



## **Partial pressure (or fugacity) of carbon dioxide, pH on total scale, temperature, salinity and other variables collected from surface underway observations during the container ship Cap Blanche cruises in the Pacific Ocean from 2016-03-13 to 2016-10-19 (NCEI Accession 0158484)**

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**ABSTRACT:** This NCEI accession consists of surface underway measurements of partial pressure (or fugacity) of carbon dioxide (pCO<sub>2</sub>) in water and atmosphere, ISFET-based pH (total scale), temperature, salinity and barometric pressure collected on 4 trans-Pacific cruises in 2016 as part of a ship-of-opportunity (SOOP) time-series. Cruise names and EXPOCODEs: CB2016\_03 (AG5W20160313), CB2016\_05 (AG5W20160507), CB2016\_08 (AG5W20160829), CB2016\_10 (AG5W20161019). Since 1992, underway CO<sub>2</sub> observations have been made between New Zealand and the U.S. West Coast. In 2010, ISFET-based pH measurements (total scale) were added to this equatorial Pacific SOOP-based time-series. All pH data, when available, are reported on the total scale and at SST. This effort was conducted with the support of NOAA's Ocean Observing and Monitoring Division in the Climate Program Office (CPO) and NOAA's Ocean Acidification Program (OAP).

**CITE AS:** Cosca, Catherine E.; Alin, Simone R.; Feely, Richard A.; Lebon, Geoffrey T.; Takeshita, Yuichiro; Martz, Todd R.; Carter, Brendan R. (2017). Partial pressure (or fugacity) of carbon dioxide, pH on total scale, temperature, salinity and other variables collected from surface underway observations during the container ship Cap Blanche cruises in the Pacific Ocean from 2016-03-13 to 2016-10-19 (NCEI Accession 0158484). [indicate subset used]. NOAA National Centers for Environmental Information. Dataset. <https://doi.org/10.7289/v5833q3s>. Accessed [date].

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### **IDENTIFICATION INFORMATION FOR THIS DATA PACKAGE:**

**NCEI ACCESSION:** 0158484

**NCEI DOI:** <https://doi.org/10.7289/v5833q3s>

**EXPOCODE:** AG5W20160313; AG5W20160507; AG5W20160829; AG5W20161019;

**CRUISE ID:** CB2016\_03; CB2016\_05; CB2016\_08; CB2016\_10;

**SECTION/LEG:** SOOP;

**TYPES OF STUDY:**

Surface Underway;

**TEMPORAL COVERAGE:**

START DATE: 2016-03-13

END DATE: 2016-10-19

**SPATIAL COVERAGE:**

NORTH BOUNDARY: 36.4

WEST BOUNDARY: 153.0313 EAST BOUNDARY: -118.3813

SOUTH BOUNDARY: -34.909

**GEOGRAPHIC NAMES:**

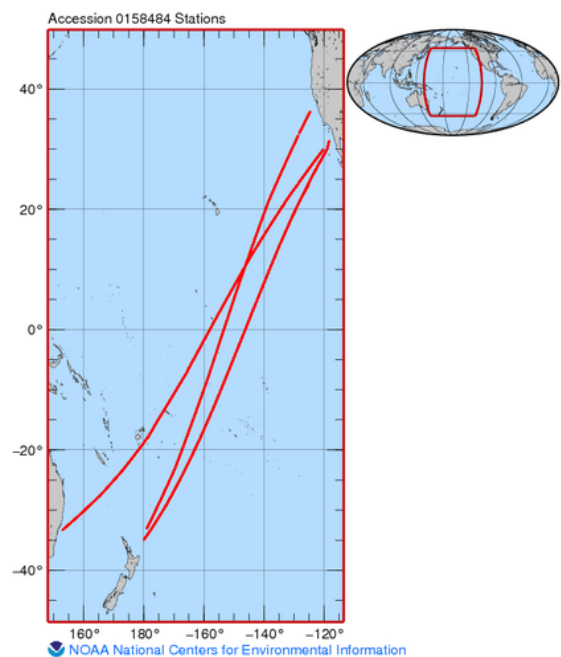
Pacific Ocean, Equatorial Pacific;

