CASE STUDY 1.3:

Water column pCO_2 measurements in coastal and open ocean regions using buoys

SUMMARY

Collecting timeseries measurements of pCO_2 in the deep and surface ocean is essential for determining water column carbon inventories and CO_2 fluxes. However, traditional methods of oceanographic data collection, such as research cruises and bottle sampling, can be costly, time consuming, and labor intensive. These types of data collection can also lead to spotty timeseries data because of issues with timing or a lack of consistency.

The deployment of buoys can help to reduce these potential problems through integrating pCO_2 sensors on the hull of the buoy and the anchor chain. By placing sensors at various points along the chain researchers can create more accurate timeseries at various water depths to help them understand the environmental dynamics. Additionally, while the upfront cost of equipping a buoy with sensors and deploying it may be high, the overall cost will be much lower than repeated research cruises.

INTRODUCTION

Two different buoy integrations are explored in this case study; one conducted by Dalhousie University in Bedford Basin and the other by the National Oceanography Centre (NOC) in the Porcupine Abyssal Plain Sustained Observatory (PAP-SO).

DALHOUSIE UNIVERSITY

The purpose of the Dalhousie-lead project is to address technology and knowledge gaps that impact the deployment of marine carbon dioxide removal (mCDR) technologies. This buoy is testing the system as well as several state-of-the-art sensors to measure CO_2, pH, and other environmentally important water properties. The main objectives are to investigate the feasibility of the buoy technology and to test if this platform and sensors can effectively measure CO_2 uptake from mCDR.

The NexSens buoy (Fondriest Environmental, Inc.) is equipped with a Pro-Oceanus CO_2-Pro CV sensor to measure pCO_2 drawdown and is located approximately in Halifax Harbour 700 meters downstream of where a mCDR technology is installed. To ensure that the sensor data measured is of the highest quality, the researchers also collect bottle samples to cross-verify the data points.

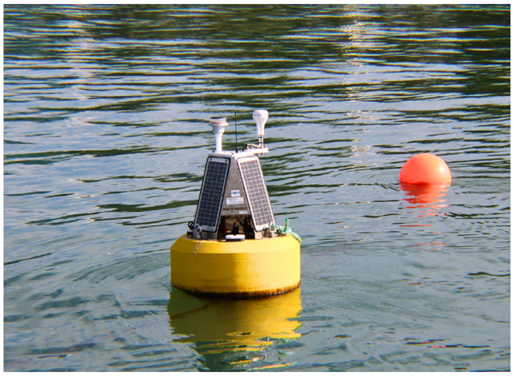

Figure 1: The Dalhousie buoy deployed in Halifax Harbour downstream from the mCDR site.

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The purpose of the NOC buoy is to serve as a fixed-point, open-ocean, scientific observatory in the Northeast Atlantic Ocean. The site has been operating since 1985 and is one of only a small number of oceanic sites that has achieved a timeseries dataset to the full ocean depth (4,850 m) over several decades. The main objective is to provide key information on the assessment of long-term changes in open ocean ecosystems.

The PAP1 buoy (Balmoral ODAS) is equipped with two Pro-Oceanus CO2-Pro Atmosphere sensors and the Autonomous Sensor Platform (ASP) located about 30 meters below the surface is equipped with a CO2-Pro CV and Mini TDGP.

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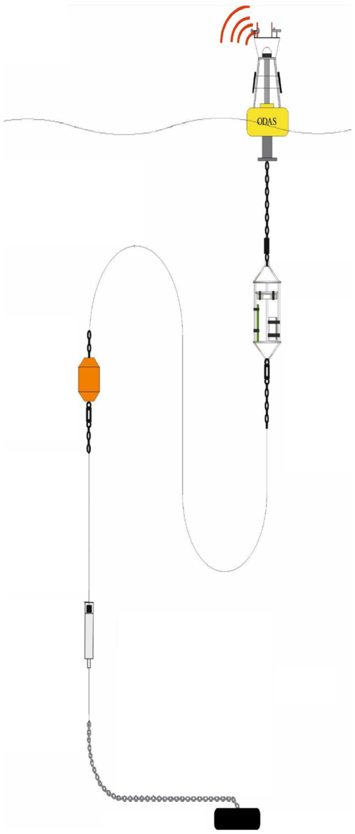

The PAP-SO site is located about midway between the European continental slope and the Mid-Atlantic Ridge. The station is considered a hybrid monitoring station with multiple moored instruments, annual cruises, use of autonomous vehicles, and sampling by partners of NOC being conducted.

