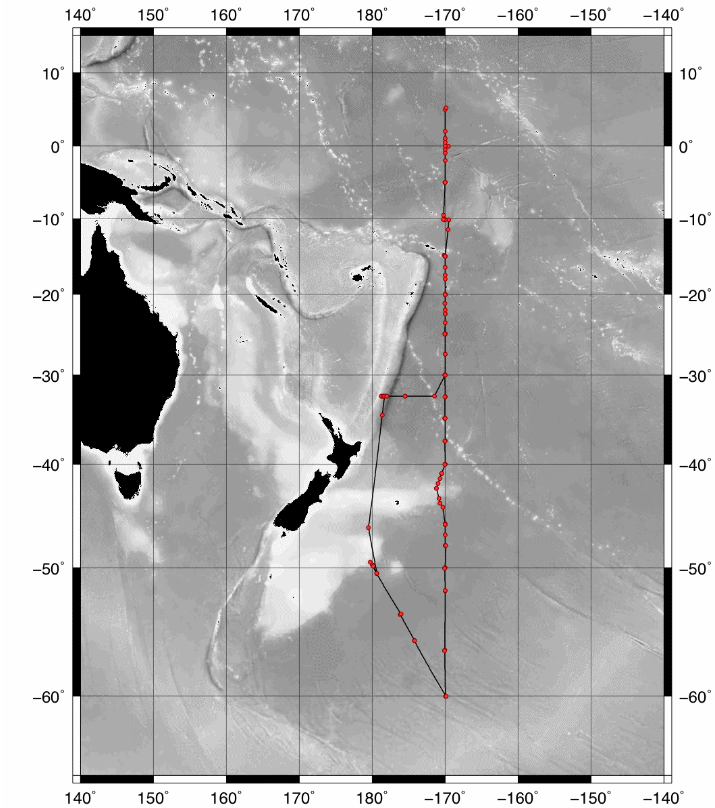
CRUISE REPORT: P15S

(Updated FEB 2013)



Highlights

Cruise Summary Information

WOCE Section Designation	**P15S**
Expedition designation (ExpoCodes)	**3175CG90_1**
Alias	**CGC-90, 3175CG90_2**
Chief Scientists	**David Wisegarver/NOAA-PMEL**
Dates	1990 FEB 22 - 1990 APR 16
Ship	*R/V MALCOLM BALDRIGE*
Ports of call	Pago Pago, American Samoa - Wellington, New Zealand - Honolulu, Hawaii
Geographic Boundaries	0° 0.7' N 179° 44.7' E 179° 59.9' W 60° 0.7' S
Stations	69
Floats and drifters deployed	0
Moorings deployed or recovered	2 deplayed, 2 recovered

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Links To Select Topics

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Cruise Summary Information	Hydrographic Measurements
Description of Scientific Program 1 2	**CTD Data:**
Geographic Boundaries	Acquisition
Cruise Track (Figure): PI CCHDO	Processing
Description of Stations	Calibration - Pre -Post
Description of Parameters Sampled	Temperature Pressure
Bottle Depth Distributions (Figure)	Salinities Oxygens
Floats and Drifters Deployed	**Bottle Data**
Moorings Deployed or Recovered	Salinity
	Oxygen
Principal Investigators	Nutrients
Cruise Participants	Carbon System Parameters
	CFCs
Problems and Goals Not Achieved	Helium / Tritium
Other Incidents of Note	Radiocarbon
Underway Data Information	**References**
Navigation Bathymetry	CTD
Acoustic Doppler Current Profiler (ADCP)	BTL
Thermosalinograph	
XBT and/or XCTD	
Meteorological Observations	**Acknowledgments**
Atmospheric Chemistry Data	
Data Processing Notes	

WOCE Section: P15S
ExpoCode: 3175CG90_1-2

NOAA Data Report ERL PMEL-44

CTD MEASUREMENTS COLLECTED ON A CLIMATE AND GLOBAL CHANGE CRUISE ALONG 170°W DURING FEBRUARY-APRIL 1990

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Pacific Marine Environmental Laboratory Seattle, Washington June 1993

UNITED STATES DEPARTMENT OF COMMERCE	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	Environmental Research Laboratories
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CTD Measurements Collected on a Climate and Global Change Cruise Along 170°W During February-April 1990

K. McTaggart[1], D. Wilson[2] , and L. Mangum

ABSTRACT

Summaries of Nell Brown Instrument System CTD measurements and hydrographic data acquired on a Climate and Global Change (CGC) cruise during the spring of 1990 aboard the NOAA ship Malcolm Baldridge are presented. The majority of these data were collected along 170°W from 5°N to 60°S. Additional data collected along a trackline from 60°S, 170°W to 46.3°S, 179.5°E, and along 32.5°S from 179°W to 170°W are also presented. Data acquisition and processing systems are described and calibration techniques are discussed. Station location, meteorological conditions, abbreviated CTD data listings, profiles, and potential temperature- salinity diagrams are shown for each cast. Section plots of oceanographic variables and hydrographic data listings are also given.

1. INTRODUCTION

In support of NOAA's Climate Program, PMEL scientists have been measuring the growing burden of greenhouse gases in the thermocline waters of the Pacific Ocean and the overlying atmosphere since 1980. During leg 1 of this cruise, hydrographic and chemical measurements were made in a detailed section along 170°W in the southwestern Pacific Ocean. Goals included the assessment of the change in inventory of CFC-11, CFC-12, and anthropogenic CO_2 since the first observations in the southwestern Pacific during 1984; observation of freons and other tracers in several crossings of the Deep Western Boundary Current; and observation of tracers in the bottom waters of the deep basin of the southwestern Pacific. During leg 2 of this cruise, measurements were made in the deep passages between the North and South Pacific Basins, across the Deep Western Boundary Current at 32.5°S, and across the equator. Figures 1 and 2 show the cruise track and station locations. In Figure 2, leg 1 stations are indicated by a circle and leg 2 stations are marked by a triangle. Table 1 provides a summary of cast information.

2. STANDARDS AND PRE-CRUISE CALIBRATIONS

The Neil Brown Mark IIIb CTD profiler is designed to make precise, high resolution measurements of conductivity, temperature, and pressure in the ocean environment. Electrical conductivity of sea water is obtained using a miniature four-electrode ceramic cell and highly precise and stable interface electronics; temperature is determined using a platinum resistance thermometer. Pressure is determined using a high performance strain gage pressure transducer. A thermistor within the pressure sensor housing corrects pressure values for the effects of temperature changes on the sensor itself.

Data from the underwater unit is transmitted in real time to a shipboard data terminal through a 3-conductor electro-mechanical cable. The data is in TELETYPE (TTY) format and uses a frequency shift key (FSK) modulated signal superimposed on the DC power supplied to the underwater unit.

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The EG&G conductivity sensor has a range of I 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 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.