**PLATFORMS:**

Cap Blanche (ID: C4MZ2);

**RESEARCH PROJECT(S):**

PMEL Sustained Investment Coastal Underway Ocean Acidification Observations; NOAA's Ocean Observing and Monitoring Division in the Climate Program Office (CPO);

**VARIABLES / PARAMETERS:*****pH*****Abbreviation:** pH\_TOT\_INSITU**pH scale:** Total**Observation type:** ISFET-based pH measurement, surface underway**Measured or calculated:** Measured**Calculation method and parameters:** N/A**Sampling instrument:** Ship's underway seawater system**Analyzing instrument:** ISFET pH systems including Honeywell Durafet III pH electrode and Orion Chloride Ion Selective Electrode built in Todd Martz's laboratory at Scripps Institution of Oceanography.**Temperature of pH measurement:** In situ**Detailed sampling and analyzing information:** Please refer to the cited methods description file.**Replicate information:** N/A**Standardization description:** pH data were calibrated using surface bottle measurements collected via the underway analytical system and preserved with mercuric chloride for later analysis in the laboratory at NOAA/PMEL (specifically for dissolved inorganic carbon [DIC] and total alkalinity [TA]).**Standardization frequency:** Calibration samples were collected every 6-12 hours, typically resulting in ~30-60 samples per roughly two-week crossing.**pH standard values:** N/A**Temperature of standardization:** In situ (=SST)**Temperature correction method:** N/A**At what temperature was pH reported:** In situ (=SST)**Uncertainty:** Accuracy: 0.007; Short term precision (hours): 0.0005; Long term precision (weeks): 0.004**Quality flag convention:** WOCE quality control flags are used: 2 = good value, 3 = questionable value, 4 = bad value**Method reference:** Martz, T. R., J. G. Connery, and K. S. Johnson (2010), Testing the Honeywell Durafet for seawater pH applications, *Limnol. Oceanogr. Methods*, 8, 172-184, doi:10.4319/lom.2010.8.172.**Researcher name:** Catherine E. Cosca**Researcher institution:** NOAA Pacific Marine Environmental Laboratory (NOAA/PMEL) and University of Washington Joint Institute for the Study of Atmosphere and Ocean

