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CHANGING WHAT'S POSSIBLE

SEA-CO2—Sensing Exports of Anthropogenic Carbon through Ocean Observation

PROJECT DESCRIPTIONS

Woods Hole Oceanographic Institution – Woods Hole, MA

Scalable, Multiparameter Chip-Size Carbon Sensors - $3,738,960

Woods Hole Oceanographic Institution (WHOI) is developing a system-on-a-chip for ocean carbon flux monitoring that would integrate the capabilities of several existing commercial sensors into a single miniature sensor chip, lightening the power requirements on ocean gliders and floats and reducing costs by an order of magnitude. The proposed system-on-a-chip would measure pH, oxygen, particulate organic carbon, and other variables. Unlike state-of-the-art sensors that are built in small batches by hand, WHOI's system-on-a-chip would fabricate and calibrate at scale using semiconductor manufacturing techniques while still meeting or exceeding current accuracy and precision standards.

University of Texas at Austin – Austin, TX

Acoustic Methods for mCDR based on Blue Carbon Burial in Seagrass Meadows - $2,034,903

The University of Texas at Austin is developing an acoustic sensor network to quantify ecosystem activity and how effectively carbon is stored in shallow seagrass beds, an important sink in the coastal blue carbon cycle. The proposed sensor network detects the acoustic signature of bubbles that are released from seagrass leaves as photosynthesis produces excess oxygen. The network also analyzes the refraction of sound through the seafloor to estimate the quantity of carbon locked in seagrass roots and sediment. This passive listening technology would aid in monitoring the performance of large-scale seagrass meadow remediation projects for marine carbon dioxide removal. The sensor network aims to be much less hands-on and more cost effective than conventional methods, which require manual sampling and laboratory analysis.

Bigelow Laboratory for Ocean Sciences – East Boothbay, ME

Monitoring, Reporting and Verification of Zooplankton-Mediated Export Pathways for Carbon Sequestration - $2,279,867

Bigelow Laboratory for Ocean Sciences is developing a biogeochemical computer model that improves our estimates of how the vast population of ocean zooplankton—tiny marine animals—move and lock away carbon in the deep ocean. Most ocean models treat zooplankton as a "black box" and lack key zooplankton behaviors that can result in carbon transport, leading to uncertainties in carbon accounting. The proposed work seeks to capture these behaviors in a plankton-focused model and then integrate these processes into other biogeochemical models to provide realistic and accurate accounting of the carbon they transport between the surface and deep ocean for carbon dioxide removal approaches, such as ocean iron fertilization and ocean macronutrient fertilization.

University of Colorado, Boulder – Boulder, CO

SLEUTH: Spectroscopy of Oceanic Liquid Environments Using Towed Optical Sensor Heads - $5,904,233

University of Colorado, Boulder (CU-Boulder) is developing a system of optical underwater sensors to sense and measure dissolved carbon compounds. CU-Boulder seeks to build a sensor head that would be towed underwater by a cable containing optical fibers attached to an autonomous wave-energy harvesting surface vehicle. The proposed system takes advantage of dual frequency comb laser stimulated Raman spectroscopy—derived from a technology developed under ARPA-E's MONITOR program—to bring laboratory-based optical spectroscopy to in-situ, persistent, and fast-moving ocean platforms.

atdepth MRV – Cambridge, MA

A Scalable, Integrated, Real-Time, GPU-Based Modeling System to Enable MRV for mCDR - $2,524,964

atdepth MRV is developing an ocean modeling system that utilizes graphical processing units (GPUs) which would dramatically improve modeling speed compared with traditional approaches that use central processing units (CPUs). The team seeks to build a model for marine carbon dioxide removal sites that would not only include global-scale ocean processes but also local processes no larger than a few meters, such as small-scale turbulence. If successful, the team could speed up regional ocean modeling systems by more than 100 times compared with legacy CPU-based approaches, create outputs in real time, and include fine-scale ocean dynamics that have been too computationally costly for CPU-based models.

