1992 CRUISE REPORT FOR WOCE PR16: A REPEAT HYDROGRAPHIC SECTION ALONG 110W

A. CRUISE NARRATIVE

A.1 HIGHLIGHTS

Expedition Designation (EXPOCODE): 31DSEP692/2

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Ship: NOAA Discoverer, R-102
Ports of Call: Manzanillo, Mexico - Salinas, Ecuador
Cruise Dates: October 12 to November 18, 1992

A.2 CRUISE SUMMARY

Cruise Tracks

Figure 1 shows the cruise track and CTD/rosette station locations for 31DSEP692/2.

Number of Stations

Thirty-one CTD/rosette profiles were collected on leg 2 of the fall EPOCS/TOGA/CO2/JGOFS cruise (31DSEP692/2) using a Neil Brown Mark IIIb CTD and General Oceanics 24 bottle rosette equipped with 24 10-liter Niskin water sample bottles. Twenty-eight of the 31 profiles were collected along 110W from 10S to 10N.

Rosette Sampling

During 31DSEP692/2, all 24 Niskin bottles were sampled for salinity each cast, with a duplicate salinity sample taken from the deepest bottle to monitor the drift of the Autosal instrument. Other samples taken from the Niskin bottles included dissolved oxygen, seawater CO2 partial pressure (pCO2), total CO2 (TCO2), total alkalinity (TALK), dissolved organic carbon and nitrogen, chlorophyll, particulate organic carbon and nitrogen, and nutrients. Nominal sampling depths were 1000(2), 800, 600, 400, 300, 250, 200, 180, 160, 150, 140, 130, 120, 110, 100, 90, 80, 60, 50, 40, 20, 10, and 0 meters. Twenty-six casts were to a depth of 1000 meters, and 3 casts were to 150 meters. Bottle sample depths for 31DSEP692/2 are shown in figure 2.

Moorings

Beginning 31DSEP692/2, a pressure/temperature gauge (PTG) was recovered and deployed in approximately 100 feet of water off Clipperton Island at approximately 10N, 110W. ATLAS mooring operations were conducted at 8N (recovery/deployment), 5N (repair), 2N (recovery/deployment), and 2S (recovery/deployment) along 110W. ATLAS moorings at 5S and 8S were inspected and found to be in good condition. ATLAS moorings were also deployed at new sites at 2S, 0N, and 2N along 95W. An equatorial current meter mooring was recovered and redeployed at 0N, 110W.

A.3 LIST OF PRINCIPAL INVESTIGATORS

Dr. Mike McPhaden, NOAA/PMEL	moorings
Dr. Richard Feely, NOAA/PMEL	CO2
Dr. Rik Wanninkhof, NOAA/AOML	CO2
Dr. Don Hansen, NOAA/AOML	drifting buoys
Dr. Don Atwood, NOAA/AOML	CO2, nutrients
Dr. Doug Wilson, NOAA/AOML	CTD
Dr. Ken Buesseler, WHOI	Th-234
Dr. Ed Peltzer, WHOI	DOC
Dr. Francisco Chavex, MBARI	plankton biology
Dr. Pat Wheeler, OSU	productivity
Dr. Frank Millero, UM/RSMAS	total alkalinity

Abbreviations

NOAA	National Oceanic and Atmospheric Administration
PMEL	Pacific Marine Environmental Laboratory, Seattle, WA
AOML	Atlantic Oceanographic and Meteorological Laboratory, Miami, FL
WHOI	Woods Hole Oceanographic Institution, Woods Hole, MA
MBARI	Monterey Bay Aquarium Research Institute, Monterey Bay, CA
OSU	Oregon State University, Newport, OR
UM	University of Miami, Miami, FL
RSMAS	Rosenstiel School of Marine and Atmospheric Science, Miami, FL

A.4 SCIENTIFIC PROGRAMME AND METHODS

The NOAA-sponsored Equatorial Pacific Ocean Climate Studies (EPOCS) and Tropical Ocean and Global Atmosphere (TOGA) research programs are designed to further understanding of the role of the tropical ocean in modifying the world's climate. A primary goal of this research is to investigate the dominant mechanisms that produce large scale, interannual variations of sea surface temperature in vast regions of the tropical Pacific Ocean. Studies indicate that such sea surface temperature anomalies are linked to perturbations in the mid-latitude atmospheric pressure fields and hence to weather.

