

<b>Dataset Expocode</b>	<b>316420220823</b>
<b>Primary Contact</b>	<b>Name:</b> Roman Battisti <b>Organization:</b> NOAA/PMEL <b>Address:</b> 7600 Sand Point Way NE Seattle, WA 98115-6349 <b>Phone:</b> <b>Email:</b> roman.battisti@noaa.gov
<b>Investigator</b>	<b>Name:</b> Dr. Adrienne Sutton <b>Organization:</b> NOAA/PMEL <b>Address:</b> 7600 Sand Point Way NE Seattle, WA 98115-6349 <b>Phone:</b> (206) 526-6879 <b>Email:</b> Adrienne.Sutton@noaa.gov
<b>Dataset</b>	<b>Funding Info:</b> NOAA <b>Initial Submission (yyyymmdd):</b> 11/05/2024 <b>Revised Submission (yyyymmdd):</b>
<b>Campaign/Cruise</b>	<b>Expocode:</b> 316420220823 <b>Campaign/Cruise Name:</b> <b>Campaign/Cruise Info:</b> <b>Platform Type:</b> <b>CO2 Instrument Type:</b> <b>Survey Type:</b> Moored Buoy <b>Vessel Name:</b> <b>Vessel Owner:</b> <b>Vessel Code:</b> TAO1
<b>Coverage</b>	<b>Start Date (yyyymmdd):</b> 20220823 <b>End Date (yyyymmdd):</b> 20230818 <b>Westernmost Longitude:</b> 165.027 E <b>Easternmost Longitude:</b> 165.027 E <b>Northernmost Latitude:</b> 0.009 N <b>Southernmost Latitude:</b> 0.009 N
<b>Variable</b>	<b>Name:</b> Date Time <b>Unit:</b> <b>Description:</b> Date and Time (UTC)
<b>Variable</b>	<b>Name:</b> xCO2 SW (wet) <b>Unit:</b> <b>Description:</b> (umol/mol) Mole fraction of CO2 in air in equilibrium with the seawater at sea surface temperature and measured humidity.
<b>Variable</b>	<b>Name:</b> CO2 SW QF <b>Unit:</b> <b>Description:</b> Flag for xCO2 sw (wet)
<b>Variable</b>	<b>Name:</b> H2O SW <b>Unit:</b> <b>Description:</b> (mmol/mol) Mole fraction of H2O in air from equilibrator.
<b>Variable</b>	<b>Name:</b> xCO2 Air (wet) <b>Unit:</b> <b>Description:</b> umol/mol) Mole fraction of CO2 in air from airblock, 4 feet above the sea surface at measured humidity.
<b>Variable</b>	<b>Name:</b> CO2 Air QF

**Unit:**  
**Description:** Quality Flag for xCO<sub>2</sub> Air (wet)

**Variable**

**Name:** H<sub>2</sub>O Air

**Unit:**

**Description:** (mmol/mol) Mole fraction of H<sub>2</sub>O in air from airblock, 4 feet above the sea surface.

**Variable**

**Name:** Licor Atm Pressure

**Unit:**

**Description:** (hPa) The air intake is approximately 1 m above the sea surface. For equilibration-based systems deployed on autonomous surface platforms, the air-sea equilibration also occurs at the sea surface, so Atmospheric Pressure reported here is equivalent to Equilibrator Pressure (P<sub>eq</sub>).

**Variable**

**Name:** Licor Temp

**Unit:**

**Description:** (C) Temperature of the Infrared Licor 820 in degrees Celsius.

**Variable**

**Name:** MAPCO<sub>2</sub> %O<sub>2</sub>

**Unit:**

**Description:** 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. We have found that the oxygen does not come to complete equilibrium so any rapid changes in oxygen do not get properly captured using this system. Therefore, we tend to use the oxygen data only as a qualitative sense of the biology. It is not a quantitative measure.

**Variable**

**Name:** SST

**Unit:**

**Description:** (C) Sea Surface Temperature. For equilibration-based systems deployed on autonomous surface platforms, the air-sea equilibration occurs at the sea surface, so SST reported here is equivalent to Equilibrator Temperature (T<sub>eq</sub>). This means that there is no warming between in situ SST and T<sub>eq</sub> as on ship-based equilibrator-based pCO<sub>2</sub> systems.

