

**Dataset Expocode** 33RO20140321

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**Dataset** **Funding Info:** NOAA Climate Observation Office/Climate Observations Division  
**Initial Submission (yyyymmdd):** 20160120  
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**Campaign/Cruise** **Expocode:** 33RO20140321  
**Campaign/Cruise Name:** RB1402  
**Campaign/Cruise Info:** TAO 95W/110W/125W/DART  
**Platform Type:**  
**CO2 Instrument Type:**  
**Survey Type:** Research Cruise  
**Vessel Name:** Ronald H. Brown  
**Vessel Owner:** NOAA  
**Vessel Code:** 33RO

**Coverage** **Start Date (yyyymmdd):** 20140321  
**End Date (yyyymmdd):** 20140408  
**Westernmost Longitude:** 114.7 W  
**Easternmost Longitude:** 79.6 W  
**Northernmost Latitude:** 14.4 S  
**Southernmost Latitude:** 16.2 N  
**Port of Call:** Arica, Chile  
**Port of Call:** San Diego, CA

**Variable** **Name:** xCO2\_EQU\_ppm  
**Unit:**  
**Description:** Mole fraction of CO2 in the equilibrator headspace (dry) at equilibrator temperature (ppm)

**Variable** **Name:** xCO2\_ATM\_ppm  
**Unit:**  
**Description:** Mole fraction of CO2 measured in dry outside air (ppm)

**Variable** **Name:** xCO2\_ATM\_interpolated\_ppm  
**Unit:**  
**Description:** Mole fraction of CO2 in outside air associated with each water analysis. These values are interpolated between the bracketing averaged good xCO2\_ATM analyses (ppm)

**Variable** **Name:** PRES\_EQU\_hPa  
**Unit:**  
**Description:** Barometric pressure in the equilibrator headspace (hectopascals)

**Variable** **Name:** PRES\_ATM@SSP\_hPa  
**Unit:**

**Description:** Barometric pressure measured outside, corrected to sea level (hectopascals)

**Variable**

**Name:** TEMP\_EQU\_C

**Unit:**

**Description:** Water temperature in equilibrator (degrees Celsius)

**Variable**

**Name:** SST\_C

**Unit:**

**Description:** Sea surface temperature (degrees Celsius)

**Variable**

**Name:** SAL\_permil

**Unit:**

**Description:** Sea surface salinity on Practical Salinity Scale (permil)

**Variable**

**Name:** fCO2\_SW@SST\_uatm

**Unit:**

**Description:** Fugacity of CO2 in sea water at SST and 100% humidity (microatmospheres)

**Variable**

**Name:** fCO2\_ATM\_interpolated\_uatm

**Unit:**

**Description:** Fugacity of CO2 in air corresponding to the interpolated xCO2 at SST and 100% humidity (microatmospheres)

