CASE STUDY 1.2:
Integration of dissolved CO_2 sensors onto a small autonomous vehicle for ocean monitoring: The BlueBoat

SUMMARY

Accurate measurements of pCO_2 in the surface ocean are essential for determining the spatial and temporal distributions of ocean sources and sinks of anthropogenic CO_2. However, traditional methods of oceanographic data collection, such as research cruises and Ships of Opportunity Progams (SOOPs), can be costly, time consuming, and labor intensive leading to a barrier in the quantity of data collected.

Recent advancements in autonomous vehicles have helped to ease these burdens, specifically for measurements made with sensors. By integrating suites of sensors on autonomous vehicles, oceanographers are able to collect more data in locations that may be difficult to reach by a vessel for longer periods of time. Additionally, the overall cost will be significantly lower than for repeated research cruises.

INTEGRATION ON A BLUEBOAT

INTRODUCTION

The Pro-Oceanus CO_2-Pro CV Atmosphere has been integrated onto a Blue Robotics BlueBoat by researchers at Dalhousie University and is currently being used to collect measurements of pCO_2 in Bedford Basin, Halifax, Nova Scotia. The basin, located northwest of the Halifax peninsula, is connected to the Atlantic Ocean by "The Narrows" and Halifax Harbour, creating a unique semi-isolated body of water. A detailed schematic cross-section of Bedford Basin and Halifax Harbour is in Figure 1 (below) from Burt et al., 2013.

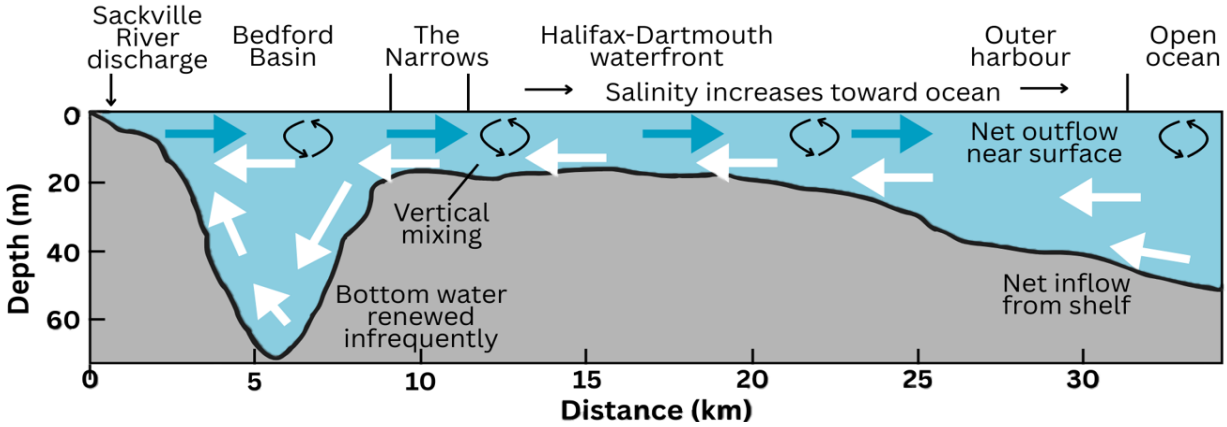

Figure 1: Schematic cross-section of Bedford Basin, The Narrows, Halifax Harbour, and the Outer harbour. Figure from Burt et al., 2013.

The CO_2-Pro CV Atmosphere is designed to measure both the water-side and air-side carbon dioxide concentration, which makes it an ideal solution for monitoring CO_2 fluxes at the air-water interface. The Water-block air intake, for air-side measurements, is intended for use in dynamic environments with motion-tolerant operation and a compact design. When used together dependable air-water CO_2 flux measurements can be collected.

The CO_2-Pro CV Atmosphere sensor with a water pumped-head was mounted parallel to the hulls of the BlueBoat, secured with hose clamps, and positioned just below the waterline. A water pump was secured to the bottom of one of the hulls with an aluminum bracket and tubing connects the pump to the CV allowing for water-side measurements.