Pre-cruise calibrations were done at Northwest Regional Calibration Center (NRCC) in Bellevue, Washington. The CTD was placed in a temperature controlled bath and compared against a calibration standard at nine different temperatures ranging from 0 to 30°C. A linear fit was calculated for the platinum thermometer. A calibrated piston gauge was used to determine separate third- order fits for the pressure sensor at four temperatures for increasing pressure (a range of seven pressure values from 0 to 6300 db) and decreasing pressure (a range of six values from 6300 to 0 db). Temperature and pressure calibrations were crudely checked at sea by comparing values with those from deep reversing thermometers, but the stability of the temperature and pressure sensors is such that the sensors are more accurate than the reversing thermometers. The conductivity sensor, on the other hand, is not as stable relative to water sample values and is more accurately calibrated using water sample salinities. Immediately prior to tripping the rosette, values of pressure, temperature, and conductivity were recorded from the CTD deck unit. These upcast CTD values were used for comparison with the water sample values.

3. DATA ACQUISITION

The CTD was deployed off the starboard platform of the Malcolm Baldrige using an Interocean winch throughout both legs of the cruise. A total of 64 CTD profiles were collected at 36 stations on leg 1 along 170°W from 15°S to 60°S, and along a trackline from 60°S, 170°W to 46.3°S, 179.5°E, including 21 deep casts to within 50 db of the bottom and 6 test/freon calibration casts. Cast 63 and 64 were freon calibration casts. CTD data from cast 63 is included in the data set although no bottle salts were drawn, but CTD data from cast 64 was not processed. A total of 46 CTD profiles were collected during leg 2 along 32.5°S from 178.8°W to 171.5°W, and along 170°W from 30°S to 5°N, including 13 deep casts to within 50 db of the bottom.

PMEL's Nell Brown CTD/O_2 S/N 2044 (sampling rate 31 Hz) and a General Oceanics 24-bottle rosette were used for casts 0-10. Eight-hundred pounds of lead weight were attached to the frame to reduce the effects of surging. AOML's Neil Brown CTD S/N 2043 (sampling rate 31 Hz) and a General Oceanics 12-bottle rosette with 400 pounds of lead weight were used for casts 11-64 of leg 1 and throughout leg 2. Casts to within 50 meters of the bottom were made using a Benthos acoustic pinger mounted low and opposite the CTD sensor arm on the frame. The position of the package relative to the bottom was monitored on the ship's Precision Depth Recorder. Ten-liter Niskin bottles were used to collect water samples for salinity, oxygen, nutrients, CFC, helium, total CO, alkalinity, and dissolved inorganic carbon. Reversing thermometers were mounted on several Niskin bottles on each cast and were used to verify rosette trip sequence and monitor the CTD temperature sensor for calibration shifts.

The package entered the water and was lowered at a rate of 30 m/min for the first 50 meters. To reduce the chance of contamination in the bottles, the package was not stopped just beneath the surface on its descent. Speed was increased at 50 meters to 45 m/min, and increased again at 200 meters to 60 m/min. Ship roll sometimes caused substantial variation about these mean lowering rates.

A Neil Brown Mark III deck unit received the FSK signal from the CTD and displayed pressure, temperature, and conductivity values. An analog signal was forwarded from the deck unit to an XYY' recorder which monitored the data acquisition in real-time for signal spiking and problems with the electrical termination. An audio signal was forwarded to a video cassette recorder as a backup. The digitized data were forwarded to a microVAX and written directly to a disk file. Digitized data were also recorded on 9-track magnetic tape as an additional backup. The acquisition microVAX was equipped with Scientific Computer System (SCS) data acquisition software modified from PMEL/AOML source code. The disk files were transferred to a processing microVAX where PMEL's standard processing and plotting software were installed. Plots were generated after each cast to check for problems and monitor sensor drift. Backups of the raw and processed data were made on TK50 cartridge tapes and returned to PMEL.

3.1 Data Acquisition Problems

Early into leg 1, patches of deteriorated cable were identified from near- surface to greater than 5000 meters. Efforts were made to reinforce damaged areas in order to continue with CTD operations.

The oxygen sensor on CTD S/N 2044 started losing sensitivity before the cap was inadvertently left on during a deep cast which ruptured the sensor's membrane. Before the sensor could be replaced, the entire underwater package was lost during cast 10 when the cable parted with approximately 600 meters of cable out. An additional 4100 meters of cable was discarded and operations continued with the 12-bottle package. Multiple casts were made at selected stations to adequately sample the water column. CTD oxygen data were not processed.

Problems existed throughout the cruise with the rosettes and the rosette deck units of both packages. Several deck units were tried. A strip chart recorder connected to the rosette deck units to monitor the signal voltages was helpful in determining misfires. Bottle salinity, oxygen and nutrient data were also used in an effort to determine the actual depth of each bottle fired. No bottles closed during cast 63 owing to a nicked connector.

3.2 Salinity Analyses

Bottle salinity analyses were performed by survey personnel in a climate- controlled van using two Guildline Autosal Model 8400A inductive salinometers and IAPSO Standard Seawater from Wormley batch P 112. The commonly accepted precision of the Autosal is 0.001 psu, with an accuracy of 0.003 psu. The Autosals were standardized before each run and either at the end of each run or after no more than 48 samples. 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.

Problems developed with both autosals midway through the cruise but were fixed by ship's personnel. Generally, there was good agreement between preliminary CTD data and bottle salinities, with a standard error near .005 psu. Calibrated CTD salinities replace problem bottle salinities in the hydrographic data listing and are indicated by an asterisk.

4. POST-CRUISE CALIBRATIONS

Pressure and temperature values for both CTDs were corrected using pre-cruise calibration coefficients. Reversing thermometer data showed no shifts in temperature and pressure calibrations within the resolution of these measurements. The new International Temperature Scale of 1990 (ITS-90) was not applied to the temperature values of this data set.

Final calibrations for conductivity were determined by reading uncalibrated CTD upcast and sample salinity data and calculating a least squares linear fit between CTD and water sample conductivity, weighting all data equally. When the difference between CTD and water sample conductivity exceeded 2.8 times the standard deviation of the calculated fit, the calibration pair was thrown out. Another fit was then calculated with these points omitted and the process repeated until no calibration pairs are discarded. This cruise was separated into three groups:

	BIAS	SLOPE	MAXIMUM RESIDUAL	STANDARD DEVIATION
Casts 0-10:	-2.0077199E-02	0.9993219	-0.019	0.0068 mmho/cm
Casts 11-63:	-0.7075790E-02	0.9987081	-0.010	0.0038 mmho/cm
Casts 65-110:	-1.4587455E-02	0.9986109	-0.010	0.0039 mmho/cm
Casts 0-10:	16 values were discarded from a total of 122 in 6 repetitions.			
Casts 11-63:	36 values were discarded from a total of 555 in 8 repetitions.			
Casts 65-110:	49 values were discarded from a total of 510 in 7 repetitions.			

Deep potential temperature- salinity diagrams for each cast were used to check the quality of the fits. Where leg 1 stations were revisited on leg 2 (32.5°S, 30°S, 25°S, 20°S, and 15°S), overplots were generated. At reoccupied stations on leg 2, deep potential temperature- salinity diagrams of CTD and bottle data showed good correlation, however there was a difference of approximately 0.002 psu at two of the five reoccupied stations, 25°S and 30°S.

