

Dataset Expocode 33RO20150114

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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:** 33RO20150114
Campaign/Cruise Name: RB1501A
Campaign/Cruise Info: CALWATER II Leg 1
Platform Type:
CO2 Instrument Type:
Survey Type: Research Cruise
Vessel Name: Ronald H. Brown
Vessel Owner: NOAA
Vessel Code: 33RO

Coverage **Start Date (yyyymmdd):** 20150115
End Date (yyyymmdd): 20150129
Westernmost Longitude: 158 W
Easternmost Longitude: 122.6 W
Northernmost Latitude: 21.2 S
Southernmost Latitude: 38.0 N
Port of Call: Honolulu, HI
Port of Call: San Francisco, 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: yes

Manufacturer: Vaisala

Model: PTB330
Accuracy: ± 0.2 hPa (hPa if units not given)
Precision: ± 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: ± 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: ± 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: CA04957, 282.55 ppm; Std 2: CC105863, 380.22 ppm; Std 3: CB09696, 453.04 ppm; Std 4: CB09032, 539.38 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: ± 0.025 °C (°C if units not given)
Precision: ± 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: ± 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: ± 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 6011 measurements were taken with 5661 flagged as good, 342 flagged as questionable, and 8 flagged as bad. All measurements flagged as 4 (bad) have been removed from the final data file. (3.) There was a 17-1/2 hour dropout of EqT readings at the start of the cruise. New values were determined using a relation between equilibrator temperature and SST. The equation used was $EqT = 0.9734 * SST + 0.7735$, $n = 124$, $r^2 = 0.9630$. All of these values have been flagged 3. (4.) On 1/22 at 1730, an emergency shutdown of the system occurred due to water getting into the atm condenser. The survey tech cleared out the water and restarted the system on 1/26 at 0519. No data was acquired during the shutdown period.

Citation for this Dataset:

Wanninkhof, R., R. D. Castle, and J. Shannahoff. 2013. Underway pCO₂ measurements aboard the R/V Ronald H. Brown during the 2014 cruises. 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 pCO₂ 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 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 CO_2 in seawater. Nature 300: 511-513.