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Title: Surface seawater and marine boundary layer CO₂ observations from October 2023 to December 2023 made from the Kwakshua Channel (KC) Buoy on the central coast of British Columbia

Abstract: Kwakshua Channel, located near Fitz Hugh Sound on the central coast of British Columbia, has been a site for moored, high-resolution measurements of surface seawater and marine boundary layer CO₂ content since May 2018. Measurements of in situ temperature, salinity, seawater and atmospheric CO₂ partial pressure are made using a Battelle Seaology (MApCO₂) System. This data contribution consists of measurements from October 16, 2023 to December 21, 2023.

Cite as: Evans, W., K. Pocock, S. Hateley, and J. Barrette (2025). Surface seawater and marine boundary layer CO₂ observations from October 2023 to December 2023 made from the Kwakshua Channel (KC) Buoy on the central coast of British Columbia. Version 1.0. Hakai Institute. Dataset. [access date].

Type of Study: Measurements of surface ocean and marine boundary layer CO₂ from a surface buoy

Temporal Coverage: October 16, 2023 to December 21, 2023

Spatial Coverage: Surface ocean and marine boundary layer CO₂ measurements from the mouth of Kwakshua Channel; Fitz Hugh Sound; central British Columbia coast; 51.6507°N, 127.9697°W

Geographic Names: Kwakshua Channel; Fitz Hugh Sound; central British Columbia coast; Gulf of Alaska; North Pacific Ocean

Expocode: 187F20221129

Platforms: KC Buoy

Version: 1.0

Submission Date: January 13, 2025

Change log:

This is Version 1.0 of this dataset.

Sampling frequencies:

October 2023 - December 2023: 1 hour

Data processing segments:
October 2023 - December

Flagging windows:
Only data flagged was during an equilibrator pressure issue in December.

Dataset Metadata note:
As part of the QC process, a trend analysis is performed on the CO₂ measurements in which an average xCO₂ and standard deviation is computed over a set time window around each value (i.e. number of points on each side of the measurement). These values are then compared to the measured xCO₂ to determine whether the measurement should be flagged. Due to the variable nearshore environment of the deployment location, the flagging range used in the QC of this record was decreased from the default of 48 points on each side of the measurement (with a 3-hour sample frequency) to 3 points on each side of the measurement.

Filename: KC_BUOY_Oct2023_Dec2023.csv

Data dictionary / header information:

- (1) Mooring Name: Name/description of mooring
- (2) Latitude: Mooring latitude in decimal degrees
- (3) Longitude: Mooring longitude in decimal degrees
- (4) Date: UTC date (mm/dd/yyyy)
- (5) Time: UTS time (hh:mm)
- (6) xCO₂ SW (wet): (umol/mol) Mole fraction of CO₂ in air in equilibrium with the seawater at sea surface temperature and measured humidity
- (7) CO₂ SW QF: Flag for xCO₂ sw (wet)
- (8) H₂O SW: (mmol/mol) Mole fraction of H₂O in air from equilibrator
- (9) xCO₂ Air (wet): (umol/mol) Mole fraction of CO₂ in air from airblock, 4 feet above the sea surface at measured humidity.
- (10) CO₂ Air QF: Quality Flag for xCO₂ Air (wet)
- (11) H₂O Air: (mmol/mol) Mole fraction of H₂O in air from airblock, 4 feet above the sea surface.
- (12) Licor Atm Pressure: (hPa) Atmospheric pressure at the airblock, 4 feet above the sea surface.
- (13) Licor Temp: (C) Temperature of the Infrared Licor 820 in degrees Celsius.
- (14) MAPCO₂ %O₂: The percent oxygen of the surface seawater divided by the percent oxygen of the atmosphere at 4 feet above the sea surface. Disclaimer: The oxygen measurement is made in the equilibrated air and does not come to complete equilibrium therefore this measurement is qualitative and for diagnostic use only.
- (15) SST: (C) Sea Surface Temperature.
- (16) Salinity: Sea Surface Salinity on the practical scale.
- (17) xCO₂ SW (dry): (umol/mol) Mole fraction of CO₂ in air in equilibrium with the seawater at sea surface temperature (dry air).
- (18) xCO₂ Air (dry): (umol/mol) Mole fraction of CO₂ in air at the airblock, 4 feet above the sea surface (dry air).

