CASE STUDY 1.4:

Surface Ocean pCO_2 measurements using Voluntary Observing Ships

SUMMARY

Consistent year-over-year oceanographic studies have become increasingly difficult to implement with the high costs of operating research vessels for oceanographic monitoring. For many, surface ocean monitoring program's Voluntary Observing Ships (VOS) have shown to be a viable alternative to dedicated research cruises with teams of technical and scientific staff. VOS have generally been used for monitoring ocean parameters such as sea-surface temperature, salinity, and carbonate chemistry, including pCO_2, for ocean acidification research. The use of VOS serve as a valuable tool to make connections between the limited research cruise data, as well as to provide a more global understanding of patterns and changes in the world's oceans.

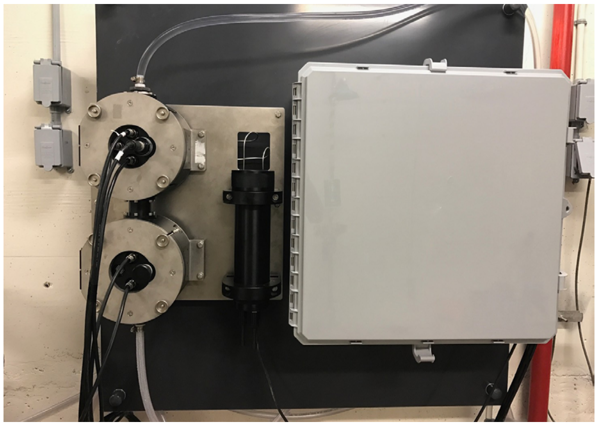
Accurate measurements of pCO_2 in the surface ocean are essential for determining the spatial and temporal distributions of ocean sources and sinks for anthropogenic CO_2. To acquire these measurements, the Joint Global Ocean Flux Study (JGOFS) Science Plan called for "seeding the oceans with pCO_2 sensors". A powerful additional means of measuring surface water pCO_2 is offered through making underway measurements from VOS while they conduct normal operations.

INTRODUCTION

Commercial vessels make regular transits on the ocean and can offer an excellent opportunity to collect important scientific data at a reduced cost, without the need for dedicated scientific vessels. The complicated logistics of oceanographic measurements has limited the amount of data that can be collected by VOS. The installation of oceanographic instruments requires a clean water supply, adequate flow rates, protection from biofouling, sufficient ship space, and availability of technical staff.

In order to make accurate underway measurements of surface water pCO_2, several requirements must be met. The system must be rugged, self-contained, and able to monitor continuously under high flow conditions over long periods of time unattended. These requirements are a major challenge for researchers and their VOS monitoring systems.

Pro-Oceanus worked with researchers and engineers at Dalhousie University to design and integrate a customized solution for measuring pCO_2 within a unique and compact shipboard flow-through monitoring system from Aanderaa, the SOOGUARD FerryBox System.



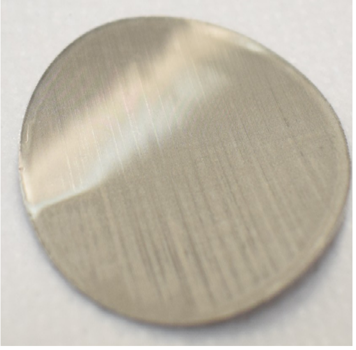


Figure 1 (left): Customized SOOGuard System with integrated CO_2-Pro CV sensor installed.

Figure 2 (right): EnduraFlux™ Multi-Layer Membrane.

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Proof of integrity at elevated water pressure was required for ship certification, and to achieve this Pro-Oceanus utilized a design based on the submersible CO_2-Pro CV sensor to ensure adequate sealing of the entire system to 10 bar of water pressure.

The need for operability under high flow rates required modifications to the equilibration membrane design used in traditional sensors to ensure reliable, long-term measurements could be achieved. Pro-Oceanus developed a new multi-layered semi-permeable membrane to overcome this substantial barrier. This new membrane, EnduraFlux™, is now used on all Pro-Oceanus products.

RESULTS

The first test run for this VOS system took place in April 2018 aboard the Irish vessel *Celtic Explorer* during the A02 Go-Ship Cruise on return crossings of the North Atlantic Ocean from Galway, Ireland, to St. John's, Newfoundland. The test was a comparison with the GO-8050 (General Oceanics, Miami, U.S.) and OceanPack2 (SubCTech GmbH, Kiel, Germany) systems. The GO-8050 is the most widely used and characterized system, thus the researchers compared all results to that of the GO-8050. The results of the comparison of the CO_2-Pro CV system to other systems was published by Arruda et al., 2019 and are also below in Figure 3.