<b>Abbreviation:</b>	fCO <sub>2</sub> W@SST
<b>Unit:</b>	uatm
<b>Observation type:</b>	Surface underway
<b>In-situ / Manipulation / Response variable:</b>	In-situ observation
<b>Measured or calculated:</b>	Measured
<b>Sampling instrument:</b>	Seawater pump
<b>Location of seawater intake:</b>	Bow
<b>Analyzing instrument:</b>	General Oceanics 8050. PMEL system ID: GO7
<b>Detailed sampling and analyzing information:</b>	The sampling and analyzing methods of the Neill/General Oceanics Underway pCO <sub>2</sub> systems are described in detail in: Pierrot, D.; Neill, C.; Sullivan, K.; Castle, R.; Wanninkhof, R.; Luger, H.; Johannessen, T.; Olsen, A.; Feely, R.A.; and Cosca, C.E. (2009). Recommendations for autonomous underway pCO <sub>2</sub> measuring systems and data-reduction routines. Deep-Sea Res., II, v. 56, pp. 512-522.
<b>Equilibrator type:</b>	Shower head
<b>Equilibrator volume:</b>	~0.5 L
<b>Is the equilibrator vented or not:</b>	Vented
<b>Water flow rate:</b>	3 L/min
<b>Gas flow rate:</b>	~0.8 L/m
<b>How was temperature inside the equilibrator measured:</b>	Hart Scientific model 1521 digital thermometer, serial number A77488, with an NIST traceable model 5610 thermistor probe, serial number A9B0916. Accurate to ± 0.01°C.
<b>How was pressure inside the equilibrator measured:</b>	Setra 239 differential pressure transducer, accurate to ± 0.15 hPa. The equilibrator was passively vented to a secondary equilibrator, and the Licor sample output was vented to the laboratory when CO <sub>2</sub> measurements were made, thus equilibrator headspace pressure was assumed to be laboratory pressure. Pressure in the laboratory was measured with a GE Druck barometer, serial number 3013024, with an accuracy of ± 0.01.
<b>Drying method for gas:</b>	From Pierrot, et al.: Sample air is dried in a condenser that is cooled to 4-5 °C by a Peltier thermoelectric device. This partially dried air flushes a chamber that is vented and remains at ambient pressure. The dried air inside the chamber is used as the counter flow in the Nafion® tubing. A vacuum pump pulls the dried air from the chamber first through a fixed restrictor and then through the Nafion® tubes, thus creating an absolute pressure and corresponding partial pressure gradient for water vapor across the membrane. When atmospheric air is measured, some of the partially dried air (80- 100 ml/min) is pushed through a Nafion® tube, the analyzer and out a vent instead of flushing the chamber. The headspace gas, when being measured, is circulated in a closed loop through the analyzer at a rate similar to that of the atmospheric air (80-100 ml/min). It is dried first in the condenser, then in a Nafion® tube prior to entering the analyzer and being returned to the equilibrator. Typically, the water mole fraction (xH <sub>2</sub> O) in the dried gas is about 2 parts per thousand (ppt), which corresponds to a dew point temperature of about -20 °C. The liquid water condensed out of the sample air streams is removed by peristaltic pumps into the vent equilibrator at intervals determined by the user.
<b>SEA CO<sub>2</sub> gas detector manufacturer:</b>	Licor, Inc
<b>SEA CO<sub>2</sub> gas detector model:</b>	Licor 7000, IRG4-0560
<b>SEA CO<sub>2</sub> gas detector resolution:</b>	0.2 µatm
<b>SEA CO<sub>2</sub> gas detector uncertainty:</b>	0.3 µatm for equilibrator measurements, 0.2 µatm for atmospheric measurements
<b>Standardization technique:</b>	The system runs a full cycle in approximately 7 hours. The cycle starts with 4 standard gases, then measures three rounds of 6 atmospheric samples followed by 50 surface water samples. Each new gas is flushed through the Licor Analyzer for 2 minutes prior to a stop-flow measurement.
<b>Standardization frequency:</b>	Every 7 hours
<b>Standard gas manufacturer:</b>	Standard gases are supplied by NOAA's Earth System Research Laboratory, Global Monitoring Division, in Boulder, CO, and are directly traceable to the WMO scale.
<b>Standard gas concentration:</b>	LL83535, 246.77 ppm; LL108050, 399.22 ppm; LL108059, 496.103 ppm; LL154371, 628.59 ppm
<b>Standard gas uncertainty:</b>	0.01 ppm
<b>Water vapor correction method:</b>	Details of the data reduction are described in Pierrot, et.al. (2009).

**Temperature correction method:** Details of the data reduction are described in Pierrot, et.al. (2009).

**At what temperature was pCO<sub>2</sub> reported:** In situ sea surface temperature

**Uncertainty:** ± 2 µatm

**Quality flag convention:** WOCE quality control flags are used: 2 = good value, 3 = questionable value, 4 = bad value

**Method reference:** Pierrot, D.; Neill, C.; Sullivan, K.; Castle, R.; Wanninkhof, R.; Luger, H.; Johannessen, T.; Olsen, A.; Feely, R.A.; and Cosca, C.E. (2009). Recommendations for autonomous underway pCO<sub>2</sub> measuring systems and data-reduction routines. Deep-Sea Res., II, v. 56, pp. 512-522.

**Researcher name:** Catherine E. Cosca

**Researcher institution:** Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration

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### *Sea Surface Temperature*

**Abbreviation:** SST(TSG)\_C

**Unit:** Degree Celcius

**Observation type:** Surface Underway

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

**Measured or calculated:** Measured

**Sampling instrument:** Seabird 38, serial number 3848581-0383

**Uncertainty:** 0.0025°C

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### *Salinity*

**Abbreviation:** SAL(TSG)\_PERMIL

**Unit:** permil

**Observation type:** Surface Underway

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

**Measured or calculated:** Measured

**Sampling instrument:** Seabird 45, serial number 4539646-0143

**Uncertainty:** 0.005 PSU

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### *Mole fraction of CO<sub>2</sub> in the equilibrator headspace (dry) at equilibrator temperature*