Historical data from 1967 Scorpio, 1987 TEW, and 1974 GEOSECS cruises were examined and there also existed differences between these cruises in salinity of the deepest water masses of about 0.002 psu. Comparing the 1990 data set with these historical data, leg 1 salinity data was within this 0.002 psu difference. Therefore leg 2 data at stations 25°S and 30°S along 170°W (casts 77-84) were corrected. This was done by regridding leg 1 and leg 2 data at these two stations according to potential temperature. The range of potential temperature was around 0.6 to 0.8°C, with a grid size of 0.01°C. The mean difference in salinity between leg 1 and leg 2 casts was computed. For the station at 25°S, this value was 0.0018 psu; for the station at 30°S, it was 0.0021 psu. For each regridded scan of leg 2 data, a new conductivity was calculated using the value of salinity plus delta-salinity. The differences between the old and new conductivities were averaged (25°S = 0.0014 mmho/cm, 30°S = 0.0018 mmho/cm) and added to the conductivity calibration bias applied. Corrections were linearly interpolated over casts 77-84.

5. PROCESSING

Raw CTD data files were restored from TK50 cartridge tapes and processed on PMEL microVAX node NBVAX. In order to eliminate anomalous excursions in the raw temperature and conductivity data associated with reversals in the direction of movement of the CTD package, as well as when the package decelerates due to ship roll, program DPDNB was used to read the SCS LOGGER raw data files and compute a fall rate every 60 scans (about 2 seconds). Fall rate was then carried along with the original unprocessed data.

Program DLAGAV read the raw data files with fall rates and applied pre-cruise calibrations. Window outliers (acceptable ranges were -12 to 6500 db for pressure, -2 to 33°C for temperature, and 24 to 68 mmho/cm for conductivity) and first-differencing outliers (acceptable differences between scans were 1.0 db for pressure, 0.07°C for temperature, and 0. 1 mmho/cm for conductivity) were removed. Gaps in the data were filled by linear interpolation. DLAGAV lagged conductivity, edited data exceeding the fall rate criteria (minimum fall rate acceptable was 0.5 db/60 scans or about 15 meters per minute and pressure interval to skip beyond the point of failure was 1.2 db as determined at sea), and computed 1-decibar data files.

First-differencing outliers were tentatively flagged if the differences between two scans were greater than the above mentioned preset values. If the difference between the next scan and the last good scan exceeded twice the allowable difference between scans, it too was flagged. If five scans in a row failed in this manner it was assumed that there was a gap in the data record and all scans were retained. Or if the next, third, fourth or fifth scan had values close enough to the last good scan, then the flagged scans were rejected.

The filter applied to conductivity to account for the response time difference between the conductivity sensor and the slower platinum thermometer is described in Fofonoff et al. (1974). The conductivity is lagged as follows:

$$C(n) = (I-A)\ CM(n) + A \cdot C\ (n-1)$$

where C is the lagged conductivity, CM is the measured conductivity, n is the scan number, and A is a constant empirically determined (Home and Toole, 1980) to best match temperature and conductivity (A = 0.87).

Program EPCTD read calibrated pressure, calibrated temperature, and raw conductivity data output from DLAGAV. EPCTD corrected raw conductivity for thermal and pressure effects, applied conductivity calibrations, and computed salinity using the 1978 Practical Salinity Scale (UNESCO, 1981). Single-point spikes were eliminated using maximum allowable gradients of 0.05°C for temperature and 0.025 psu for salinity above 200 db, and 0.01°C for temperature and 0.0 1 psu for salinity below 200 db. Additional salinity spikes were omitted from casts 12, 24, 5 1, 58, 70, and 95 as specified by the processor. Missing data were filled by linear interpolation for a value to exist every whole decibar. Final conductivity values were recomputed from salinity.

The conductivity cell dependence on temperature and pressure was corrected using the following (Fofonof et al., 1974):

$$C = CR \cdot (1-ALPHA \cdot (T-15.) + BETA \cdot (P/3.))$$

where CR is lagged conductivity, ALPHA is 6.5E-06, and BETA is 1.5E-08.

EPCTD then calculated potential temperature, sigma-t, and sigma-theta using the 1980 equation of state algorithms described by Fofonoff and Millard (1983). Dynamic height in dynamic meters was calculated by integrating from the sea surface. When the uppermost pressure was not equal to 0 db, surface values of temperature and salinity were filled with the values associated with the shallowest pressure for which values did exist (provided this pressure was less than 10 db). EPCTD output finalized CTD data in PMEL's Equatorial Pacific Information Collection (EPIC) format (Soreide and Hayes, 1988).

6. DATA PRESENTATION

The final calibrated data in EPIC format were used to produce the plots and listings which follow. The majority of the plots were produced using Plot Plus Scientific Graphics System (Denbo, 1992). Tables 2-6 define the abbreviations and units used in the CTD data summary listings. Plots and summary listings of the CTD data follow for each cast. Hydrographic bottle data at discrete depths are listed in the final section.

7. PERSONNEL

		Leg 1	Leg 2
John Bullister, NOAA Pacific Marine Environmental Laboratory (PMEL)	CFC	x	
David Wisegarver, (Chief Scientist, legs I and 2), PMEL	CFC	x	x
Fred Menzia, PMEL	CFC	x	x
Jeff Benson, PMEL	CTD	x	
Dana Greeley, PMEL	C02/CTD	x	x
Paulette Murphy, PMEL	C02	x	x
Marilyn Roberts, PMEL	C02	x	x
Linda Mangum, PMEL	CTD	x	
Kristy McTaggart, PMEL	CTD	x	
Lloyd Moore, NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML)	Nutrients	x	x
Rick Van Woy, Scripps Institute of Oceanography	CFC	x	
Gary Wick, University of Colorado	SST	x	x
Mike Behrenfeld, Western Washington University (WWU)	UV-b	x	
Andrew Hanneman, WWU	UV-b	x	
Michael Mathewson, Woods Hole Oceanographic Institute	Helium	x	
Bob Byrnes, University of Southern Florida (USF)	pH	x	
Tanya Clayton, USF	pH	x	
Doug Wilson, AOML	ADCP	x	
Rick Cole, USF	Moorings		x
Margie McCarty, PMEL	CTD		x
Lt. Cliff Wilson, PMEL	Moorings		x
Rolf Beck, Ocean Science Institute, University of Sydney	CFC	x	
Jeff Donavan, USF	Moorings		x

8. ACKNOWLEDGMENTS

The assistance of the officers and crew of the NOAA ship Malcolm Baldrige is gratefully acknowledged. The survey department (Dennis Sweeney and Tom Lantry), under the supervision of Chief Survey Technician Robert Hopkins, provided valuable assistance in operations during this cruise.

We wish to thank Margie McCarty for the acquisition and preliminary calibration of leg 2 CTD data, as well as Jeff Benson and Dana Greeley for their help with the rosette, bottles, and CTD operations.