- (19) $f\text{CO}_2$ SW (sat): (uatm) Fugacity of CO_2 in air in equilibrium with the seawater at sea surface temperature (100% humidity). Since the measurements are taken at the sea surface, warming calculations are not necessary.
- (20) $f\text{CO}_2$ Air (sat): (uatm) Fugacity of CO_2 in air at the airblock, 4 feet above the sea surface (100% humidity)
- (21) $df\text{CO}_2$: Difference of the fugacity of the CO_2 in seawater and the fugacity of the CO_2 in air ($f\text{CO}_2$ SW - $f\text{CO}_2$ Air).
- (22) $p\text{CO}_2$ SW (sat): (uatm) Partial Pressure of CO_2 in air in equilibrium with the seawater at sea surface temperature (100% humidity)
- (23) $p\text{CO}_2$ Air (sat): (uatm) Partial Pressure of CO_2 in air at the airblock, 4 feet above the sea surface (100% humidity).
- (24) $dp\text{CO}_2$: Difference of the partial pressure of CO_2 in seawater and air ($p\text{CO}_2$ SW - $p\text{CO}_2$ Air).

Researcher Contact: Please direct questions regarding these data to Wiley Evans (wiley.evans@hakai.org).

Researcher institution: Hakai Institute

Core Variables:

Seawater partial pressure of carbon dioxide at sea surface temperature

Abbreviation: $p\text{CO}_2$ SW (sat)

Unit: μatm

Observation type: Measurements from moored buoy with M ApCO_2 system

In-situ/Manipulation/Response variable: In situ observation

Measured or calculated: Calculated from measured CO_2 mole fractions ($x\text{CO}_2$) and ambient atmospheric pressure.

Sampling instrument: M ApCO_2 equilibrator

Analyzing instrument: Battelle Seaology (M ApCO_2) System with LI-COR LI-820

Detailed sampling and analyzing information: All measurements are at sea surface temperature and atmospheric pressure. During the equilibration cycle, a closed loop of air equilibrates with seawater for 10 minutes. Once the equilibration period is complete, the pump stops and the system opens to the atmosphere allowing the pressure to equilibrate with atmospheric pressure. Measurements are recorded for 30 seconds at 2 Hz and then averaged. During the air cycle, fresh air is pumped through the detector for 1 minute. Once the pump stops, the system opens to the atmosphere allowing the pressure to equilibrate with atmospheric pressure. Measurements are recorded for 30 seconds at 2 Hz and then averaged. The gas streams for both the air cycle and equilibrator cycle are partially dried before entering the detector. The values listed as wet $x\text{CO}_2$ generally have relative humidity levels ranging from 40 to 80 percent. The humidity levels increase over the course of a deployment. Sampling occurs every 60 minutes. The infrared detector is calibrated at the beginning of every sampling period using a zero and span gas. To calculate the dry measurements, the water mole fraction in the Licor detector is measured using a relative humidity sensor located immediately downstream of the detector.

Replicate information: N/A

Standardization description: Measurements calibrated using onboard zero and span gas with a known concentration. Span gas used to generate this dataset was 900.67 ppm from Linde. Linde standard gas was re-calibrated in the laboratory using a zero (N₂) and span gas (NOAA Earth System Research Laboratory WMO CO₂_x2019_extended scale 1567.44 ppm) that bracketed the standard gas concentration.

Standardization frequency: Every measurement

CRM manufacturer: Linde and ESRL

Poison name: N/A

Poison volume: N/A

Poison correction: N/A

Uncertainty: 2 ppm for calibrated xCO₂; ~2 µatm for pCO₂

Quality flag convention: No quality flag applied

Method reference: Sutton, A.J., Sabine, C.L., Maenner-Jones, S., Lawrence-Slavas, N., Meinig, C., Feely, R.A., Mathis, J.T., Musielewicz, S., Bott, R., McLain, P.D., Fought, H.J., and Kozyr, A. (2014). A high-frequency atmospheric and seawater pCO₂ data set from 14 open-ocean sites using a moored autonomous system. *Earth System Science Data* 6, 353-366.