**Variable**

**Name:** Salinity

**Unit:**

**Description:** (PSU) Sea Surface Salinity.

**Variable**

**Name:** xCO<sub>2</sub> SW (dry)

**Unit:**

**Description:** (umol/mol) Mole fraction of CO<sub>2</sub> in air in equilibrium with the seawater at sea surface temperature (dry air).

**Variable**

**Name:** xCO<sub>2</sub> Air (dry)

**Unit:**

**Description:** (umol/mol) Mole fraction of CO<sub>2</sub> in air at the airblock, 4 feet above the sea surface (dry air).

**Variable**

**Name:** fCO<sub>2</sub> SW (sat)

**Unit:**

**Description:** (uatm) Fugacity of CO<sub>2</sub> 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.

**Variable**

**Name:** fCO<sub>2</sub> Air (sat)

**Unit:**

**Description:** (uatm) Fugacity of CO<sub>2</sub> in air at the airblock, 4 feet above the sea surface (100% humidity).

**Variable**

**Name:** dfCO<sub>2</sub>

**Unit:**

**Description:** Difference of the fugacity of the CO<sub>2</sub> in seawater and the fugacity of the CO<sub>2</sub> in air (fCO<sub>2</sub> SW - fCO<sub>2</sub> Air).

**Variable**

**Name:** pCO<sub>2</sub> SW (wet)

**Unit:**

**Description:** (uatm) Partial Pressure of CO<sub>2</sub> in air in equilibrium with the seawater at sea surface temperature (100% humidity)

**Variable**

**Name:** pCO<sub>2</sub> Air (wet)

**Unit:**

**Description:** (uatm) Partial Pressure of CO<sub>2</sub> in air at the airblock, 4 feet above the sea surface (100% humidity).

**Variable**

**Name:** dpCO<sub>2</sub>

**Unit:**

**Description:** Difference of the partial pressure of CO<sub>2</sub> in seawater and air (pCO<sub>2</sub> SW - pCO<sub>2</sub> Air)

**Variable**

**Name:** pH SW

**Unit:**

**Description:** pH of Seawater (total scale)

**Variable**

**Name:** pH QF

**Unit:**

**Description:** Quality Flag for pH

**Variable**

**Name:** CHL

**Unit:**

**Description:** Total Chlorophyll (ug/l)

**Variable**

**Name:** CHL QF

**Unit:**

**Description:** Quality Flag for CHL

**Variable**

**Name:** NTU

**Unit:**

**Description:** Nephelometric Turbidity Unit(NTU Units)

**Variable**

**Name:** NTU QF

**Unit:**

**Description:** Quality Flag for NTU

**Variable**

**Name:** DOXY

**Unit:**

**Description:** Salinity-Compensated dissolved oxygen(umol/kg)

**Variable**

**Name:** DOXY QF

**Unit:**

**Description:** Quality Flag for DOXY

**Sea Surface  
Temperature**

**Location:** 1m

**Manufacturer:** SeaBird

**Model:** ATLAS Temperature and Salinity Module

**Accuracy:** < 0.01 (°C if units not given)

**Precision:** (°C if units not given)

**Calibration:** ~ Annually by SeaBird

**Comments:** Temperature data are internally recorded and collected during the equilibration period. Data are not post-calibrated. Annual drift for this deployment was minimal and does not impact the fCO<sub>2</sub> and pCO<sub>2</sub> calculations (within the degree of accuracy of the CO<sub>2</sub> measurement). Contact us if you would like the CTD post-calibration information.

**Sea Surface Salinity**

**Location:** 1m

**Manufacturer:** SeaBird

**Model:** ATLAS Temperature and Salinity Module

**Accuracy:** < 0.05

**Precision:**

**Calibration:** ~ Annually by SeaBird

**Comments:** Conductivity data are internally recorded and collected during the equilibration period. Data are not post-calibrated. Annual drift for this deployment was minimal and does not impact the fCO<sub>2</sub> and pCO<sub>2</sub> calculations (within the degree of accuracy of the CO<sub>2</sub> measurement). Contact us if you would like the CTD post-calibration information.