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9. REFERENCES

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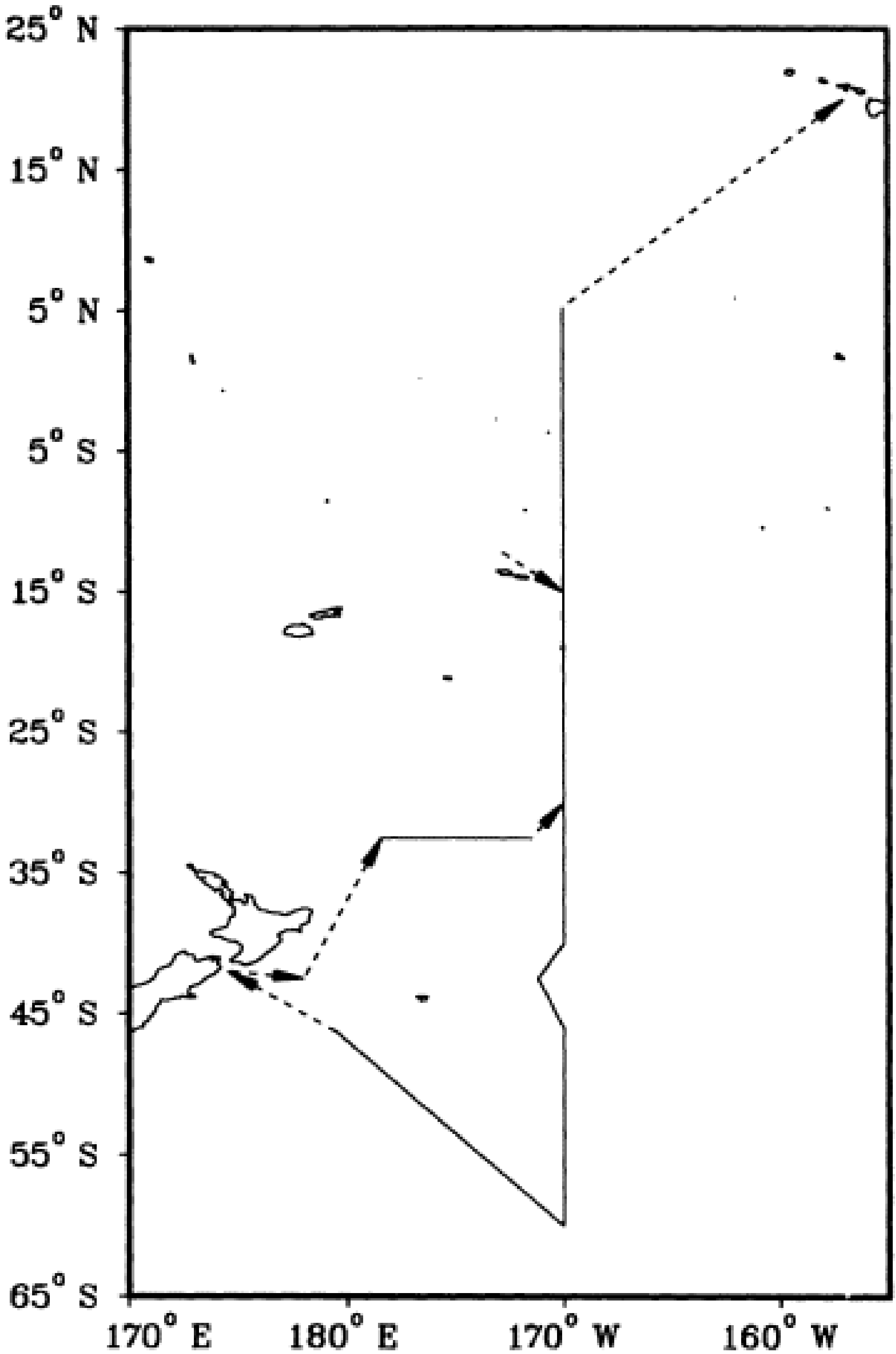
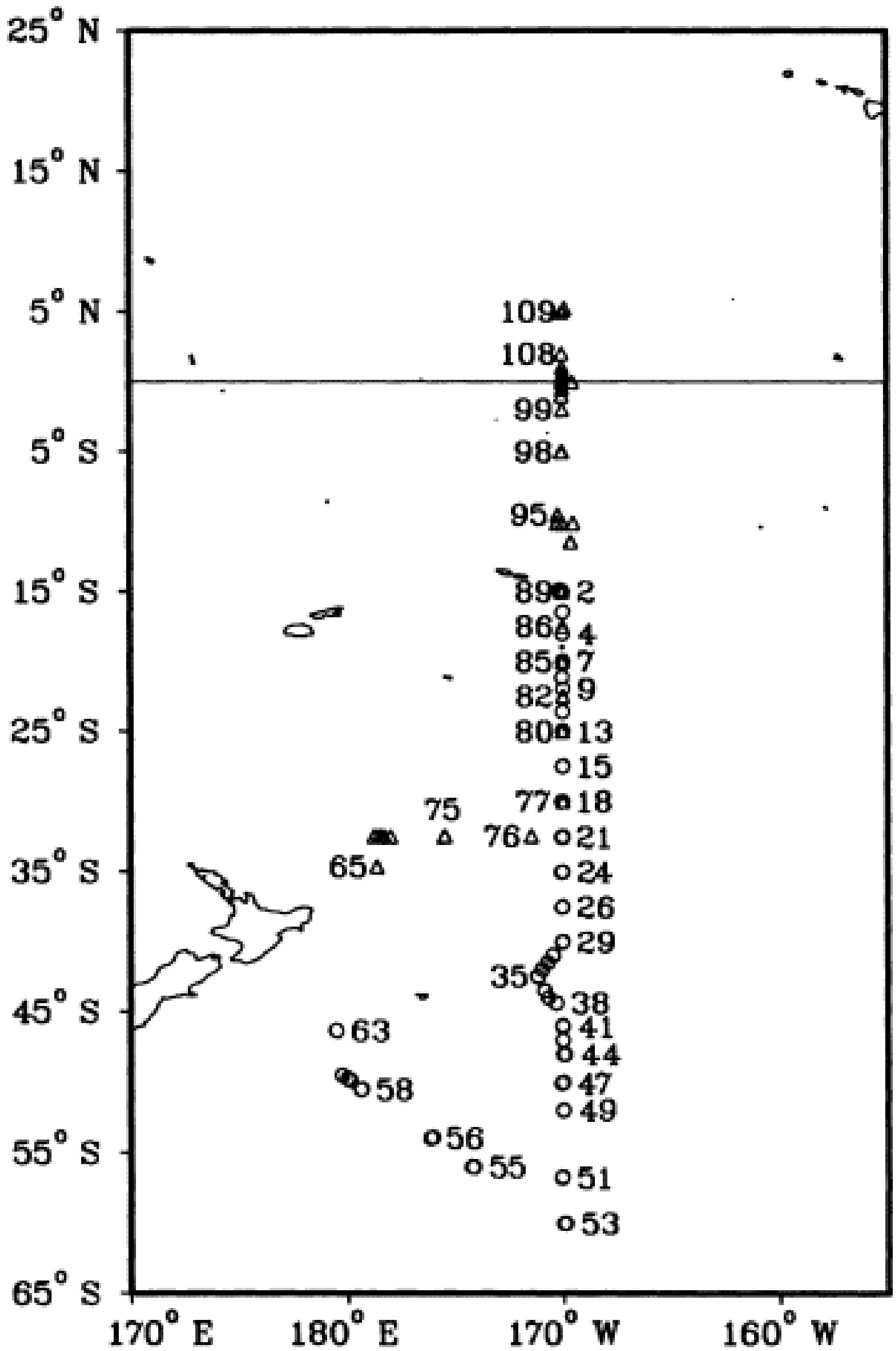


CGC-90-MB CRUISE TRACK
February 22 - April 16,1990
Pago Pago, Samoa - Wellington, NZ - Honolulu, HI

Figure 1. CGC-90-MB cruise track.