Ocean currents play an important role in determining the local temperature change through heat advection. Therefore, an associated goal of the EPOCS/TOGA program is to study the horizontal, vertical and temporal variations of the currents and how they are affected by the wind field. Variability in currents, temperature, and winds are studied using numerous techniques including current meter moorings, thermistor chain moorings (ATLAS), underway acoustic doppler current profiling (ADCP), CTD profiles, drifting buoys, and other shipboard physical oceanographic and meteorological measurements.

The NOAA Office of Global Programs (OGP) has sponsored the Ocean-Atmosphere Carbon Dioxide Exchange (CO2) program in order to examine the rate at which CO_2 is taken up and released by the oceans. Research is designed to determine the relative effects of biological fixation of carbon within the zone of equatorial upwelling, ther vertical flux of that fixed carbon to abyssal depths, and the outgassing CO_2.

The focus of the joint National Science Foundatation (NSF)/NOAA sponsored U.S. Joint Global Ocean Flux Studies (JGOFS) is to determine the relationship between the biogeochemical cycles of carbon and nitrogen species and physical forcing in the upper ocean.

The primary objectives of 31DSEP692/2 were to maintain the array of near-equatorial ATLAS and current meter moorings along 110W and 95W in the eastern tropical Pacific, conduct hydrographic measurements in the area, and determine the concentrations of carbon species in the area with attendant modeling the flux of carbon through the system.

Temperature (figure 3) and salinity (figure 4) sections along 110W for 31DSEP692/2 show warm water throughout the section, with surface water warmer than 25C north of 1N. A well-developed thermocline exists around 100 db, with the 15C isotherm sloping to about 175 db from 4S to 10S. The equatorial undercurrent appears south of the equator.

Figure 5 shows the TS relationship between CTD casts taken along 110W during 31DSEP692/2. Salinity sample data are overplotted on each.

A description of the methods of measurement, calibration and processing of the NBIS CTD/O2 data is given in section C.2 of this report.

A.5 PROBLEMS ENCOUNTERED ON THE CRUISE

Twenty-eight casts were made from 10N to 10S along 110W. AOML Neil Brown Mark IIIb CTD #4 and 24-bottle rosette sampler was used for the first 18 casts of this leg before the package was lost at 4S, 110W when the cable parted with 950 meters out. The remaining casts employed AOML Neil Brown Mark IIIb CTD #1 and 12-bottle rosette sampler. Two casts were done at each station (0-150 m and 175-1000 m) to cover the same sampling depths as the 24-bottle package.

A.6 OTHER INCIDENTS OF NOTE

A.7 LIST OF CRUISE PARTICIPANTS

Dr. Rik Wanninkhof, NOAA/AOML	Co-Chief Scientist
Ms. Linda Mangum, NOAA/PMEL	Co-Chief Scientist
Mr. Rick Miller, NOAA/PMEL	ATLAS moorings
LT. Dave Zimmerman, NOAA/PMEL	current meter moorings
Mr. Lloyd Moore, NOAA/AOML	nutrients
Mr. George Berberian, NOAA/AOML	nutrients
Mr. Gregg Thomas, NOAA/AOML	CTD operations, salinity
Mr. Robert Roddy, NOAA/AOML	CTD operations, oxygen
Mr. Mike Shoemaker, NOAA/AOML	electronics
Mr. Mat Steckley, NOAA/AOML	pCO2
Mr. Hua Chen, NOAA/AOML/RSMAS	pCO2
Mr. David Jones, NOAA/AOML	TCO2
Mr. Thomas Lantry, NOAA/AOML	TCO2
Ms. Coleen O'Keefe, MBARI	phytoplankton biology
Ms. Cindy Venn, MBARI	phytoplankton biology
Ms. Rachel Zimmerman, MBARI	plankton biology
Ms. Leslie Redmond, WHOI	DOC
Ms. Mary Hartman, WHOI	Th-234

Mr. Sanjay Mane, UM/RSMAS	total alkalinity, TCO2
Mr. David Purkerson, UM/RSMAS	total alkalinity, TCO2
Mr. Kitack Lee, UM/RSMAS	total alkalinity, TCO2
Mr. Marcellino Suzuki, OSU	productivity
Mr. Scott Libby, OSU	productivity

B. UNDERWAY MEASUREMENTS

B.1 XBT

XBT measurements were made in accordance with SEAS instructions (5.2.1). XBT data were collected and transmitted via the ship's SEAS unit. For each XBT cast, the following information was recorded on log sheets: wind direction, wind speed, barometric pressure, air temperature, bucket temperature, intake temperature, time, and ship's position. XBTs from the scientific party's supply were launched by the Survey Department at the discretion of the Chief Scientist.