**Atmospheric Pressure**

**Location:** 1m height

**Normalized to Sea Level:**

**Manufacturer:** LICOR

**Model:** LICOR 820

**Accuracy:** 2 hPa (hPa if units not given)

**Precision:** 1 hPa (hPa if units not given)

**Calibration:** Compared annually with Paros 765 Pressure Standard

**Comments:**

**Atmospheric CO<sub>2</sub>**

**Measured/Frequency:** yes, 3hr cycle

**Intake Location:** unused

**Drying Method:** unused

**Atmospheric CO<sub>2</sub> Accuracy:** 1 uatm

**Atmospheric CO<sub>2</sub> Precision:** 0.6 uatm

**Aqueous CO<sub>2</sub> Equilibrator Design**

**System Manufacturer:**

**Intake Depth:** 14cm - 20cm

**Intake Location:**

**Equilibration Type:** Bubble Equilibrator

**Equilibrator Volume (L):** N/A

**Headspace Gas Flow Rate (ml/min):** ~600 cc/min

**Equilibrator Water Flow Rate (L/min):** N/A

**Equilibrator Vented:** Yes

**Equilibration Comments:**

**Drying Method:**

**Aqueous CO<sub>2</sub> Sensor Details**

**Measurement Method:** Absolute, non-dispersive infrared (NDIR) gas analyzer

**Method details:**

**Manufacturer:** Licor

**Model:** LI-820

**Measured CO<sub>2</sub> Values:**

**Measurement Frequency:** 3hr cycle

**Aqueous CO<sub>2</sub> Accuracy:** 2 uatm

**Aqueous CO<sub>2</sub> Precision:** 0.7 uatm

**Sensor Calibrations:**

**Calibration of Calibration Gases:** At the beginning of each sample, the instrument self-calibrates using a zero and high standard. The zero standard is generated by cycling a small amount of air through a soda lime chamber. The high standard is from a cylinder of calibrated standard reference gas, 548.95  $\mu\text{mol/mol}$ , from ESRL. ESRL standards are traceable to WMO scale. All standard values were obtained from the most current WMO/GAW scale at the time of the start of the deployment. For more information on estimates of accuracy and precision of the MAPCO<sub>2</sub> system, see Sutton et al. 2014 (reference below).

**Number Non-Zero Gas Standards:**

**Calibration Gases:**

NOAA Earth System Research & Laboratory (ESRL)

**Comparison to Other CO<sub>2</sub> Analyses:**

**Comments:**

**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, J., Kozyr, A., 2014b. A high-frequency atmospheric and seawater pCO<sub>2</sub> data set from 14 open ocean sites using a moored autonomous system. Earth Sys. Sci. Data, 6, doi: 10.5194/essd-6-353-2014, 353-366.