University of Utah – Salt Lake City, UT

SEAfloor Self-sustaining CO_2 Assessment Probe Edge (SEASCAPE) - $2,004,554

University of Utah is developing a micro-optical, micro-electronic seafloor probe that would extend the longevity and persistence of current-day seafloor carbon storage measurement tools. The proposed probes—deployed in a group across a wide seafloor area—would be inserted directly into the seafloor to measure the accumulation of carbon in ocean sediments for more than a year. University of Utah's probe would house a newly developed sensor that evaluates carbon dioxide and pH using a novel bubble mechanism, a low-power method that avoids the degradation, calibration, and power issues of conventional sensors.

General Electric (GE) Research – Niskayuna, NY

Spatially Resolved Multi-Parameter Sensing Of Ocean Carbon Dynamics Utilizing Fiber Optic Time-Of-Flight Sensors - $4,274,658

General Electric (GE) Research is developing a fiber optic sensor cable that would span multiple kilometers of ocean volume and measure chemical ocean carbon parameters over large areas when towed from marine vessels. Conventional methods take measurements of ocean pH and dissolved carbon dioxide in water using sensors that are fixed at one point or lowered slowly from a stationary vessel. GE's approach distributes chemical sensing capabilities over a continuous fiber optic cable cladded with polymer-based optical fiber coating, increasing the volume of water that can be measured and dramatically reducing costs compared with current-day technologies.

[C]Worthy – Boulder, CO

Computational Systems for Tracking Ocean Carbon (C-Star) - $3,884,825

[C]Worthy is developing a community framework for model building and data assimilation that would provide the structure and processes necessary to incorporate observations, manage model complexity, and meet the need for accurate carbon accounting for marine carbon dioxide removal. The proposed framework would incorporate observational and forcing datasets, data assimilation, an ocean general circulation model, biogeochemistry, tracers, and marine carbon dioxide removal and marine ecosystem modules to estimate the ocean's state.

University of Pittsburgh – Pittsburgh, PA

Hybrid Distributed pH, CO_2, Temperature, and Acoustic Sensing for Monitoring and Verification of Marine Carbon Dioxide Removal Applications - $2,274,859

University of Pittsburgh is developing buoy-based optical fiber sensors for measuring pH and carbon dioxide in seawater from the ocean's surface to the seafloor. Using chemically selective and optically sensitive coatings, the proposed project would integrate a fiber optic sensing technology into low-cost commercial fibers used for marine buoy sensor systems. A reel-to-reel continuous manufacturing approach enables straightforward large-scale manufacturing. University of Pittsburgh's approach would aid monitoring of nearshore marine carbon dioxide removal technologies, particularly those in need of continuous monitoring such as ecosystem recovery, alkalinity enhancement, and electrochemical solutions.

Woods Hole Oceanographic Institution – Woods Hole, MA

Quantification of Atmospheric Carbon Dioxide Removal Using an Autonomous Ocean Sensor that Measures Sinking Particulate Carbon Flux - $4,802,245

Woods Hole Oceanographic Institution (WHOI) is developing a natural thorium decay sensor that would attach to gliders, autonomous vehicles, and profiling floats to quantify the flux rates of particulate organic carbon to the deep ocean for marine carbon dioxide removal. WHOI's proposed sensor takes advantage of the naturally occurring radioactive isotope thorium-234, which provides a "clock", much like carbon dating, that indicates the rate of carbon-containing planktonic detritus sinking from the surface to the deep ocean. Unlike current methods that require multi-step laboratory analysis, the proposed sensor doesn't require ship-based sample preparation and can analyze large volumes of water in the ocean, autonomously, for periods of at least a year.

Pacific Northwest National Laboratory – Seattle, WA

Integrated Experimental and Modeling Assessment of Ocean Alkalinity Enhancement for Scalable Marine Carbon Dioxide Removal - $2,080,715

Pacific Northwest National Laboratory (PNNL) is developing a model and mesocosm experiments to evaluate the effectiveness and impact of the marine carbon dioxide removal technique Ocean Alkalinity Enhancement (OAE) in three major coastal areas in the United States. Unlike current models that lack ground-truth data to accurately simulate OAE, PNNL will conduct tank-based laboratory experiments to validate new models that may improve our capability to estimate the effectiveness of OAE. If successful, the project could inform the growth of the maritime carbon capture industry and protection against regional ocean acidification by pinpointing the most effective OAE size, location, frequency, and duration.