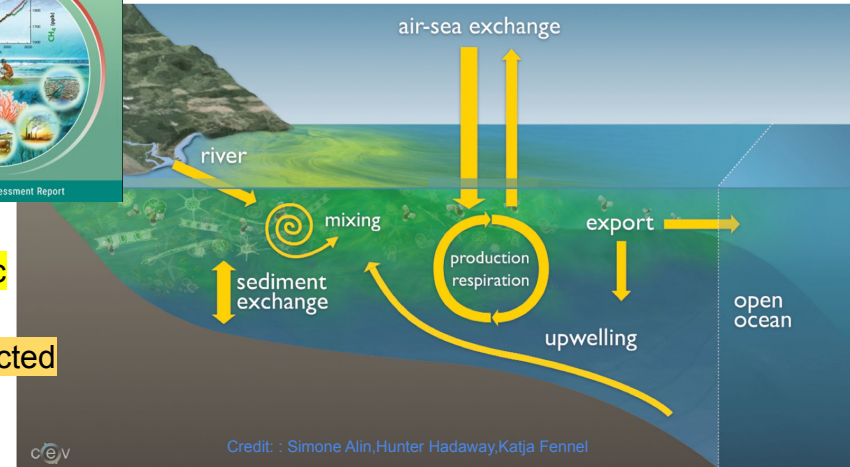
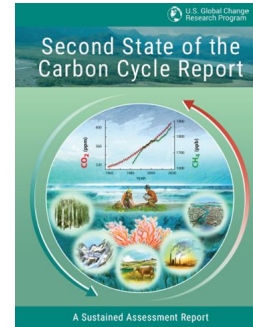
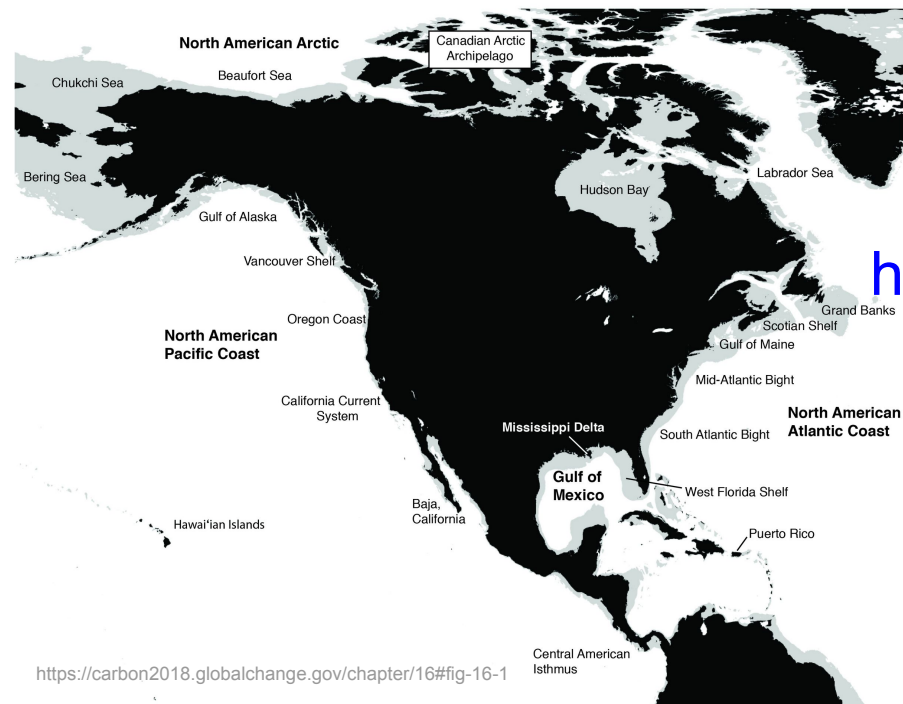
E. Fossil Fuel Emissions Estimates for North
America