**Equilibrator  
Temperature Sensor**

**Location:**

**Manufacturer:**

**Model:**

**Accuracy:** ( $^{\circ}\text{C}$  if units not given)

**Precision:** ( $^{\circ}\text{C}$  if units not given)

**Calibration:**

**Comments:**

**Equilibrator  
Pressure Sensor**

**Location:**

**Manufacturer:**

**Model:**

**Accuracy:** (hPa if units not given)

**Precision:** (hPa if units not given)

**Calibration:**

**Comments:**

**Other Sensor**

**Description:**

**Manufacturer:** Maxtec Oxygen Sensor

**Model:** Max-250

**Accuracy:** 2.0% Full Scale over operating temperature range. 1.0% Full Scale @ constant temperature and pressure

**Precision:**

**Calibration:** Factory calibrated before purchase. Recalibrated to sea level atmospheric air every 7 days

**Comments:**

**Other Sensor**

**Description:**

**Manufacturer:** Sensirion Humidity Sensor

**Model:** SHT71

**Accuracy:** > 0.01%

**Precision:**

**Calibration:** Factory calibrated before purchase.

**Comments:**

## Additional Information

### Suggested QC flag from Data Provider:

**Additional Comments:**

- o All measurements are at sea surface temperature and atmospheric pressure.
- o 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 hertz and then averaged.
- o 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 hertz and then averaged.
- o The gas streams for both the air cycle and equilibrator cycle are partially dried before entering the detector. The values listed as wet xCO<sub>2</sub> generally have relative humidity levels ranging from 40 to 80 percent. The humidity levels increase over the course of a deployment.
- o Sampling occurs every 3 hours. The infrared detector is calibrated at the beginning of every sampling period. Averaged data and standard deviations for each measurement are transmitted back daily.
- o To calculate the dry measurements, the water mole fraction in the Licor detector must be known. A relative humidity sensor is located immediately downstream of the detector.
- o As part of the QC process, each data set is compared with the Marine Boundary Layer (MBL) data from GlobalView-CO<sub>2</sub>.
- o As part of the QC process, xCO<sub>2</sub> air measurements are compared to the following data sets when available: previous MAPCO<sub>2</sub> deployment if overlap on recovery/deployment, following MAPCO<sub>2</sub> deployment if overlap on recovery/deployment, and Marine Boundary Layer (MBL) xCO<sub>2</sub> air data from GlobalView-CO<sub>2</sub>. The available comparison data sets are in good agreement with the MAPCO<sub>2</sub> air data and no adjustment was made. Dlugokencky, E.J., K.W. Thoning, P.M. Lang, and P.P. Tans (2019), NOAA Greenhouse Gas Reference from Atmospheric Carbon Dioxide Dry Air Mole Fractions from the NOAA ESRL Carbon Cycle Cooperative Global Air Sampling Network. Data Path: [ftp://aftp.cmdl.noaa.gov/data/trace\\_gases/co2/flask/surface/](ftp://aftp.cmdl.noaa.gov/data/trace_gases/co2/flask/surface/).
- o MBL Data were last downloaded from ESRL on 09/24/2024
- o During the QC process, an adjustment to the Licor pressure is also made based on each sensor's bias to barometric pressure as measured in the lab. This system has Licor pressure bias of +0.300 applied. Averaged wet xCO<sub>2</sub> measurements are post-calibrated using a simple linear regression between original averaged measurements and span coefficients, a method similar to the post-cal established by the underway pCO<sub>2</sub> community as described here: Feely, R.A., R. Wanninkhof, H.B. Milburn, C.E. Cosca, M. Stapp, and P.P. Murphy, A new automated underway system for making high precision pCO<sub>2</sub> measurements onboard research ships, *Analytica Chim. Acta*, 377, 185-191, 1998.
- o Post calculation correlation between Licor temperature and coefficient is:  $\text{Licor coef} = -0.000663 * \text{Temp} + 0.7373$   $r^2 = 1$
- o During the QC process, the community-established calibration bias of 2 for the WET Labs ECO-series fluorometer was applied to these in situ fluorometric chlorophyll values. See: Roesler, C., and others. 2017. Recommendations for obtaining unbiased chlorophyll estimates from in situ chlorophyll fluorometers: A global analysis of WET Labs ECO sensors. *Limnol. Oceanogr.: Methods* 15: 572-585. doi:10.1002/lom3.10185.
- o Only nighttime measurements of chlorophyll (defined as 21:00 to 03:00 local time) are published, given the lack of validation data for correcting daytime quenching. All daytime measurements are flagged as missing (QF = 5). Calibration issues during deployment required a recalculation of span coefficients and subsequent xCO<sub>2</sub> measurements using lab test data. As all xCO<sub>2</sub> data were affected, they have been marked at minimum questionable.
- o No data = -999
- o calibration issue required xCO<sub>2</sub> recalculation from post-hoc

lab experiments. Recalculated data marked with minimum flag 3. o These data are made freely available to the public and the scientific community in the belief that their wide dissemination will lead to greater understanding and new scientific insights. The availability of these data does not constitute publication of the data. We rely on the ethics and integrity of the user to assure that PMEL receives fair credit for our work. Please send manuscripts using this data to PMEL for review before they are submitted for publication so we can insure that the quality and limitations of the data are accurately represented.

**Citation for this Dataset:**

Sutton, A., S. Maenner, S. Musielewicz, R. Battisti, S. Dougherty, R. Bott, and J. Osborne. 2022. High-resolution ocean and atmosphere pCO<sub>2</sub> time-series measurements from mooring TAO165E\_0N.

**Other References for this Dataset:**

None