B.2 ADCP

Aboard the NOAA ship Discoverer, the ADCP was interfaced with a Magnavox GPS navigator and received data at 2 second intervals through the selection of code 208, data control option 1. Accurate ship navigation is essential to absolute ADCP current measurements. The ship provided a fully operational Magnavox 1107 TRANSIT/GPS navigator with an atomic frequency standard throughout the cruise. The ship's Survey Department was responsible for changing data disks as necessary.

B.3 SST AND SSS

Near sea surface temperature (SST) and salinity (SSS) measurements were recorded continuously throughout the cruise using a thermosalinograph accurate to within 0.1C and 0.01 psu. The Survey Department translated the data from the thermosalinograph to ASCII listings and plots daily. Bucket temperature and salinity samples were collected with each XBT and the continuous record annotated with the date/time and bucket temperature.

B.4 SEAWATER SAMPLING

Continuous water sampling was conducted using the ship's bow intake system capable of delivering 100 liters per minute of seawater to the Oceanographic Laboratory, where a sea/air equilibrator system was located. Care was taken to prevent contamination from smoke, solvent fumes, cleaning solutions, etc.

B.5 ATMOSPHERIC SAMPLING

Air samples were collected from the bow. In order to minimuze contamination, no deck work or smoking was allowed forward of the main exhaust stack. A mast was extended approximately 7 meters upward from G-deck to the level of the Bridge for the air sampling lines. Air sampling lines ran from the mast to the Oceanographic Laboratory.

C. DESCRIPTION OF MEASUREMENT TECHNIQUES AND CALIBRATIONS

C.1 SAMPLE SALINITY MEASUREMENTS (Gregg Thomas, AOML)

The salinity analysis of samples was carried out exclusively on Guildline Autosal salinometers (model 8400A). The instruments were operated in the ship's constant temperature laboratory at a bath temperature of 24C. Standardization was effected by use of IAPSO Standard Seawater batch P1??. The commonly accepted precision of the Autosal is 0.001 psu, with an accuracy of 0.003 psu. The Autosals were standardized before and after each run. The drift during each run was monitored and individual samples were corrected for the drift during each run by linear interpolation. Bottle salinities were compared with computed CTD salinities to identify leaking bottles, as well as to monitor the conductivity sensor performance and drift. "Agreement between bottle salinity and CTD salinity was excellent. For the shallow water CTD (AOML #4), the sensor derived salinity was on average 3 to 5 parts per million (ppm) saltier, and for the deep CTD (AOML #1) used after the loss of the shallow underwater unit, the sensor read 3 to 5 ppm fresher than corresponding bottle values."

Note: SALNTY quality flag not available from OCDMS data base.

C.2 CTD MEASUREMENTS

Equipment

The fall EPOCS/TOGA/CO2/JGOFS cruise shallow (0-1600 db) underwater package was comprised of a Neil Brown Mark IIIb CTD, a General Oceanics 24-bottle rosette, and 24 10-liter Nisken water sample bottles. A .322 inch diameter conducting cable was used on an Interocean winch to lower and raise the package. Data from the underwater unit was transmitted in real time to a shipboard data terminal through the 3-conductor electro-mechanical cable in TELETYPE (TTY) format using a frequency shift key (FSK) modulated signal superimposed on the DC power supplied to the underwater unit. A Neil Brown 1150 deck unit was used to receive, demodulate, and convert the data.

Standards

The EG&G conductivity sensor has a range of 1 to 65 mmho, an accuracy of 0.005 mmho, resolution of 0.001 mmho, and stability of 0.003 mmho/month. The Rosemount platinum thermometer has a range of -32 to 32 C, an accuracy of 0.005 C (-3 to 32 C), resolution of 0.0005 C, and stability of 0.001 C/month. The deep water Paine pressure sensor has a range of 0 to 6500 db, an accuracy of 6.5 db, resolution of 0.1 db, and stability of 0.1%/month.

