The equivalent problem in the ocean is far more difficult because of (1) the different physical forcing; (2) the complex reaction rates between CO₂ and seawater; (3) the lack of supporting infrastructure and adequate sensors, and (4) the need for straightforward and relatively low-cost electronics and software. We have overcome almost all of these challenges, and related working systems have already been successfully deployed on the Great Barrier Reef coralite flats with Australian colleagues.

We have used the MARS (Monterey Accelerated Research System) cabled observatory to carry out deep-ocean (880 m depth) experiments. The experimental unit is a 1 m x 1 m x 50 cm high chamber with side arms of approximately 3 m length to provide the required decay times for the reaction between admixed CO₂ enriched sea water and emergence of the pH signal. Controllable hvac/cool maintains a steady flow of seawater through the experiment. We have developed extremely low noise pH sensors that show for the first time the scale and frequency of the tidally driven pH fluctuations in the deep ocean. The software controlling this complex system in real time is robust and a graphical user interface allows the operator remote control of the system over the internet.

Hardware

FOCE's external frame is outfitted with a variety of instruments for both science and engineering monitoring (Figure 3). These include the ADCP, three cameras and a lidar, a pH and CO₂ sensor, and two motor-controller combinations. All instrumentation is wired to the main electronics enclosure. A number of internal and external water detection probes, an external CO₂ gas delivery probe, two water detection probes, an external CO₂ gas delivery probe, and two water detection probes, wired to the main electronics enclosure. A number of internal and external power and Ethernet connections. The CO₂ subsystem is a critical component in the monitoring and control of the pH during delivery experiments. Convention with the WOCE data are monitored by two sets of motor-driven fan switches.

Power and communications for the CO₂ experiment are provided by the MARS node via a 50 m cable. CO₂ gas is delivered to the sealed chamber through a multi-channel gas delivery manifold. The gas delivery system is comprised of multiple needle valve/inlet manifold assemblies coupled to a high flow rate peristaltic pump that is controlled by the MARS node. The CO₂ delivery system was designed to enable reliable and accurate delivery of CO₂ to the seawater and to control the enclosure's internal pH. The system is comprised of multiple components to permit filling, containment and delivery of CO₂ enriched seawater. Monitoring pH values and electronic feedback controls are added to this system. The CO₂ delivery enclosure is fabricated from 316 stainless steel and has an internal volume of 248 liters. CO₂ enrichment occurs by simple diffusion between the overhead CO₂ pool (pCO₂ cures 500–1000 p.p.m.) and seawater flowing through the bottom of the chamber. When the enclosure is repressed, the CO₂ gas dissolved in the seawater is released to the atmosphere. Electrical power and communications for the CO₂ experiment are provided by the MARS node. FOCE's external frame is out

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