**Abbreviation:** xCO<sub>2</sub>W\_ppm

**Unit:** ppm

**Observation type:** Surface Underway

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

**Measured or calculated:** Measured

**Sampling instrument:** Licor 7000, IRG4-0560

**Analyzing instrument:**

**Duration:**

**Detailed sampling and analyzing information:** See Pierrot et al. for details.

**Uncertainty:** 0.3 ppm

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### *Mole fraction of CO<sub>2</sub> measured in dry outside air*

**Abbreviation:** xCO<sub>2</sub>A\_ppm

**Unit:** ppm

**Observation type:** Surface Underway

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

**Measured or calculated:** Measured

**Sampling instrument:** Licor 7000, IRG4-0560

**Analyzing instrument:**  
**Duration:**  
**Detailed sampling and analyzing information:** See Pierrot et al. for details.  
**Uncertainty:** 0.2 ppm

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*Mole fraction of CO<sub>2</sub> measured in dry outside air associated with each water analysis.*

**Abbreviation:** xCO<sub>2</sub>A\_interpolated\_ppm  
**Unit:** ppm  
**Observation type:** Surface Underway  
**In-situ / Manipulation / Response variable:** In-situ observation  
**Measured or calculated:** Measured  
**Calculation method and parameters:** Values are interpolated between measurements of xCO<sub>2</sub>A\_ppm  
**Sampling instrument:** Licor 7000, IRG4-0560  
**Analyzing instrument:**  
**Duration:**  
**Detailed sampling and analyzing information:** See Pierrot et al. for details.  
**Uncertainty:** 0.2 ppm

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*Partial pressure and fugacity of CO<sub>2</sub> in air corresponding to the interpolated xCO<sub>2</sub> (xCO<sub>2</sub>A\_interpolated\_ppm) at SST and 100% humidity*

**Abbreviation:** pCO<sub>2</sub>A\_uatm, fCO<sub>2</sub>A\_uatm  
**Unit:** μatm  
**Observation type:** Surface Underway  
**In-situ / Manipulation / Response variable:** In-situ observation  
**Measured or calculated:** Measured  
**Calculation method and parameters:** Values are interpolated between measurements of xCO<sub>2</sub>\_ATM\_ppm  
**Sampling instrument:** Licor 7000, IRG4-0560  
**Analyzing instrument:**  
**Duration:**  
**Detailed sampling and analyzing information:** See Pierrot et al. for details.  
**Uncertainty:** 0.2 μatm

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**DATA PACKAGES RELATED TO THIS ONE:**

NCEI Accession(s) [SOOP M/S Cap Blanche Lines](#);

**PUBLICATIONS DESCRIBING THIS DATA SET:**

Pierrot, D.; Neill, C.; Sullivan, K.; Castle, R.; Wanninkhof, R.; Luger, H.; Johannessen, T.; Olsen, A.; Feely, R.A.; and Cosca, C.E. (2009). Recommendations for autonomous underway pCO<sub>2</sub> measuring systems and data-reduction routines. *Deep-Sea Res., II*, v. 56, pp. 512-522.

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.

Wanninkhof and Thoning, Measurement of fugacity of Carbon Dioxide in surface water and air using continuous sampling methods, *Marine Chemistry*, 44, 189-205, 1993.

Martz, T. R., J. G. Connery, and K. S. Johnson (2010), Testing the Honeywell Durafet for seawater pH applications, *Limnol. Oceanogr. Methods*, 8, 172-184, doi:10.4319/lom.2010.8.172.

**ADDITIONAL INFORMATION:**

<http://www.pmel.noaa.gov/co2/>

**FUNDING AGENCY:**

NOAA's Climate Program Office and Ocean Acidification Program

*PROJECT TITLE:* Surface Water pCO<sub>2</sub> Measurements from Ships; West Coast Ocean Acidification Monitoring Network: Volunteer Observing Ships

*PROJECT ID:*

**SUBMITTED BY:** Catherine E. Cosca (Cathy.Cosca@noaa.gov)

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