CGC-90-MB CTD STATIONS
February 22 - April 16,1990
Pago Pago, Samoa - Wellington, NZ - Honolulu, HI

Figure 2. Location of stations occupied during CGC-90-MB. Leg I stations are indicated by a circle, leg 2 stations are shown with a triangle.

170°W POTENTIAL TEMPERATURE (C)
February 24 - April 12, 1990

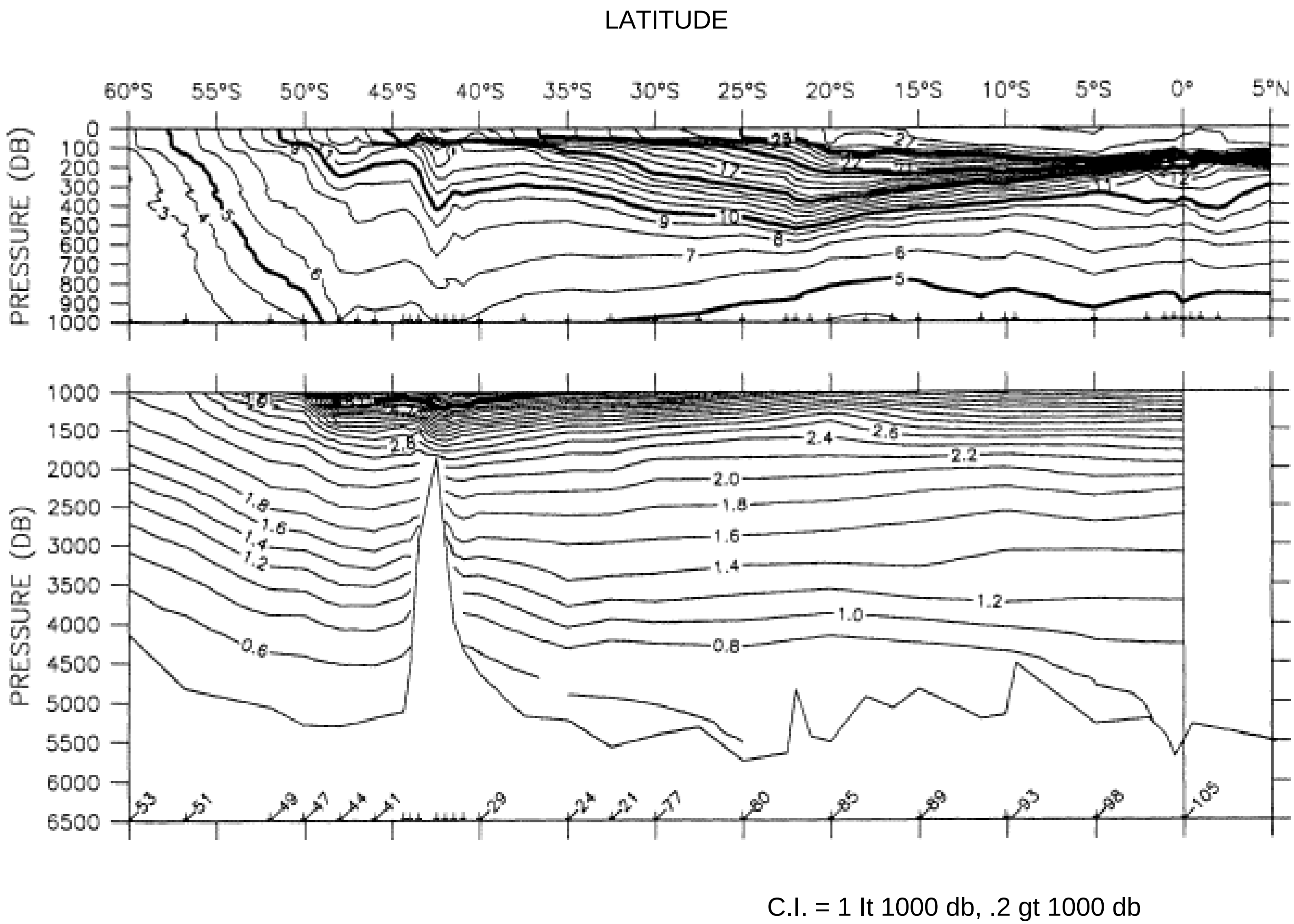
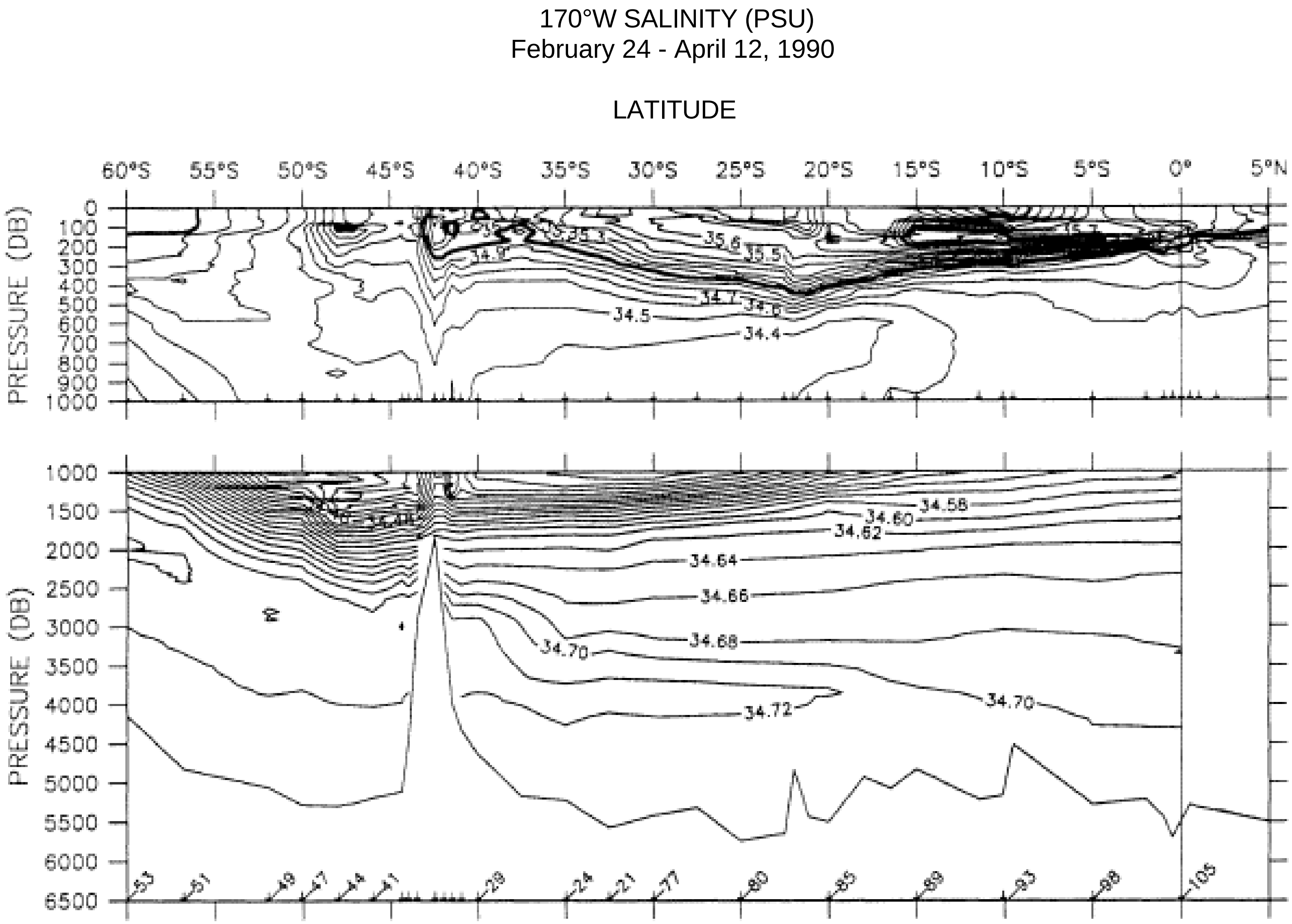