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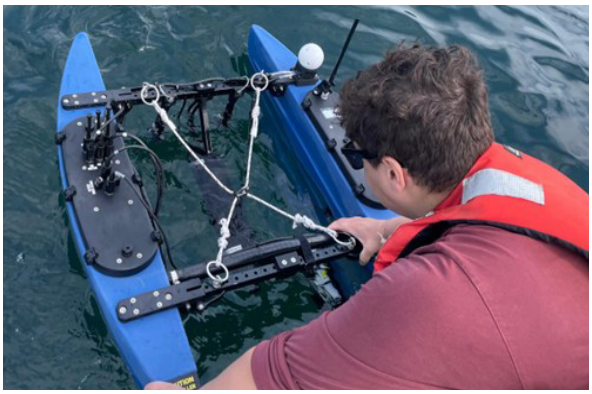


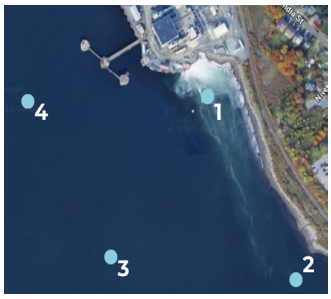
Figure 2: Top down view of the BlueBoat being deployed with the CO_2-Pro CV Atmosphere in between the two hulls and the air intake on top of the starboard hull. Image courtesy of Sean Morgan.

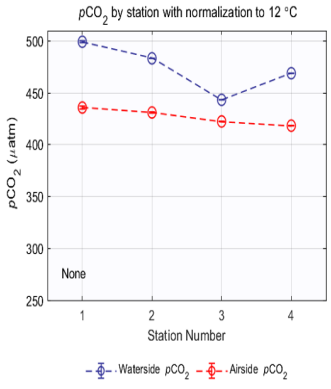
Concurrently, the Water-block air intake for air-side measurements has been mounted to the top of the starboard hull. Figure 2 shows a top down view of the sensor layout. This configuration allows researchers to calculate the air-sea CO_2 flux at various waypoints along the path of the BlueBoat.

RESULTS

The current area of focus for the Dalhousie BlueBoat is just outside of Nova Scotia Power's (NSP) Tufts Cove Power Generation Station Cooling Outfall #6. This location is of interest to the researchers as it is where the marine Carbon Dioxide Removal (mCDR) company Planetary has an ongoing field trial for their Ocean Alkalinity Enhancement (OAE) method. Additionally, the outfall is occasionally turned off for internal maintenance by NSP which changes the aeration dynamics in the area. A change in aeration would impact the air-sea flux of CO_2 in the area directly adjacent to the outfall, which can be see in Figure 3.

The preliminary data suggest that when the outfall is off, there is a clear separation between the water-side and air-side measurements. With the most noticeable difference occurring next to the outfall at Station 1. When the outfall is on, the difference between the water-side and air-side measurements is not as dramatic with all stations having relatively similar values. Most interesting is perhaps that the water-side measurement is lower than the air-side at Station 4 which is a significant distance away from the outfall.





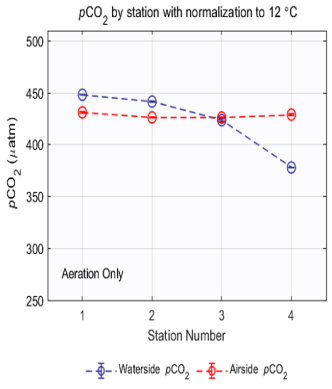


Figure 3: Map view of the BlueBoat waypoints (right) and data for when the outfall was off (bottom left) and on (bottom right). Data figures courtesy of Sean Morgan.

While no definitive conclusions have been made from this data yet, it is interesting to note the difference that aeration makes in the pCO_2 measurements. While integrated onto the Blue Robotics BlueBoat, the CO_2-Pro CV Atmosphere has produced reliable data that has helped the researchers understand the changing environmental dynamics of the region.

REFERENCES

Burt, W. J., Thomas, H., Fennel, K., and Horne, E.: Sediment-water column fluxes of carbon, oxygen and nutrients in Bedford Basin, Nova Scotia, inferred from ^{224}Ra measurements, Biogeosciences, 10, 53-66, https://doi.org/10.5194/bg-10-53-2013, 2013.

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