CTD Data Capture and Reporting

Aboard the Discoverer, NBIS CTD data were collected using a Zenith personal computer equipped with novel CTD acquisition software written by Dave Bitterman of AOML. Both the downcast and upcast were written to hard disk. Syquest tapes held the archived data set. A color monitor displayed real-time profiles and a real-time listing was produced on an HP lineprinter. As a backup, the original audio FSK CTD data signal was recorded on video cassette tapes.

Following each cast at sea, calibrated pressure, temperature, conductivity, and computed CTD salinities marked at the time of bottle closure confirmation were read from the real-time listing and given to the Ocean Chemistry Data Management System (OCDMS) manager.

Conductivity Calibration

The fall EPOCS/TOGA/CO2/JGOFS cruises consisted of 3 legs and 31DSEP692/2 was calibrated and processed together with legs 1 and 3. Pre-cruise calibrated, 1-db averaged, ASCII CTD data files were received from AOML on 8mm tape in February 21, 1994. A finalized version of the bottle data base (EQ92FALE.CSV) was released by AOML on February 17, 1994. A calibration (.CAL) file was created using the program CALAOML. CTD and/or bottle data did not exist for casts 1, 7, 16, 22, 25, 34, 39, 48, 52, 53, 71, 75, 82, 83, 84, and 120, and these casts were not included in the .CAL file.

Because the process of how pre-cruise calibration coefficients (pressure being nonlinear) and cell corrections were applied to the data set, it was decided that CTD and bottle salinities would be fit rather than backed out conductivities. Program LINCALW was modified to read and compute a fit to salinities. Salinity slope (A1) and bias (A0) were applied using CALMSTRW (program descriptions are given below). Note:

EP592 consisted of stations 1- 48, CTD casts 1- 53.
EP692 consisted of stations 49- 74, CTD casts 54- 84.
EP792 consisted of stations 75-107, CTD casts 85-146.
AOML CTD #4 was used for stations 1- 66.
AOML CTD #1 was used for stations 67-107.

Fits were computed for the following groups of stations to correct for cast dependent drifts:

AOML4A consisted of stations 1-22, CTD casts 1-25:
A0 = -0.1592176E-01
A1 = 0.1000271E
maximum residual = 0.0156
standard dev = 0.0056
70 values discarded from 466 values in 10 repetitions.

AOML4B consisted of stations 23-48, CTD casts 26-53: (end EP592)
A0 = 0.1783609E-01
A1 = 0.9993343E
maximum residual = 0.0182
standard dev = 0.0067
59 values discarded from 531 values in 7 repetitions.

AOML4C consisted of stations 49-67, CTD casts 54-71: (end AOML CTD #4)
A0 = -0.1083432E
A1 = 0.1003059E
maximum residual = -0.0117
standard dev = 0.0042
53 values discarded from 404 values in 8 repetitions.

AOML1A consisted of station 67, CTD casts 72-73: (start AOML CTD #1)
A0 = -0.2837561E
A1 = 0.1007903E
maximum residual = -0.0124
standard dev = 0.0049
2 values discarded from 23 values in 3 repetitions.

AOML1B consisted of stations 68-74, CTD casts 74-84: (end EP692)
A0 = 0.9982839E-01
A1 = 0.9972650E
maximum residual = 0.0069
standard dev = 0.0029
12 values discarded from 83 values in 6 repetitions.

AOML1C consisted of stations 75-107, CTD casts 85-146: (end EP792)

A0 = 0.3461486E-01
A1 = 0.9990724E
maximum residual = 0.0064
standard dev = 0.0023
97 values discarded from 731 values in 8 repetitions.