F. Acronyms, Abbreviations, and Units

G. Glossary

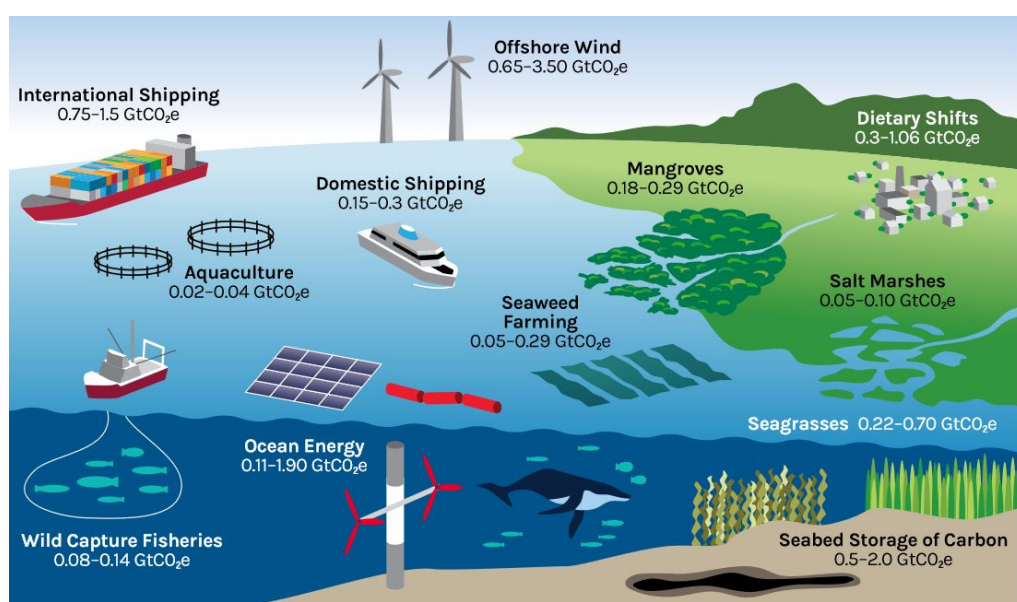
Informing Ocean CDR Options e.g. Learning from SOCCR2 decadal science findings

<https://carbon2018.globalchange.gov>



- 'North American coastal waters clearly act as a net sink of atmospheric carbon BUT regional variations and uncertainties are large.'
- 'In the future, warmer and more CO₂-enriched ocean waters are expected to take up less additional CO₂.'
- 'Compared to terrestrial systems, there is only rudimentary understanding of ocean and coastal system resilience to climate- or carbon-driven perturbations and the speed with which they may recover from short-term disturbances under climate change.'

- 'Ocean CO₂ uptake is not credited to any nation under UNFCCC carbon accounting; instead, ocean uptake is viewed as an internationally shared public commons.'

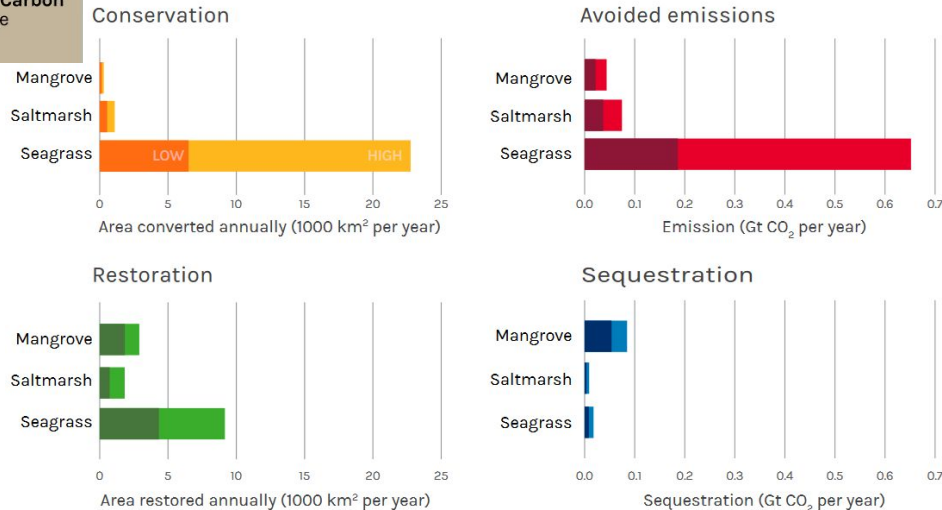


Some initial questions

Given the high potential ocean-based or ocean-related carbon mitigation options such as those described by the recent Global Ocean Panel (2019), how could ocean CDR be considered and integrated with those options for future implementation?