Figure 2: Diagram of the NOC PAP-SO buoy in the water. Image from Hartman, 2019.

RESULTS

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As discussed above, several Pro-Oceanus sensors are integrated onto the PAP1 buoy either on the keel or the ASP. A suite of other chemical, biological, and physical oceanographic sensors are also integrated onto the buoy keel and ASP. Additionally, bottle samples are collected via a CTD for chemical and biological parameters during annual cruises to the PAP-SO site when routine recalibrations and maintenance are performed.

The CO_2-Pro Atmosphere on the buoy keel is configured to measure pCO_2 twice a day, with an Automatic Zero Point Calibration (AZPC) scheduled for every 12 hours. An additional CO_2-Pro Atmosphere has been added to the keel to serve as a backup and measures pCO_2 every 6 hours, with an AZPC scheduled every 12 hours. On the ASP, the CO_2-Pro CV has also been configured to measure every 8 hours and for an AZPC every 24 hours. Lastly, the Mini TDGP was configured to measure every thirty minutes and was equipped with a copper faceplate to help prevent biofouling of the sensor.

Unfortunately, during the 2018/19 deployment, the buoy power supply failed 40 days after deployment which also meant that the CO_2-Pro Atmosphere lost power and stopped collecting data. The CO_2-Pro CV on the ASP was able to continue collecting data during the year, which is in Figure 3a below from Hartman, 2019. During the 2022/23 deployment, the CO2-Pro Atmosphere functioned as expected until there was a failure with the humidity cell on November 4 (Figure 3b).

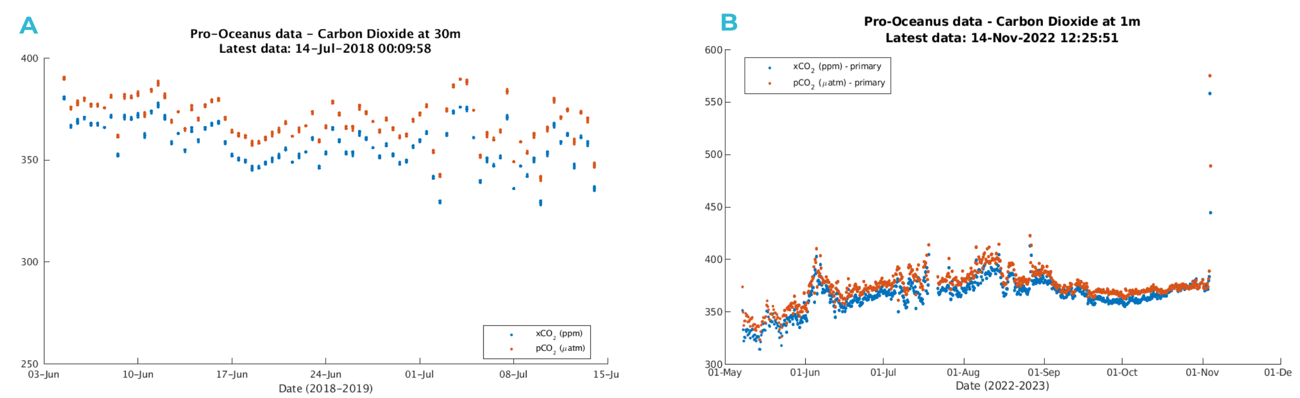

Figure 3: (A) pCO_2 data from the sensor frame in 2018. Figure modified from Hartman, 2019. (B) pCO_2 data from the buoy hull in 2022. Figure modified from Gates, 2023.

REFERENCES

Hartman, S. E. (2019). Water column and seafloor time-series studies at the Porcupine Abyssal Plain Sustained Observatory (Report No. 61) [Cruise Report]. Retrieved from https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/17223/.

Gates, A. R. (2023). Multidecadal Research at the Porcupine Abyssal Plain – Sustained Observatory (Report No. 76) [Cruise Report]. Retrieved from https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/18301/.

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PRO OCEANUS Dissolved Gas Sensors

80 Pleasant Street,
Bridgewater, Nova Scotia
Canada B4V 1N1

Phone +1-902-530-3550
sales@pro-oceanus.com
Pro-Oceanus.com