CO2 Deep Sea Sequestration Sampling System

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Sponsor

The Rohwer lab is our sponsor for this project, providing financial support and guidance. The Rohwer lab studies microbial ecology, focusing on interactions between microbes and viruses, and their role in coral reefs, the deep sea and human ecosystems. The lab's main study systems of study are coral reefs and human lungs.

CO2 Sequestration Theory

Carbon dioxide sequestration is the practice of capturing, securing, and storing carbon dioxide emissions from the atmosphere. This is done by sinking marine algae into the deep ocean where it remineralizes itself into the atmosphere through the short carbon cycle. The short carbon cycle is the process of cycling carbon dioxide from the earth to the atmosphere, typically through decomposition of plants and other organisms, a process that takes between 100-200 million years to complete. The long carbon cycle offers a manner of transferring carbon dioxide through the crust of the earth which is more beneficial towards repairing the damages from fossil fuels.

Problem Statement

The Rohwer lab is researching the effects of the long carbon cycle as opposed to the short carbon cycle, and if so, how it can contribute to restoring the state of the atmosphere. The proposed system will sequester carbon dioxide in the deep ocean, thus entering the long carbon cycle, providing data on how this carbon dioxide sequestration influences the chemistry and biology of the deep ocean.

Requirements

Eco-Friendly:

- Made entirely of polycarbonate, high-density polyethylene (HDPE), and AISI 316 stainless steel.

Size Specifications:

- Must be 3’ x 3’ x 3' or smaller
- Hold 10 Niskin bottles
- Contain a central Vitrovex glass sphere

Conditions:

- Withstand ocean conditions at 5000 meters of depth
- Remain at depth and open for 30 days
- Retrieve water samples without contamination/spillage
- Reusable (10+ times)
- Simple design for assembly/disassembly on a boat
- Must be attachable to Global Ocean Designs Lander

Finalized Design

Figure 1: Assembled Rosette

Figure 2: Niskin Bottle

Rosette Components

- **Frame:** Two frames are made from HDPE and act as the Horizontal unit, holding the Niskin bottles and Vitrovex in place.
- **Vitrovex**: Glass sphere in the center of the unit will house cameras to document the samples throughout the experiment.
- **Support Rods:** 10 AISI 316 stainless steel rods are bolted to the frames for structural support.

Niskin Bottle Components

- **Polycarbonate Tube:** 20” L x 3” D polycarbonate tube is the body for our bottles, holding the samples and water.
- **End Caps:** Two caps made of polycarbonate are placed on each bottle to keep the sample intact during retrieval. A matching cuff is glued to the tube, allowing a clamp to be placed over it for permanent sealing during transport.
- **Central Housing:** One polycarbonate housing is placed inside each bottle, allowing water to flow through the sample while protecting the samples.
- **Surgical Tubing:** Connects the caps to the central housing, creating tension to close the caps.
- **Mounting Cuffs:** HDPE cuff that connects the Niskin bottle to the rosette frame, allowing for easy removal.
- **Galvanic Timed Release System:** A controlled corrosion reaction in the GTR will release the wire connection between the caps, closing them after thirty days.

Testing

The system was tested in a residential pool at a depth of 3 Feet, using zip ties in place of a Galvanic Timed Release to connect and release the wires on the end caps.

Figure 3: Testing Apparatus

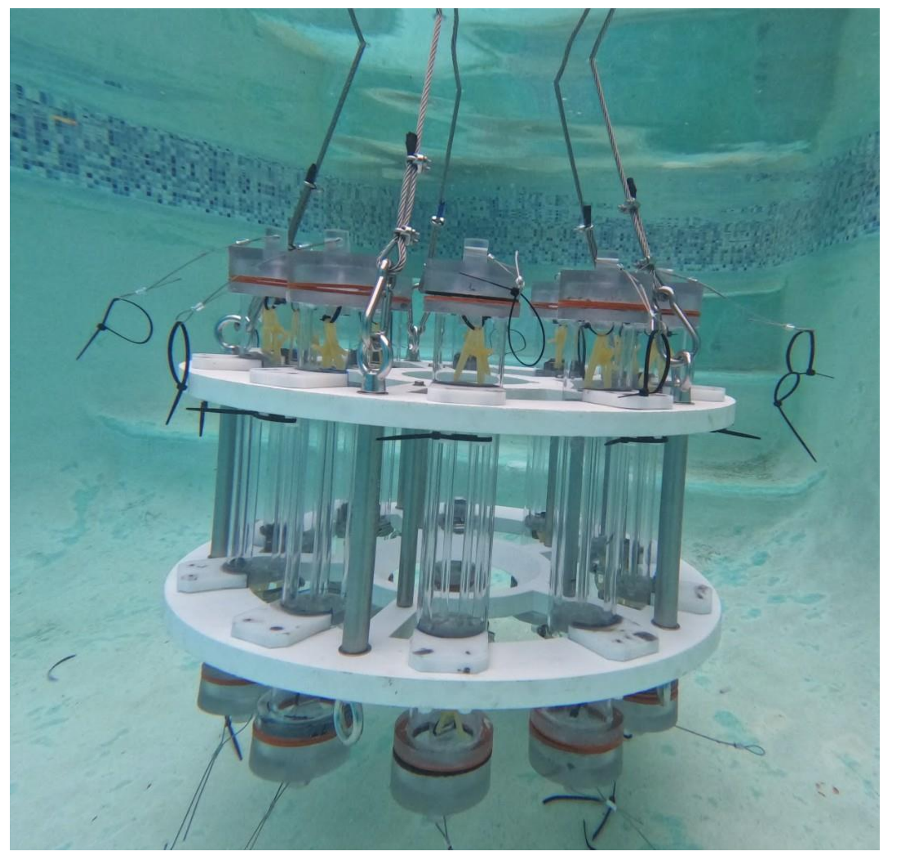

Figure 4: System Post-Test

Results

Our deep sea sampling system meets all requirements outlined by the Rohwer lab that can be tested at limited depth. Our system maintains an open position when deployed, and all Niskin bottles shut when the connecting system is released. Each Niskin bottle can be individually removed from the rosette and brought up to dry land. When removed from the water, all Niskin bottles maintain a tight seal, limiting water loss to below 10%. Once the end cap cuff is added, our Niskin bottles are virtually watertight, allowing for short term transport.

Conclusion and Future Work

While we have met all requirements that can be tested in a controlled environment, the rosette still stands to be tested at its working depth of 5000 meters below the ocean for a period of 30 days. All components of our system have been designed with the pressure, temperature, and duration of deployment in mind, so we do not foresee any failures due to the increased depth or duration of deployment. In the future, this design can be improved by making the frame lighter and the Niskin bottles easier to rig up. Marine grade aluminum could be a possible design change to significantly decrease the weight of the frame, while a complete redesign of the Niskin may be necessary to allow for a more user friendly set up.

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