**Variable**

**Name:** dfCO2\_uatm

**Unit:**

**Description:** Sea water fCO2 minus interpolated air fCO2 (microatmospheres)

**Variable**

**Name:** WOCE\_QC\_FLAG

**Unit:**

**Description:** Quality control flag for fCO2 values (2=good, 3=questionable)

**Variable**

**Name:** QC\_SUBFLAG

**Unit:**

**Description:** Quality control subflag for fCO2 values, provides explanation when QC flag=3

**Sea Surface Temperature**

**Location:** Bow thruster room, before sea water pump, ~5 m below water line.

**Manufacturer:** Seabird

**Model:** SBE-21

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

**Precision:** 0.001 °C (°C if units not given)

**Calibration:** Factory calibration

**Comments:** Manufacturer's resolution is taken as precision. Maintained by ship.

**Sea Surface Salinity**

**Location:** Attached to underway system at sea water input.

**Manufacturer:** Seabird

**Model:** SBE-45

**Accuracy:** ± 0.005 permil

**Precision:** 0.0002 permil

**Calibration:** Factory calibration.

**Comments:** Manufacturer's resolution is taken as precision.

**Atmospheric Pressure**

**Location:** On bulkhead exterior on the port side of the radio room aft of the bridge at ~14 m above the sea surface.

**Normalized to Sea Level:**

**Manufacturer:** Vaisala

**Model:** PTB330

**Accuracy:**  $\pm 0.2$  hPa (hPa if units not given)

**Precision:**  $\pm 0.08$  hPa (hPa if units not given)

**Calibration:** Factory calibration

**Comments:** Manufacturer's resolution is taken as precision. Maintained by ship.

## Atmospheric CO2

**Measured/Frequency:** Yes, 5 readings in a group every 3.25 hours.

**Intake Location:** Bow tower ~10 m above the sea surface.

**Drying Method:** Gas stream passes through a thermoelectric condenser (~5 °C) and then through a Perma Pure (Nafion) dryer before reaching the analyzer (90% dry).

**Atmospheric CO2 Accuracy:**  $\pm 0.2$  ppm

**Atmospheric CO2 Precision:** 0.01 ppm

## Aqueous CO2

### Equilibrator Design

**System Manufacturer:**

**Intake Depth:** 5 meters

**Intake Location:** Bow

**Equilibration Type:** Sprayhead above dynamic pool, with thermal jacket

**Equilibrator Volume (L):** 0.95 L (0.4 L water, 0.55 L headspace)

**Headspace Gas Flow Rate (ml/min):** 70 - 150 ml/min

**Equilibrator Water Flow Rate (L/min):** 1.5 - 2.0 L/min

**Equilibrator Vented:** Yes

**Equilibration Comments:** Primary equilibrator is vented through a secondary equilibrator

**Drying Method:** Gas stream passes through a thermoelectric condenser (~5 °C) and then through a Perma Pure (Nafion) dryer before reaching the analyzer (90% dry).

## Aqueous CO2

### Sensor Details

**Measurement Method:** Infrared absorption of dry sample gas.

**Method details:**

**Manufacturer:** LI-COR

**Model:** LI-6262

**Measured CO2 Values:**

**Measurement Frequency:** Every 150 seconds

**Aqueous CO2 Accuracy:**  $\pm 1$  microatmospheres

**Aqueous CO2 Precision:** 0.01 microatmosphere

**Sensor Calibrations:**

**Calibration of Calibration Gases:** The analyzer is calibrated every 3.25 hours with standards from ESRL in Boulder, CO that are directly traceable to the WMO scale. The zero gas is 99.9% nitrogen.

**Number Non-Zero Gas Standards:** 4

**Calibration Gases:**

ESRL in Boulder, CO. Std 1: CA06709, 284.75 ppm; Std 2: CA02813, 363.24 ppm; Std 3: CA07921, 423.57 ppm; Std 4: CA07931, 545.88 ppm

**Comparison to Other CO2 Analyses:**

**Comments:**

**Method Reference:**

Pierrot, D., C. Neil, K. Sullivan, R. Castle, R. Wanninkhof, H. Lueger, T. Johannson, A. Olsen, R. A. Feely, and C. E. Cosca (2009),

Recommendations for autonomous underway pCO2 measuring systems and data reduction routines, Deep-Sea Res II, 56, 512-522.

## Equilibrator

### Temperature Sensor

**Location:** In Hydro Lab, inserted into equilibrator ~ 5 cm below water line.

**Manufacturer:** Hart

**Model:** 1521  
**Accuracy:**  $\pm 0.025$  °C (°C if units not given)  
**Precision:**  $\pm 0.01$  °C (°C if units not given)  
**Calibration:** Factory calibration  
**Comments:**

**Equilibrator  
Pressure Sensor**

**Location:** Attached to CO2 analyzer exit to lab.  
**Manufacturer:** Setra  
**Model:** 270  
**Accuracy:**  $\pm 0.05$  hPa (hPa if units not given)  
**Precision:** 0.015 hPa (hPa if units not given)  
**Calibration:** Factory calibration.  
**Comments:** Pressure reading from the Setra-270 on the exit of the analyzer was added to the differential pressure reading from Setra-239 attached to the equilibrator headspace to yield the equilibrator pressure.

