5.5 MM FOR OCEAN CARBON SEQUESTRATION

Technology Description

Introduction

There are two approaches for carbon sequestration in the ocean – direct injection and fertilization. These require somewhat different measuring and monitoring (MM) strategies. For direct injection, the separation, capture, and transportation of CO_2 must be addressed as well.[2] Sequestering CO_2 in the deep ocean below the main thermocline (depths of >1,000–1,500 m) should result in extended residence times, and the main measure of performance will be quantities of CO_2 injected and then tracking the dispersion of the concentrated CO_2 plume. MM systems are needed to monitor spatial and temporal CO_2 concentration histories. For fertilization strategies, the primary measure of performance will be the quantity of carbon exported deeper in the water column and its longevity. Sensors for direct measure augmented by remotely sensed indicators for the surface ocean and water column will be required.

System Concepts

- Injection: MM systems are needed to provide histories of CO_2 concentration profiles near the injection sites and track the dispersion and potential release of CO_2 to the atmosphere.
- Fertilization: MM systems should address both direct measurements of CO_2 concentration as well as indirect measures of performance that might be easier to accomplish.
- Alternatively, models of ocean circulation and biogeochemistry could be used to provide projections of CO_2 leakage rates and representative small volumes of the ocean would be intensively monitored for validation of model accuracy.

Representative Technologies

- Measurement of comprehensive trace gas parameters [Total CO_2 (TCO_2), Total Alkalinity (TALK), partial pressure of CO_2 (pCO_2), and pH] that represent an amount of CO_2 concentration in seawater (measurement of any two of these four parameters could result in calculation of other pair); extensive use of floats that cover various depths and report data back directly to data handling systems.
- Indirect indicators of fertilization effectiveness may be possible (phytoplankton biomass, pH, particulates, etc) rather than CO_2 measurements; satellite-based sensors may be able to provide quantitative indicators with selective validation via physical measurements.
- CO_2 sensors that "track" the dissolved CO_2 plume from injection locations.

Technology Status/Applications

- Extensive use of floats and buoys is ongoing for studies of the carbon cycle, but these are expensive and ship-intensive.
- Determining CO_2 concentration via comprehensive measurement is ongoing, but costs and complexity are prohibitive from an MM viewpoint.

Current Research, Development, and Demonstration

RD&D Goals

- Develop integrated MM concepts that include direct measurement, model analysis, and indirect indicators that can be used across the scales needed to verify process information and ocean-wide observations.
- Data transmission and analysis systems that avoid expensive ship time.
- Quantitative satellite-based sensors for surface ocean indicators of sequestration effectiveness.
- Determine whether direct measurement of plume dispersion or model analysis with selective validation is needed for direct injection MM.

RD&D Challenges

- Development and testing of robust sensors working at the pressure of deep oceans are still needed.
- Develop the ability to track the fate of direct injected CO_2.

[2] MM strategies for separation, capture, and transport of CO2 are addressed in technology Profile 5.3 MM for Geologic Carbon Sequestration.

- Develop sensors to provide robust measurements of CO_2, and other species introduced by impurities with CO_2 in seawater under a range of temperature and pressure conditions, from the deep ocean to the surface.
- Calibrate and test the sensors using the inter-comparison with proven equipment method in the laboratory and at sea conditions.
- Reduce uncertainty in measurements.
- Develop the ability to transfer measurements via satellite systems to centralized data collecting stations.

RD&D Activities

- For more than 10 years (1990-2000) the U.S. DOE and NOAA have sponsored the ocean carbon dioxide survey during the World Ocean Circulation Experiment (WOCE), monitoring the carbon concentration in the Indian, Pacific, and Atlantic oceans from the research oceanographic ships. The global WOCE carbon data set includes ~23,000 oceanographic stations.
- Low-cost discrete measurement sensors are under development. These sensors will be used in conjunction with the conductivity, temperature, depth (CTD), and oxygen sensors to measure the ocean profile on oceanographic stations.
- Development of floats with CO_2 sensors (SOLO) is underway through the NOPP program.
- Remote sensors are being developed to measure indicators of CO_2 parameters.

Recent Progress

- MBARI has demonstrated the ability to inject and monitor via video camera and other sensors at depths; the challenge is to develop these into routine sensor systems.
- Experimental facilities for testing sensors in simulated seawater at representative pressure and temperature are available at ORNL.

Commercialization and Deployment Activities

- Total CO_2 is measured worldwide by use of single-operator multiparameter metabolic analyzers SOMMAs) coupled with coulometers; Total Alkalinity and pH are measured by closed-cell automated potentiometric titration system developed at University of Miami; discrete pCO_2 is measured by an automated equilibrator-IR analyzer system, developed at LDEO.