Researcher name: Wiley Evans

Researcher institution: Hakai Institute

Atmospheric partial pressure of carbon dioxide

Abbreviation: ATM pCO₂ wet

Unit: µatm

Observation type: Measurements from air intake on M/V Columbia foredeck

In-situ/Manipulation/Response variable: In situ observation

Measured or calculated: Calculated from measured CO₂ mole fractions (xCO₂) and ambient atmospheric pressure.

Sampling instrument: Air intake

Analyzing instrument: Battelle Seaology (MApCO₂) with LI-COR LI-820

Detailed sampling and analyzing information: All measurements are at sea surface temperature and atmospheric pressure. During the equilibration cycle, a closed loop of air equilibrates with seawater for 10 minutes. Once the equilibration period is complete, the pump stops and the system opens to the atmosphere allowing the pressure to equilibrate with atmospheric pressure. Measurements are recorded for 30 seconds at 2 Hz and then averaged. During the air cycle, fresh air is pumped through the detector for 1 minute. Once the pump stops, the system opens to the atmosphere allowing the pressure to equilibrate with atmospheric pressure. Measurements are recorded for 30 seconds at 2 Hz and then averaged. The gas streams for both the air cycle and equilibrator cycle are partially dried before entering the detector. The values listed as wet xCO₂ generally have relative humidity levels ranging from 40 to 80 percent. The humidity levels increase over the course of a deployment. Sampling occurs every 60 minutes. The infrared detector is calibrated at the beginning of every sampling period using a zero and span gas. To calculate the dry measurements, the water mole fraction in the Licor detector is measured using a relative humidity sensor located immediately downstream of the detector.

Replicate information: N/A

Standardization description: Measurements calibrated using onboard zero and span gas with a known concentration. Span gas used to generate this dataset was 900.67 ppm from Linde. Linde

standard gas was re-calibrated in the laboratory using a zero (N₂) and span gas (NOAA Earth System Research Laboratory WMO CO₂_x2019_extended scale 1567.44 ppm) that bracketed the standard gas concentration.

Standardization frequency: Every measurement

CRM manufacturer: Linde and ESRL

Poison name: N/A

Poison volume: N/A

Poison correction: N/A

Uncertainty: 2 ppm for calibrated xCO₂; ~2 µatm for pCO₂

Quality flag convention: No quality flag applied

Method reference: Sutton, A.J., Sabine, C.L., Maenner-Jones, S., Lawrence-Slavas, N., Meinig, C., Feely, R.A., Mathis, J.T., Musielewicz, S., Bott, R., Mclain, P.D., Fought, H.J., and Kozyr, A. (2014). A high-frequency atmospheric and seawater pCO₂ data set from 14 open-ocean sites using a moored autonomous system. *Earth System Science Data* 6, 353-366.

Researcher name: Wiley Evans

Researcher institution: Hakai Institute

Sea surface temperature

Abbreviation: Intake T

Unit: °C, ITS-90 scale

Observation type: Measurements from surface buoy (1 m depth)

In-situ/Manipulation/Response variable: In situ observation

Measured or calculated: Measured

Sampling instrument: N/A

Analyzing instrument: SBE16plusV2

Detailed sampling and analyzing information: Data captured using a Campbell Scientific data logger onboard the surface buoy

Replicate information: N/A

Standardization description: N/A

Standardization frequency: N/A

CRM manufacturer: N/A

Poison name: N/A

Poison volume: N/A

Poison correction: N/A

Uncertainty: 0.005°C

Quality flag convention: No quality flag applied

Method reference:

Researcher name: Wiley Evans

Researcher institution: Hakai Institute

Seawater Salinity

Abbreviation: TSG Salinity

Unit: 1978 Practical Salinity Scale

Observation type: Measurements from surface buoy (1 m depth)

In-situ/Manipulation/Response variable: In situ observation

Measured or calculated: Calculated from conductivity and temperature measurements

Sampling instrument: N/A

Analyzing instrument: SBE16plusV2

Detailed sampling and analyzing information: Data captured using a Campbell Scientific data logger onboard the surface buoy

Replicate information: N/A

Standardization description: N/A

Standardization frequency: N/A

CRM manufacturer: N/A

Poison name: N/A

Poison volume: N/A

Poison correction: N/A

Uncertainty: 0.0005 S/m

Quality flag convention: No quality flag applied

Method reference:

Researcher name: Wiley Evans

Researcher institution: Hakai Institute