**Other Sensor**

**Description:**  
**Manufacturer:** Setra  
**Model:** 239  
**Accuracy:**  $\pm 0.052$  hPa  
**Precision:**  
**Calibration:** Factory calibration  
**Comments:** Pressure reading from the Setra-270 on the exit of the analyzer was added to the differential pressure reading from Setra-239 attached to the equilibrator headspace to yield the equilibrator pressure.

**Additional  
Information**

**Suggested QC flag from Data Provider:**  
**Additional Comments:** (1.) It was determined that there was a 2.68 minute offset between the SST data record from the SBE-21 in the bow and the Hart 1521 temperature sensor in the equilibrator. The SST data were interpolated using this offset to determine the SST at the time of the equilibrator measurement. (2.) A total of 8780 measurements were taken with 8765 flagged as good, 13 flagged as questionable, and 2 flagged as bad. All measurements flagged as 4 (bad) have been removed from the final data file. (3.) Licor pressure readings dropped from year day 82.881 to 83.058 and from year day 83.894 to 84.192 (approximately 8.5 hours total). During these two periods, the Licor pressure readings were replaced with readings from the ship's barometer, adding an offset of -0.155 hectopascals to correct for the difference between the two. The offset was determined by using the average difference between the 2 readings during an interval of approximately 24 hours where the readings were in the same range as the questionable Licor readings.

**Citation for this Dataset:**

Wanninkhof, R., R. D. Castle, and J. Shannahoff. 2013. Underway pCO<sub>2</sub> measurements aboard the R/V Ronald H. Brown during the 2014 cruises. [http://cdiac.ornl.gov/ftp/oceans/VOS\\_Ronald\\_Brown/RB2013/](http://cdiac.ornl.gov/ftp/oceans/VOS_Ronald_Brown/RB2013/). Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/OTG.VOS\_RB\_2012

**Other References for this Dataset:**

DOE (1994). Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water; version 2. DOE.

Feely, R. A., R. Wanninkhof, H. B. Milburn, C. E. Cosca, M. Stapp and P. P. Murphy (1998) A new automated underway system for making high precision pCO<sub>2</sub> measurements onboard research ships.

Analytica Chim. Acta 377: 185-191.

Ho, D. T., R. Wanninkhof, J. Masters, R. A. Feely and C. E. Cosca (1997). Measurement of underway  $f\text{CO}_2$  in the Eastern Equatorial Pacific on NOAA ships BALDRIGE and DISCOVERER, NOAA data report ERL AOML-30, 52 pp., NTIS Springfield.

Pierrot, D., C. Neill, K. Sullivan, R. Castle, R. Wanninkhof, H. Luger, T. Johannessen, A. Olsen, R. A. Feely, and C. E. Cosca (2009), Recommendations for autonomous underway  $p\text{CO}_2$  measuring systems and data-reduction routines. Deep Sea Research II, 56: 512-522.

Wanninkhof, R. and K. Thoning (1993) Measurement of fugacity of  $\text{CO}_2$  in surface water using continuous and discrete sampling methods. Mar. Chem. 44(2-4): 189-205.

Weiss, R. F. (1970) The solubility of nitrogen, oxygen and argon in water and seawater. Deep-Sea Research 17: 721-735.

Weiss, R. F. (1974) Carbon dioxide in water and seawater: the solubility of a non-ideal gas. Mar. Chem. 2: 203-215.

Weiss, R. F., R. A. Jahnke and C. D. Keeling (1982) Seasonal effects of temperature and salinity on the partial pressure of  $\text{CO}_2$  in seawater. Nature 300: 511-513.