A total of 294 values were discarded from 2238; 13% of the fit pairs were greater than 2.8 times the standard deviations. However, all bottle data were included in the EPIC (Soreide and Hayes, 1988) .BOT files. Bottles were not shifted around in the .CAL files. However, the following positions were reported to AOML OCDMS manager for consideration as mistrips or samples analyzed out of order:

CTD cast 3 bottle position 4.
CTD cast 38 bottle positions 5, 6, 7.
CTD cast 54 bottle positions 20, 21, 22.
CTD cast 57 bottle positions 17 and 18.
CTD cast 61 bottle positions 7 and 8.
CTD cast 65 bottle positions 3 and 4.
CTD cast 80 bottle positions 8 and 9.
CTD cast 125 bottle positions 4 and 5.
CTD cast 129 bottle positions 6 and 7.
CTD cast 131 bottle positions 4 and 5, 7 and 8.
CTD cast 135 bottle positions 6 and 8.

Conductivity Calibration Programs and PPLUS Command (.PPC) Files

CALAOML creates .CAL raw data file of CTD observations at the time of bottle closures and analyzed water sample values.

LINCALW reads .CAL raw data file (may be broken into groups), computes a linear least squares fit to CTD-bottle conductivity data, applies the model coefficients, discards observations greater than 2.8 times the standard deviation, then refits the remaining data. The process continues until no further observations are rejected. LINCALW writes .COEF file containing model coefficients and .LOG file. Water sample conductivity is obtained using the FORTRAN routine SAL78 described by Fofonoff and Millard (1983).

CALMSTRW reads .CAL raw data file, applies slope and bias to salinity, and writes .CLB calibrated data file and .SEA calibrated data file in WOCE format.

CALMCONW.PPC (Denbo, 1992) reads .CLB calibrated data file and makes five plots of discrete measurements: P, T, C, S, and cast number verses CTD-bottle conductivity. These are examined for cast breaks and drifts in the CTD.

CALMDEEPW.PPC reads .CLB calibrated data file and makes two plots: CTD salinity and bottle salinity verses potential temperature from theta = 0.6 to 2.2 C.

Temperature Calibration

Pre-cruise calibrations were the only corrections applied to temperature measurements. Temperature measurements, calibrations, and computation of derived oceanographic variables used the 1968 temperature scale. Temperatures were converted to the ITS90 scale for WOCE reporting according to:

$$T68 = 1.00024 * T90$$

as suggested by Saunders (1990):

Pressure Calibration

Pre-cruise calibrations were the only corrections applied to pressure measurements.

CTD Data Processing

Program EPAOML read AOML's 1-db averaged files of pressure, temperature, salinity, oxygen current, oxygen temperature, and number of scans per bin. CTD oxygen values were not computed because AOML advised that the sensor was bad. No additional calibrations were applied to pressure or temperature. Salinity slopes and offsets computed using LINCALW were applied to salinity. Final data are in EPIC format.

CTD Data Processing Programs and PPLUS Command (.PPC) Files

EPAOML reads AOML .AVG file of calibrated P, T, S, OXC, OXT, and bin size. EPAOML applies a salinity slope and offset, has an option to eliminate 1-point spikes according to the gradients restrictions given in the source code (not used by default), omits additional spikes as specified in the command file, fills data by linear interpolation for a value to exist every whole meter, recomputes conductivity from salinity, and calculates other oceanographic variables. EPAOML writes the final .CTD data file in EPIC format, and a .LOG file of editted and filled data points.

EPICBOMSTRW reads .CLB calibrated bottle data file and .CTD EPIC data files (for header information) and writes final .BOT bottle data files in EPIC format.

DEEPCTD.PPC reads .CTD EPIC pointer file and .BOT EPIC pointer file of deep casts only and overplots discrete bottle salinity data on the CTD salintiy trace from theta=0.8 to 2.4 C.

FULLTS.PPC reads .CTD EPIC pointer file and .BOT EPIC pointer file and overplots bottle and CTD salinity data from theta = 0 to 30 C for each cast.

TSPLTEP.PPC reads .CTD EPIC pointer file and .BOT EPIC pointer file and overplots full water column bottle salinity and CTD trace as well as sigma-t lines for each profile. TSPLTB.PPC is used to include oxygen data.

TEXTNOX reads .CTD EPIC pointer file and writes a PPLUS command file containing label commands for table listings of subsampled CTD data for each cast to be used with 3PLTNOX.

3PLTNOX.PPC reads TEXTNOX output and .CTD EPIC pointer file and overplots profiles of temperature, salinity, and sigma-t vs. pressure to 1000 db with subsampled CTD data listed in table form for each station. 4PLT1DB.PPC is used to include oxygen data.

References

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