Comparison of Conservation and Restoration Pathways for Coastal and Marine Ecosystems

<https://oceanpanel.org>



How do we implement carbon mitigation and ocean CDR with climate change risk resilient adaptation across human systems and interfaces?

What is the ocean's 'risk resilience to climate- or carbon-driven perturbations and the speed with which they may recover'? (SOCCR2, 2018)

Biological Pump

⚙️ Artificial Upwelling

Upward transport of deep nutrient-rich waters to increase net primary production

🌿 Blue Carbon Management

Restoration and protection of blue carbon ecosystems to ensure long-term below-ground storage of organic carbon

🌾 Macroalgal Cultivation

Cultivation and harvest of macroalgae as a means to remove CO₂ from surface waters

🐠 Ocean Fertilization

Addition of nutrients to the surface ocean to increase net primary production

Abiotic Pumps

💧 Alkalinity Enhancement

Addition of alkaline minerals to seawater to increase alkalinity and so increase CO₂ solubility and carbon storage

⚙️ Artificial Downwelling

Downward transport of CO₂-saturated surface waters to accelerate CO₂ equilibration with the deep ocean

🏗️ Deep Storage

Use of the ocean's deep stable layers, seafloor, and sediment to store liquid CO₂, organic carbon, or other carbon rich materials

⚗️ Direct Capture

Extraction of dissolved carbon from seawater via chemistry, electrochemistry, gas exchange, or other methods

Ocean CDR approaches boosting
Earth's natural carbon pumps

Federal Research Funding Ocean Carbon

Grants.gov

Search: 'Ocean Carbon'

> 4000 total funding instruments from
2006 to present (archived, current,
closed, forced) from federal agencies

- ☒ All Funding Instruments
- ☐ Cooperative Agreement (2,940)
- ☐ Grant (1,654)
- ☐ Other (167)
- ☐ Procurement Contract (134)

- Over 80 posted/current as of today

Research Needs Related to Enhanced Weathering as a Mechanism for Carbon Dioxide Removal	DOE-NETL
Energy and Carbon Optimized Synthesis for the Bioeconomy (ECOSynBio)	DOE-ARPAE
Carbon Ore, Rare Earths and Critical Minerals (CORE-CM) Initiative for U.S. Basins	DOE-NETL
Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) Initiative for United States (U.S.) Basins	DOE-NETL
ROSES 2020: Carbon Cycle Science	NASA-HQ
Enabling Gasification of Blended Coal, Biomass and Plastic Wastes to Produce Hydrogen with Potential for Net Negative Carbon Dioxide Emissions.	DOE-NETL
Ocean Exploration Fiscal Year 2021 Funding Opportunity	DOC
Ocean Drilling Program	NSF
FY 2021 Implementation of the U.S. Integrated Ocean Observing System (IOOS®)	DOC
Ocean Technology and Interdisciplinary Coordination	NSF
Improving Undergraduate STEM Education: Pathways into the Earth, Ocean, Polar and Atmospheric & Geospace Sciences (IUSE:GEOPATHS)	NSF
ECOSynBio SBIR/STTR	DOE-ARPAE
Oceanographic Facilities and Equipment Support	NSF
Sustainable Landscapes Broad Agency Announcement	USAID
Chemical Oceanography	NSF
Critical Aspects of Sustainability	NSF
Addressing the Impacts of Multiple Stressors on Shellfish Aquaculture through Research/Industry Partnerships	DOC
FY21 Regional Ecosystem Research Program: Understanding Species' Habitat Usage and Connectivity	DOC
FY21 Effects of Sea Level Rise (ESLR)	DOC
Physical Oceanography	NSF

How could the availability, accessibility, transparency and provenance of details on specific ocean CDR or any CDR research funding, funded projects and findings across all involved entities (government agencies, foundations, private sector) be enhanced for researchers, practitioners, implementers, stakeholders?

- Artificial Upwelling
- Ocean Fertilization
- Blue Carbon Management
- Macroalgal Cultivation
- Alkalinity Enhancement
- Direct Capture
- Deep Storage
- Artificial Downwelling

Some related deliberative questions/comments

Impact of Ocean CDR on land, atmosphere, ocean society - risks and uncertainties

Impact of Land-based CDR on Ocean CDR viability and permanence

Governance and equitable stakeholder inclusion needs (end-to-end)

Gaps and opportunities for broader multi-agency involvement

Gaps and opportunities for broader science funder partnerships and involvement (e.g. govt, foundations, private sector, venture capitalists) for research, implementation, long-term monitoring of impacts, permanence

Is there a need for a central, comprehensive and transparent database of historical and current federal funding and funded research and findings, accessible by anyone, esp. researchers and program managers themselves for ocean CDR and other climate intervention approaches?