Figure 3. CGC-90-MB upper ocean and deep water potential temperature (°C) sections along 170°W.



C.I. = .1 lt 1000 db, .02 gt 1000 db

Figure 4. CGC-90-MB upper ocean and deep water salinity (psu) sections along 170°W.

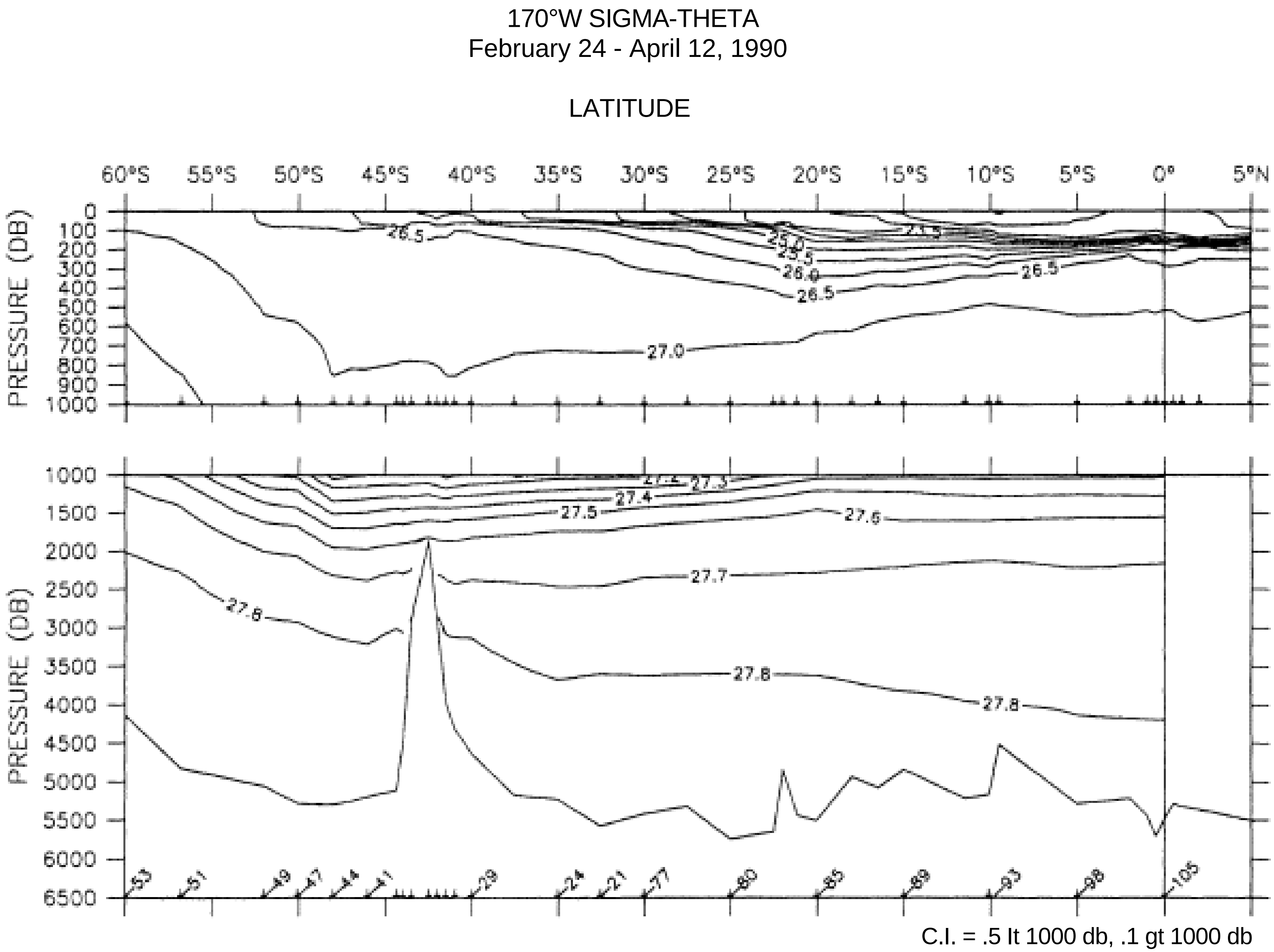
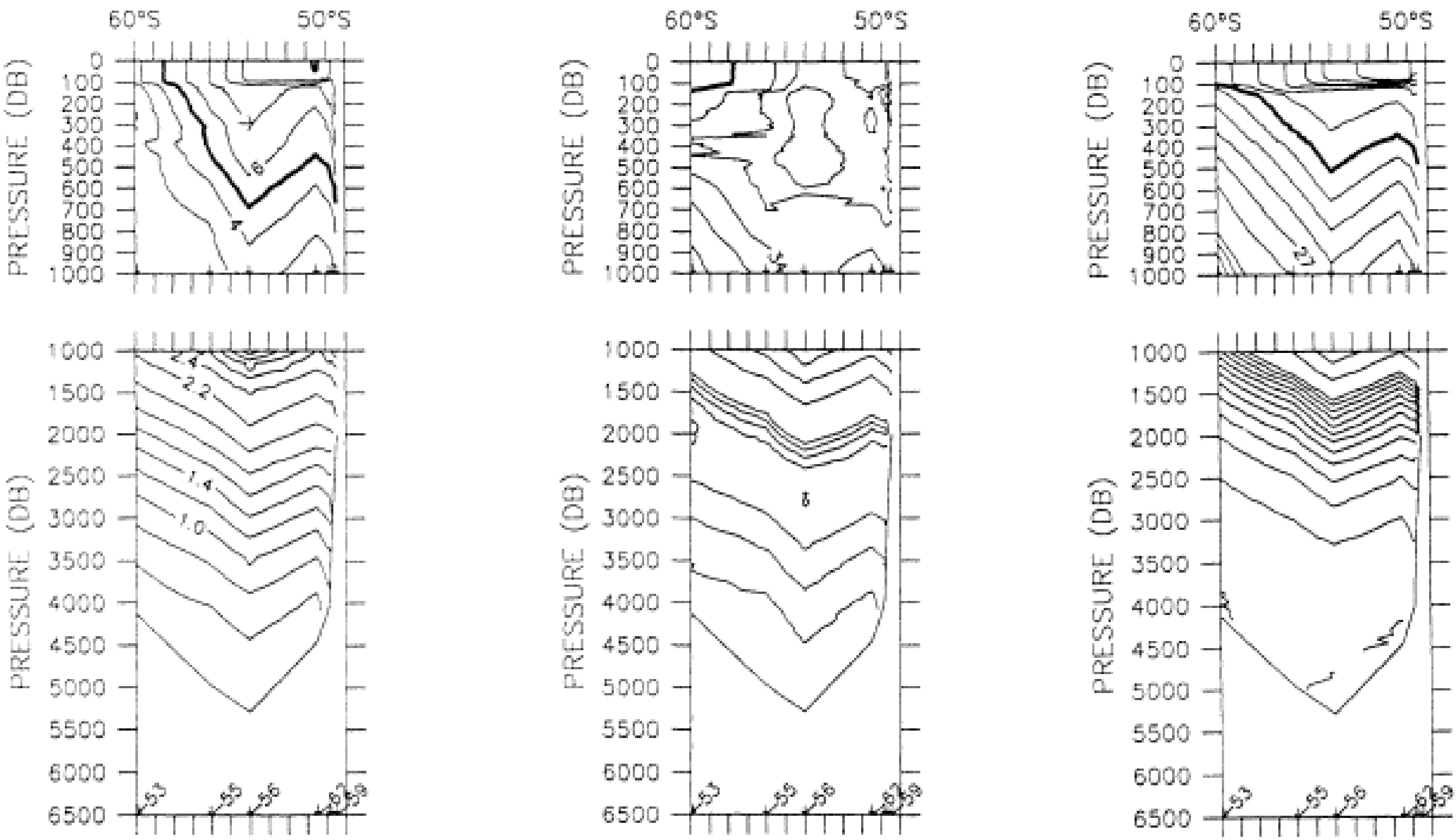