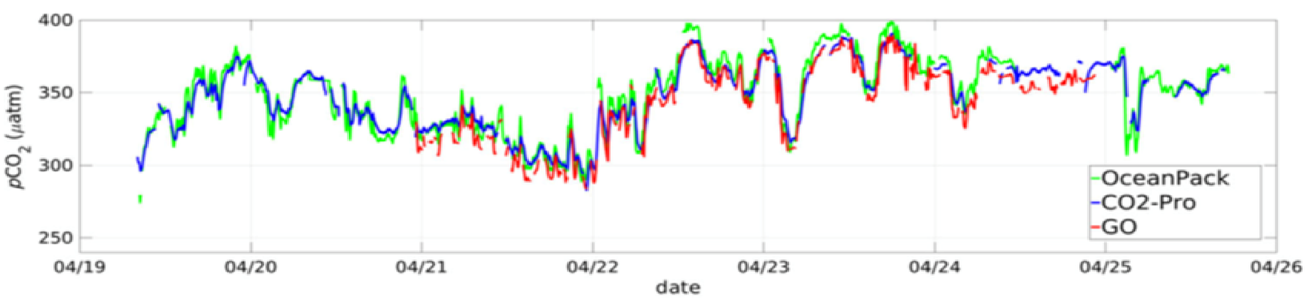

Figure 3: Comparison data between the three pCO_2 measurement systems on the first leg of the A02 Go-Ship Cruise. Figure from Arruda et al., 2019.

Researchers, Dr. Douglas Wallace and Dr. Dariia Atamanchuk, partnered with Atlantic Towing Services to provide real-time underway measurements of water quality using the new VOS system onboard the *Atlantic Condor*, a multi-purpose offshore supply vessel. The Condor makes weekly return trips from Dartmouth, Nova Scotia to the Deep Panuke gas platform off Sable Island on the Scotian Shelf of Atlantic Canada. The data collected is used for understanding local processes in the coastal and near-shore ocean.

Figure 4: The Atlantic Condor in port in Halifax, Nova Scotia, Canada. Figure from dal.ca.

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More recent results of the system on return transects from Dartmouth, NS to the Deep Panuke Natural Gas platform on the Scotian Shelf reveal a range of interesting features that were not measured previously.

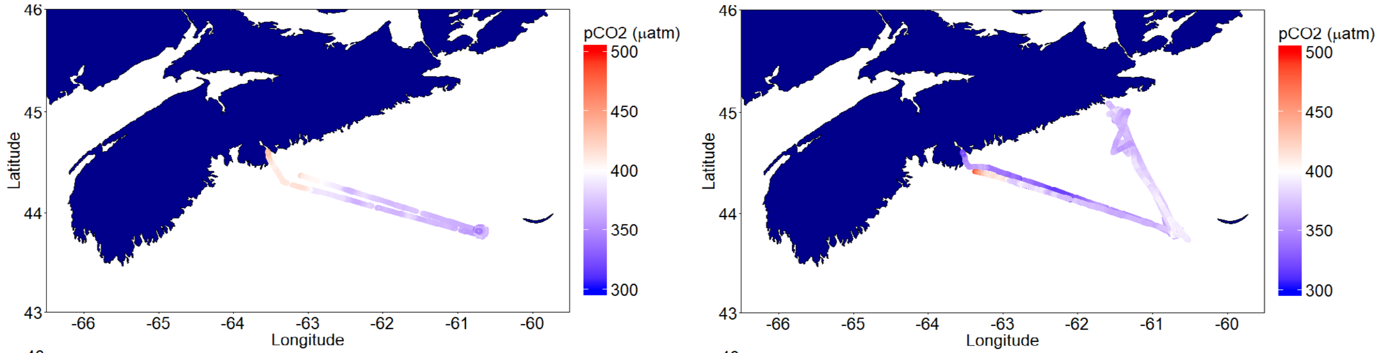

Figure 5: Data from the underway system on the *Atlantic Condor* comparing the observations in February and May, they show the seasonal change of pCO_2 before and during the spring bloom. Figure from dal.ca.

REFERENCES

Arruda, R., Atamanchuk, D., Cronin, M., Steinhoff, T. and Wallace, D.W.R. (2020). At-sea intercomparison of three underway pCO_2 systems. Limnol Oceanogr Methods, 18: 63-76. https://doi.org/10.1002/lom3.10346

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