

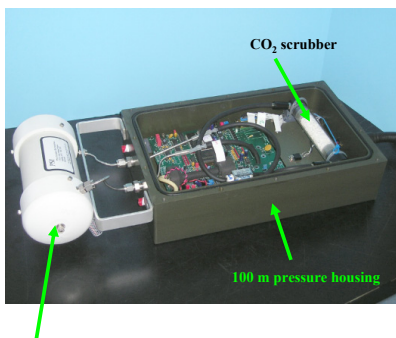
Preliminary Results Using a New Fast Response Infra-Red Absorption $p\text{CO}_2$ Sensor

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IR Module

The IR analyzer is an NDIR analyzer with the following specifications:

- Range 0-700 ppm
- Linearity < 1%
- Response time 1.6 seconds
- Power drain: ~ 9 W at 12 V
- Long term stability is controlled by an internal auto-calibration mode that uses a CO_2 -scrubbed air stream to provide a **periodic zero calibration (PZC)**

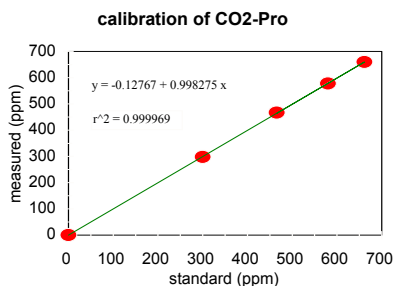


Fast response membrane interface

The gas-water membrane interface is designed to be flushed for profiling applications. The interface has been tested over a depth range of 0-350 m during several months and has proved to be very reliable. The membrane material is PDMS (polydimethylsiloxane), patent pending by Pro-Oceanus Systems, Inc.

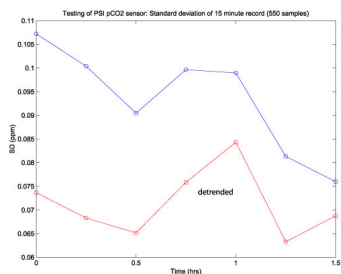
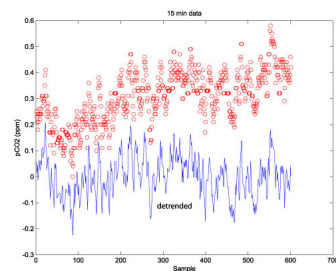
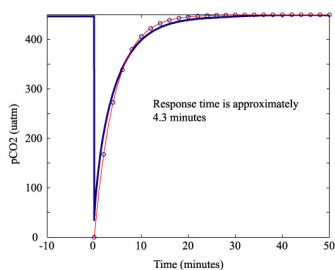
Calibration

Performed using standard gas mixtures (air phase). The calibrations below were performed 6 months after original calibrations and several field tests. Noting that the module automatically updates with PZC information, the sensor's output remained linear to within 1.4 ppm (0.2%) over this period.



Laboratory Tests

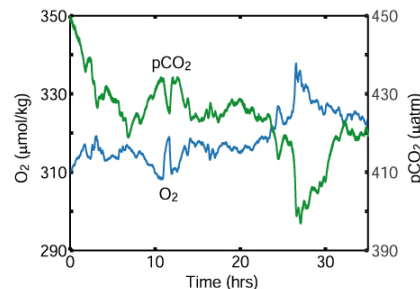
Tests performed in precision temperature controlled water bath. The variance between individual measurements is around ± 0.1 ppm. The SD of the 15 min average (~550 samples) is around 0.075 ppm.



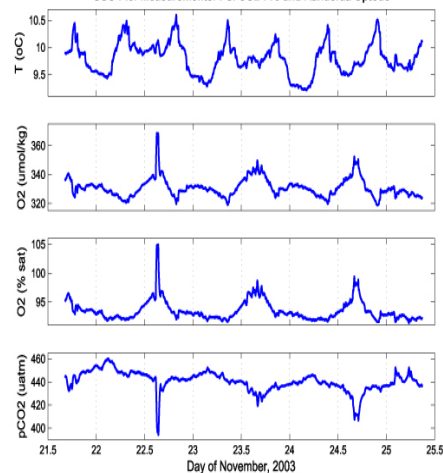
ABSTRACT: We present laboratory and first sea trials of a flexible design IR absorption $p\text{CO}_2$ sensor. The sensor is designed to be useful in moored, underway and profiling applications. The sensor consists of a self-calibrating IR absorption module and a fast-response membrane inlet equilibrator. In moored mode the auto-calibration feature is designed to enable long-term accurate measurements. In profiling mode the instrument can take advantage of the very fast-response membrane interface to allow real-time vertical profiling. The instrument outputs a continuous, calibrated, serial data stream.

Measurements in Narragansett Bay, RI

Supporting data: include water temperature (T) and dissolved oxygen (O_2) recorded by an Aanderaa optode. Notice the strong biologically induced inverse relationship between $p\text{CO}_2$ and O_2 .

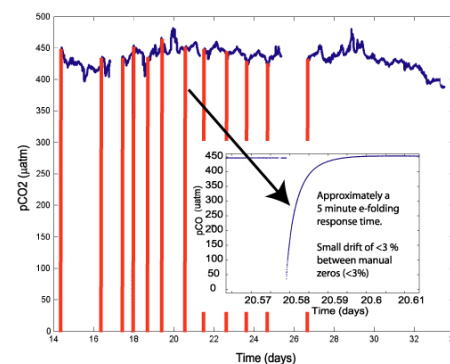


GSO Pier Measurements: PSI CO2-Pro and Aanderaa Optode



Raw data analysis

Raw data: Manual PZC's indicated by red lines. The insert shows the response time of the sensor recovering from a manual zero-calibration to be around 5 minutes. The PZC's provide a record of sensor drift. This is then used to calibrate the sensor. The sensor can be configured for automatic PZC's at any time interval specified by the user.



Overall Performance

Based on these developments, we assess that the $p\text{CO}_2$ sensor has the potential for absolute accuracy of individual measurements of ± 0.75 ppm and a precision of 0.05 ppm. Absolute conversions to $f\text{CO}_2$ in seawater (μatm) requires various assumptions regarding the difference in optical absorption for water vapor versus that of CO_2 in the optical cell. However, as the cell's gas sample has a known and constant relative humidity, these corrections should be linear and accountable by waterbath calibrations. This is work in progress. Response time is presently 4-5 minutes when pumped, but we expect this can be significantly reduced with membrane interface modifications. The depth rating of 100 m can be increased using a larger cylindrical housing. The main drawback for moored mode use is power drain. Typically, the optical cell is held at 55 $^{\circ}\text{C}$, but we have tested it at 40 $^{\circ}\text{C}$ to help reduce power consumption. Warm-up time is a few minutes. Certainly further refinements can be applied to the initial sensor, and in-situ comparisons with other systems are required.

Acknowledgements: The CO_2 -Pro™ sensor is being developed by Pro-Oceanus Systems, Inc. (Halifax, NS, Canada and Narragansett, RI, USA) with financial assistance from the National Research Council of Canada.