Figure 5. CGC-90-MB upper ocean and deep water potential density (kg/m 3) sections along 170°W.

POTENTIAL TEMPERATURE (C)
Mcrch 11 - 18, 1990
LATITUDE ALONG TRACK

SALINITY (PSU)
March 11 - 18, 1990
LATITUDE ALONG TRACK

SIGMA-THETA
March 11 - 18, 1990
LATITUDE ALONG TRACK



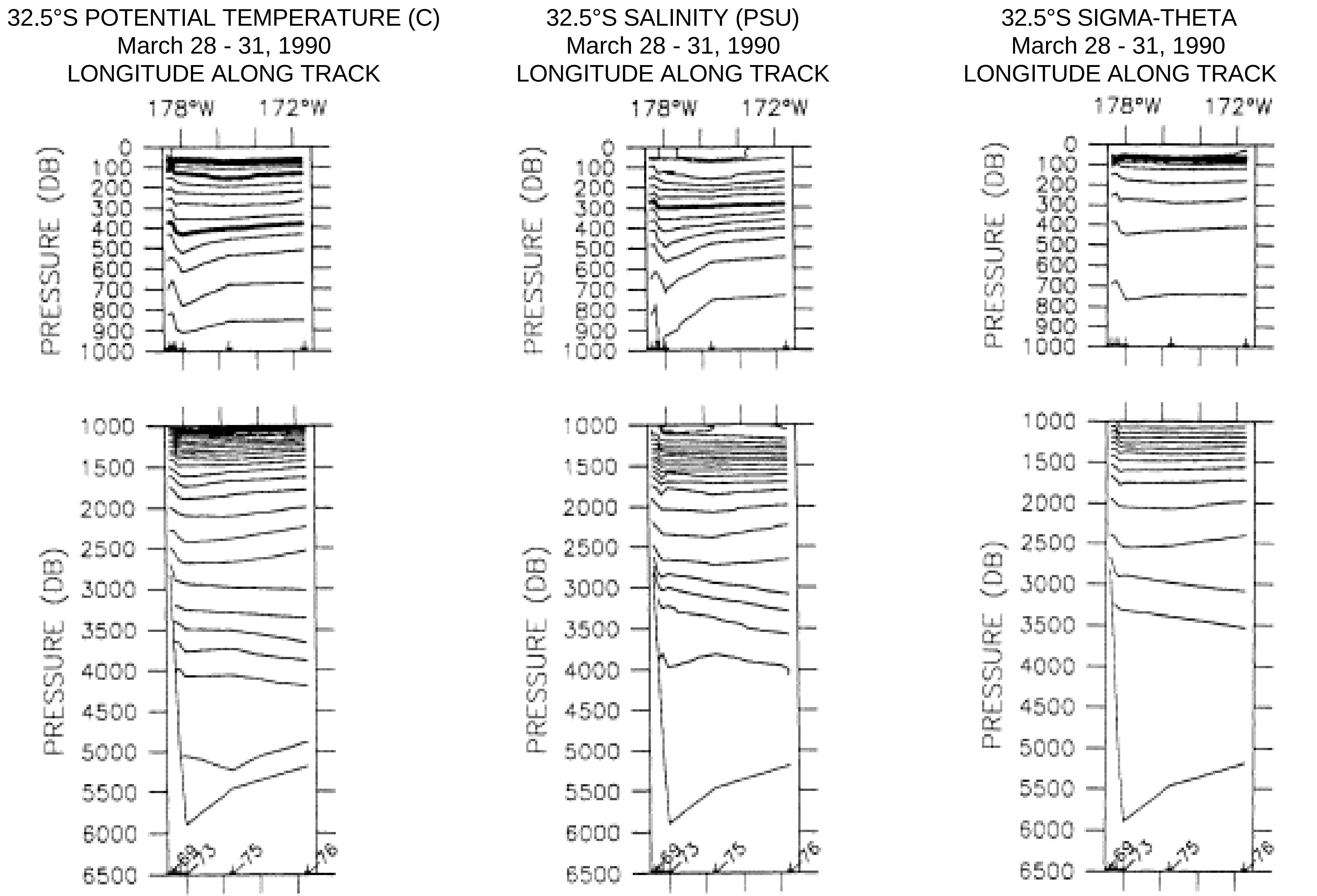
1 lt 1000 db, .2 gt 1000 db

C.I. = .1 lt 34.7 psu, .01 gt 34.7 psu

CJ. = .1 lt 27.6, .02 gt 27.6

60.°S 169.°W to 49.5°S 179.°E

Figure 6. CGC-90-MB upper ocean and deep water potential temperature (°C), salinity (psu), and potential density (kg/M3) sections along track from 60°S, 169.9°W to 49.5°S, 179.7°E.



