

Description of Underway pCO₂ System onboard the NOAA Ship *Discoverer* from 1992 through 1994

Overview: The CO₂ group at NOAA/PMEL installed and maintained an underway pCO₂ system onboard the NOAA Ship *Discoverer* for several cruises between August of 1992 through Spring of 1994.

September 1992 – December 1992

The National Oceanic and Atmospheric Administration's (NOAA) Ocean-Atmosphere Carbon Exchange Study (OACES) Program, in cooperation with the U.S. Joint Global Ocean Flux Study (U.S. JGOFS) Program, the Equatorial Pacific Ocean Climate Study (EPOCS) and Tropical Ocean Global Atmosphere (TOGA) Program, participated in a multifaceted oceanographic research cruise conducted aboard the NOAA Ship *Discoverer* from September 6 to December 8, 1992. The primary objective of this U.S. JGOFS/OACES effort was to determine the relative effects of biological fixation of carbon within equatorial upwelling, followed by vertical flux of that fixed carbon to abyssal depths, and of CO₂ outgassing. The cruise was focused on determining the concentrations of carbon species and describing ocean circulation in the upper ocean over the equatorial Pacific from 95°W to 140°W. This report includes a summary of the underway pCO₂ measurements collected during the cruise. Details of 1992 OACES/JGOFS/EPOCS/TOGA cruise can be found in Lamb et al., 1995 and Feely et al, 1995.

August 1992, March/April 1993, June 1994

In conjunction with the TOGA/TAO project, the CO₂ group at NOAA/PMEL installed and maintained an underway pCO₂ system on the *Discoverer* on three TOGA/TAO cruises between 1992 and 1994. The TOGA/TAO project is dedicated to maintaining the TAO buoy array (www.pmel.noaa.gov/tao/), in the equatorial Pacific. Details of the TOGA/TAO cruises between 1991 and 1995 are included in Johnson and Plimpton (1999).

March 1994

In the spring of 1994, NOAA participated in the Climate and Global Change (CGC94) World Ocean Circulation Experiment (WOCE) P-18 cruise on the *Discoverer*. Included in this report is a description of underway pCO₂ measurements collected along 103/110W as the ship transited between San Francisco and Punta Arenas, Chile. Details of the CGC94/WOCE P-18 cruise are included in Ho et al., 1997.

Data File Name	Start Date	End Date	Start Port	End Port	TAO Lines Serviced	System Operator	Gas standards		
							Low/Ref	Mid	High
DI1992_170.csv	20-Aug-92	27-Aug-92	Honolulu, HI	Hilo, HI	170°W, 155°W	Paulette Murphy	CC71615 352.67 ppm	CC71635 417.6 ppm	CC106646 488.51 ppm
DI1992_140.csv DI1992_125.csv	6-Sep-92	9-Oct-92	Hilo, HI	Manzanillo	140°W, 125°W	Cathy Cosca	CC71615 352.67 ppm	CC71635 417.6 ppm	CC106646 488.51 ppm
DI1992_110_95.csv	12-Oct-92	18-Nov-92	Manzanillo	Salinas, EQ	110°W, 95°W	Matt Steckley	CC71615 352.67 ppm	CC71635 417.6 ppm	CC106646 488.51 ppm
DI1993_155.csv DI1993_170.csv	25-Feb-93	14-Mar-93	Hilo, HI	Samoa	170°W, 155°W	Dana Greeley	CC114944 295.09 ppm	CC111794 352.97 ppm	CC71635 417.6 ppm
DI1994_110.csv	31-Mar-94	27-Apr-94	Easter Island	San Diego, CA	110°W	Matt Steckley	CC1782 355.83 ppm	CC1786 419.1 ppm	CC111790 482.23
DI1994_170.csv DI1994_180.csv	3-Nov-94	21-Nov-94	Honolulu, HI	Honolulu, HI	170°W, 180	Cindy Venn	CC111794 352.97 ppm	CC1786 419.1 ppm	CC111790 482.23 ppm

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Ship Name: Discoverer

Call Sign: WTEA

Country: United States

Ship Owner: National Oceanic and Atmospheric Administration (NOAA)

