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Carbon Dioxide Removal
NOAA's Current Role and Potential to Lead Future Efforts:

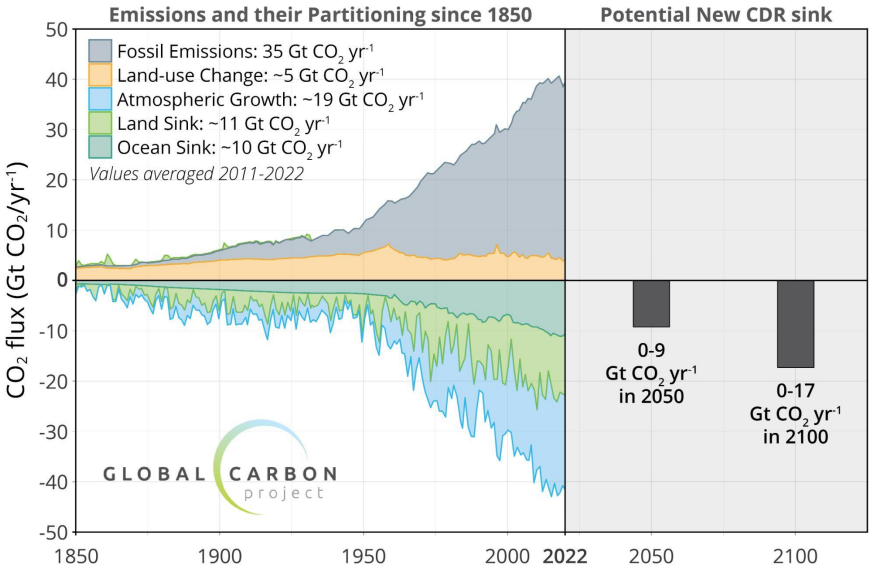
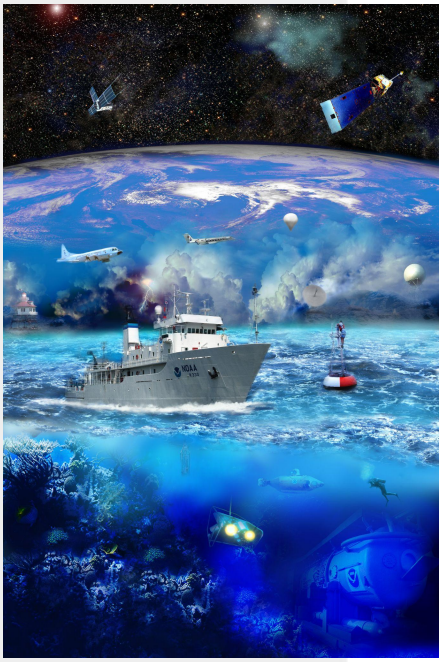


Figure modified from Minx et al. 2018

Carbon Dioxide Removal: What is it and why is it needed?

Carbon dioxide removal (CDR) refers to a portfolio of techniques that are used to remove greenhouse gasses from the atmosphere and lock them away permanently in secure reservoirs. CDR specifically references techniques that remove carbon dioxide from the atmosphere.

CDR is now considered to be an essential component of successful strategies for limiting warming to 1.5 – 2 °C. Meeting this target will require increasing reliance on CDR technologies in addition to a rapid transition to low/zero carbon energy sources. *Examples of CDR methods include: Macroalgal Cultivation, Ocean Alkalinity Enhancement (OAE), Coastal Blue Carbon (CBC), Direct Air and Ocean Capture (DAC/DOC), and Ocean Fertilization (OF).*



Why is NOAA involved in CDR?

NOAA's existing observational network and research programs position it to lead in the analysis of impact, effectiveness, feasibility, and risk of many CDR techniques. NOAA was created more than 50 years ago to study linkages between the ocean and atmosphere. Assessing the effectiveness of CDR approaches is directly related to its mission.

How is NOAA primed to engage?

NOAA's emphasis on big-picture, long-term monitoring and its research capabilities are ideally suited to understand, evaluate, and verify public and private entities' exploration of CDR efforts and their potential for success. Existing mandates, programs, and activities already intersect with CDR research:

- **NOAA's global to coastal observing networks and data assimilation**
- **NOAA's earth system and regional ocean modeling**
- **NOAA's ecosystem research**
- **NOAA's management role and stakeholder relationships**

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Scan for NOAA CDR White Paper

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Carbon Dioxide Removal Current NOAA Assets:

NOAA's existing and innovative assets, such as observations, models, ecosystem assessments, spatial planning tools, and stakeholder inputs, can inform evidence-based decisions on the implementation of carbon dioxide removal (CDR) techniques by federal and state governments, private sector interests, and nonprofit organizations. Further development of NOAA's assets and research specifically tuned to CDR could also have a strong impact on the emerging CDR economy.

Current NOAA Assets		Development Necessary for CDR	Potential Impact of new NOAA CDR Research
Observing Networks	**Global Atmospheric and Ocean Observing (e.g., GGGRN; GO-SHIP; Argo; GOA-ON)**	Fill regional gaps; develop deep-sea monitoring network	NOAA continues to verify global Carbon Budget at necessary scales to identify CDR
	Local Atmospheric and Ocean Observing (e.g., CarbonTracker; IOOS RAs; NOA-ON)	Expand to many more sites for comprehensive local-scale monitoring at CDR installations	NOAA verifies, monitors impact of single CDR projects
	Technology Development Programs (e.g., DART; ITAE)	Early investment and partnerships with industry, other agencies	NOAA catalyzes global CDR monitoring and verification potential (e.g., trading accredited offsets)
Modeling, Scaling, and Projection of CDR Pathways	**Earth System Models (e.g., CMIP6) and regional models (e.g., ROMS)**	New CDR-specific modeling packages	NOAA projects near-term and long-term CDR impacts to identify changes, risks, cobenefits for earth system
	Process study models	Development of virtual "testbeds" for CDR research	NOAA designs quality process studies for investigating the impacts of experimental CDR methods
Environmental Impacts	**National ecosystem monitoring programs**	Expand to many more sites for comprehensive local-scale monitoring at CDR installations	NOAA verifies, monitors environmental impacts of single CDR projects
	Ecosystem modeling	Modify ecosystem models to evaluate the effect of CDR	NOAA projects impacts of CDR on marine ecosystems
	Laboratory research	Design and implement CDR-specific experimental studies for key species	NOAA identifies environmental risks, cobenefits of single CDR projects
Decision Support	**Data management and synthesis (e.g., NCEI, OCADS)**	Data preservation, interoperability and compatibility, discovery and access, quality control and synthesis	Bridging the gap between observations and subsequent research, MRV efforts to account for carbon credits, and decision support based on these data
	Marine Spatial Planning (e.g., NCCOS, OCM)	Apply new CDR knowledge using existing spatial planning tools	NOAA resolves use conflicts, enhances decision support for CDR implementation requests
	Aquaculture Research, Development, and Policy	Development of sustainable farming methodology; expanded permitting support	NOAA maximizes sustainable coastal marine services
	Collaborative Research and Stakeholder Engagement (e.g., SeaGrant)	Improve pathways for stakeholder participation in NOAA CDR Research	Research reflects stakeholder needs
	Blue Carbon Conservation (e.g., CCAP)	Fill local gaps; conserve existing natural carbon storage sinks	NOAA protects and restores existing natural carbon sinks

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