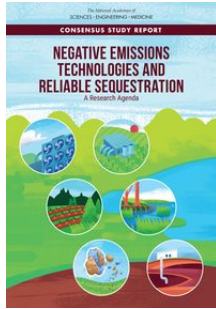
This would help everyone with informing plans and collaborations for future research on and implementation of CDR or any climate change mitigation activities.



So what are we currently doing/planning, what do we need and why?

Reviewed/reviewing
NASEM and other
reports

Identified omission of
some key federal and
interagency/CCIWG
member activities or
programs.



Planning internal
inventory/compendium
of federal (multiagency)
activities/projects/grants
involving/related to
CDR incl. ocean, land,
atmospheric, societal
and ecosystem
interfaces

Exploring multi-agency CDR workshop(s)

Where would we want to be in 10 years? What are/will be the key science and implementation gaps?

Do we need to identify our stream lanes? How do individual agencies make the case for additional funding appropriation for ocean CDR when/if it is relevant to their mission?

We would love to see a coordinated strategy -

For instance, if an agency will push for ocean CDR implementation in the next decade - which other agencies can help with filling the needs for related activities such as permitting and zoning in the ocean, for instance? Those agencies would need to know if, how and where they are going to help to implement certain approved CDR options. There is also a stakeholder inclusion need.

If one agency is going to implement related international protocol ratified by the U.S., how are those questions going to be tackled by all other pertinent research, implementation and regulatory agencies?

Need to know what different agencies are doing or not doing in CDR - need to understand the science, the science needs and the mutually understood and agreed interagency collaboration needs, options and instruments for potential future applications.



Ocean Carbon & Biogeochemistry

Studying marine ecosystems and biogeochemical cycles in the face of environmental change

<https://www.us-ocb.org>

OCB Ocean CDR perspective/plans (POC Dr. Heather Benway)

- Planning to work on raising awareness and highlighting key scientific unknowns on ocean CDR
- Entrain OCB community participation in the research that is needed to determine viability of CDR strategies
- Potential thematic webinar on ocean CDR in the near future
- 2021 Annual Meeting plenary session on ocean-based CDR strategies (June 2021)



Aquatic Continuum OCB-
NACP Focus Group

CMIP6 Working Group

Filling the gaps in
observation-based
estimates of air-sea
carbon fluxes working
group

Fish Carbon Working
Group

Lateral Carbon Flux in
Tidal Wetlands

Metaproteomic
Intercomparison

N-Fixation Working Group

Ocean Carbonate System
Intercomparison Forum

Ocean Carbon Uptake
Working Groups

Ocean Nucleic Acids
'Omics

Phytoplankton Taxonomy
Working Group

Another example of emerging science community integration effort

www.ccis.ucar.edu

COMMUNITY CLIMATE INTERVENTION STRATEGIES

‘Integrate various research communities to develop a unifying research framework to holistically assess the large collection of possible strategies, including mitigation, adaptation, and interventions including CDR and SRM....meant to target the global good, including social and ecological considerations and to develop shared principles of best practices....’

Upcoming workshop on Oct 28,29, 30



Community Exchange Forum

** Coming soon*

Broken down into categories for users to engage in thoughtful discussions

Resources



Workshops

Bringing together participants that are explicitly interested in climate interventions. It will include experts from different key areas.

Events



Working Groups

Working groups will be decided during the October workshop.

Information



Education & Outreach

Training resources intended for the geoscience community.

Resources



Webinar Series

Focuses on a set of main goals as well as overarching questions for each webinar topic.

Events



Existing Projects

View a list of our current existing projects, assessments, and more.

Resources

Thank you.



**U.S. Carbon Cycle
Science Program**

LAND • OCEAN • ATMOSPHERE • SOCIETY



<https://carboncyclescience.us>

Funding for the U.S. Carbon Cycle Science Program Office is provided by



United States Department of Agriculture
National Institute of Food and Agriculture