Location of data: www.pmel.noaa.gov/co2/uwpc02/**Experiment Name:** Underway measurement of atmospheric and surface water pCO₂**Name/Model of pCO₂ System:** System 1.0, 1992. The system is described in detail in Wanninkhof and Thoning, 1993.**Analyzer:** Li-COR 6251 (analog output) infrared (IR) analyzer**Method of analysis:** Differential analyses relative to the low standard gas which flows continuously through the Li-COR reference cell. Measures dried air and equilibrator headspace gas. Gas flow is stopped prior to IR readings.**Drying method:** Bow air and equilibrator headspace gas pass through a water trap cooled to 5°C and subsequently through a column of Mg(ClO₄)₂**Equilibrator (setup, size, flows):** Weiss style Plexiglass showerhead equilibrator, with 17 liter water reservoir and 12 liter gaseous headspace. Water flow rate of 15 l/min, pumped from the bow of the ship through a clean sampling line. Headspace gas re-circulated at 5 l/min.**Standards (number, concentrations, frequency):** Three are used with concentrations ranging from 300 ppm to 500 ppm. See table for specific concentrations. Standards are run once per hour.**Source of calibration and accuracy:** All standards come from NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL) and are traceable to the WMO scale. Stated accuracy of the standards is 0.07 ppm from 330 to 420 ppm and 0.2 ppm for higher or lower standards.**Sampling Cycle**

The system runs on an hourly cycle during which three standard gases, one air sample from the bow mast and two surface water samples (from the equilibrator head space) are analyzed on the following schedule:

Minutes after the hour	Sample
4	Low Standard
8	Mid Standard
12	High Standard
30	Water
42	Air
60	Water

The two water values are averaged to yield a single hourly value which is merged with the air value to determine the air-water difference in fugacity (ΔfCO_2). The time stamp and location are for the top of the hour after the air and two water sample analyses.

Units: All xCO_2 values are reported in parts per million(ppm)and are for dry gas and fCO_2 values are reported in microatmospheres (uatm) assuming 100% humidity at the equilibrator temperature.

Data reported:

<u>COLUMN HEADER</u>	<u>DESCRIPTION</u>
1. Group:	PMEL
2. JD_GMT:	Decimal year day
3. Date	The date format has been changed to comply with the IOCCP recommendations (DDMMYYYY)
4. Time:	GMT time
5. Latitude:	Latitude in decimal degrees (negative values are in southern hemisphere).
6. Longitude:	Longitude in decimal degrees (negative values are in western latitudes).
7. xCO_2w_ppm :	Mole fraction of CO_2 (dry) in the headspace equilibrator at equilibrator temperature (T_{eq}) in parts per million. Water comes from bow intake ~ 2 m below the water line.
8. xCO_2a_ppm :	Mole fraction of CO_2 in air in parts per million
9. Pres_sealevel_mB:	Barometric pressure at sea level, in millibars
10. EqTemp_C:	Temperature in equilibrator water in degrees centigrade. Temperature in equilibrator measured with a calibrated thermistor.
11. SST(TSG)_C:	Temperature from the ship's thermosalinograph in degrees centigrade.
12. Sal(TSG)_Permil:	Salinity from the ship's thermosalinograph on the Practical Salinity Scale
13. $fCO_2W@SST_uatm$:	Fugacity of CO_2 in sea water in microatmospheres.
14. fCO_2a_uatm :	Fugacity of CO_2 in air in microatmospheres.
15. $dfCO_2_uatm$:	Sea water fCO_2 - air fCO_2 , microatmospheres

using the average air value for the current hour.

16. pCO2W@SST_uatm: Partial pressure of CO₂ in sea water in microatmospheres.
17. pCO2a_uatm: Partial pressure of CO₂ in air in microatmospheres.
18. dpCO2_uatm: Sea water pCO₂ - air pCO₂ in microatmospheres.
using the average air value for the current hour.

Data processing and Quality Control:

Carbon measurements at PMEL undergo the data processing and quality control procedures outlined in the DOE Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water (DOE, 1994).

References:

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- Wanninkhof, R. and K. Thoning (1993) Measurement of fugacity of CO₂ in surface water using continuous and discrete sampling methods. *Mar. Chem.* 44(2-4): 189-205.
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