C.I. = 1 lt 1000 db, .2 gt 1000 db

C.I. = .1 it 1000 db, .02 gt 1000 db

C.I. = .2 lt 1000 db, .05 gt 1000 db

Figure 7.CGC-90-MB upper ocean and deep water potential temperature (°C), salinity (psu), and potential density (kg/m 3) sections along 32.5°S.

TABLE 1. CTD Cast Summary

STN #	Cast #	Latitude	Longitude	Date (GMT)	Time (°T)	W/D (kts)	W/S (m)	Depth (°C)	SST (db)	Cast
0	0	14 53.2 S	170 8.5 W	23 FEB 90	1742	-	-	4541	28.1	3013
1	1	14 59.5 S	170 0.6 W	23 FEB 90	2146	51	4	4806	28.2	200
2	2	15 0.1 S	170 0.3 W	24 FEB 90	151	-	-	4817	28.8	4847
3	3	16 28.3 S	169 59.6 W	24 FEB 90	1238	-	-	5073	28.6	2000
4	4	18 0.2 S	170 0.4 W	24 FEB 90	2149	148	7	4929	27.6	2001
5	5	20 0.2 S	169 59.6 W	25 FEB 90	816	180	8	5320	27.0	202
5	6	20 2.1 S	169 59.9 W	25 FEB 90	1100	-	-	5361	27.0	2152
5	7	20 0.7 S	169 59.6 W	25 FEB 90	2049	116	10	5320	27.0	5427
6	8	21 9.1 S	170 1.7 W	26 FEB 90	657	120	10	5433	26.7	2501
7	9	21 59.5 S	169 59.8 W	26 FEB 90	1300	103	10	4839	26.0	2004
8	10	23 37.2 S	170 0.3 W	26 FEB 90	2310	98	18	5660	25.8	600
9	11	24 59.9 S	170 1.4 W	27 FEB 90	1157	90	20	5753	24.7	2501
9	12	25 0.4 S	170 0.5 W	27 FEB 90	1509	100	18	5702	24.6	600
9	13	25 1.3 S	170 0.9 W	27 FEB 90	1837	25	5	5712	24.6	5055
10	14	27 30.2 S	170 0.3 W	28 FEB 90	727	116	14	5223	24.1	352
10	15	27 30.8 S	170 0.9 W	28 FEB 90	952	114	10	5316	24.1	2500
11	16	30 0.3 S	170 0.8 W	28 FEB 90	2215	85	19	5417	23.7	304
11	17	30 1.1 S	170 1.5 W	1 MAR 90	16	67	18	5415	23.8	1512
11	18	30 0.3 S	170 2.6 W	1 MAR 90	441	60	16	5429	23.9	5178
12	19	32 31.0 S	169 59.9 W	1 MAR 90	1825	45	22	5588	22.1	351
12	20	32 34.2 S	169 59.9 W	1 MAR 90	2032	68	24	5577	22.0	1504
12	21	32 33.2 S	170 3.1 W	2 MAR 90	30	63	20	5568	22.0	5300
13	22	35 2.0 S	170 3.3 W	2 MAR 90	1514	15	18	5172	20.7	352
13	23	35 2.0 S	170 3.4 W	2 MAR 90	1719	15	18	5128	20.7	1503
13	24	35 1.4 S	170 0.6 W	2 MAR 90	2115	355	17	5225	20.7	5278
14	25	37 30.6 S	170 1.1 W	3 MAR 90	1037	55	12	5149	19.7	400
14	26	37 32.6 S	170 2.2 W	3 MAR 90	1252	40	18	5170	19.6	2504
15	27	40 0.0 S	170 0.2 W	4 MAR 90	52	38	14	4626	17.2	398
15	28	40 0.8 S	170 0.1 W	4 MAR 90	306	40	10	4626	17.6	2301
15	29	40 1.7 S	170 1.7 W	4 MAR 90	706	168	5	4626	17.6	4678
16	30	40 59.8 S	170 28.8 W	4 MAR 90	1535	192	10	4248	17.6	2005
16	31	40 58.1 S	170 29.0 W	4 MAR 90	1908	195	14	4323	17.5	4346
17	32	41 29.4 S	170 43.4 W	5 MAR 90	41	185	14	3984	18.0	3405
18	33	41 58.9 S	170 59.0 W	5 MAR 90	554	157	18	2974	18.2	2978
19	34	42 29.5 S	171 12.2 W	5 MAR 90	1016	161	10	1826	17.8	502
19	35	42 28.7 S	171 12.5 W	5 MAR 90	1225	155	6	1857	17.8	1845
20	36	43 30.1 S	170 51.2 W	5 MAR 90	1902	97	9	2904	15.6	2923
21	37	43 59.1 S	170 41.6 W	6 MAR 90	54	58	8	4473	16.0	4648
22	38	44 22.2 S	170 19.7 W	6 MAR 90	641	43	12	5108	15.8	5186
23	39	45 58.6 S	170 0.7 W	6 MAR 90	1612	25	8	5225	14.7	352
23	40	46 3.2 S	170 0.6 W	6 MAR 90	1819	25	20	5173	14.6	1752
23	41	46 2.7 S	170 0.1 W	6 MAR 90	2207	23	21	5190	14.6	5272
24	42	47 0.4 S	170 0.8 W	7 MAR 90	538	15	14	5252	13.4	3000
25	43	48 0.3 S	169 59.5 W	7 MAR 90	1133	8	14	5307	13.7	1000
25	44	48 1.3 S	169 54.9 W	7 MAR 90	1509	30	8	5294	13.7	5205
26	45	50 0.2 S	169 59.8 W	8 MAR 90	213	358	14	5340	12.5	404
26	46	50 0.3 S	170 1.5 W	8 MAR 90	434	315	10	5340	12.6	2402
26	47	50 4.0 S	170 4.2 W	8 MAR 90	844	321	25	5279	11.6	5305
27	48	51 59.6 S	169 59.2 W	8 MAR 90	2113	256	21	4981	9.5	1003

STN #	Cast #	Latitude	Longitude	Date (GMT)	Time (°T)	W/D (kts)	W/S (m)	Depth (°C)	SST (db)	Cast
27	49	51 58.0 S	169 59.1 W	9 MAR 90	27	266	18	5054	9.4	5130
28	50	56 42.1 S	170 3.4 W	10 MAR 90	231	345	20	4883	5.5	1000
28	51	56 46.1 S	170 4.1 W	10 MAR 90	612	12	26	4822	5.5	4769
29	52	60 0.7 S	169 57.3 W	11 MAR 90	138	314	26	4139	3.8	1005
29	53	60 0.6 S	169 53.0 W	11 MAR 90	502	265	16	4139	3.8	4177
30	54	55 59.5 S	174 14.2 W	12 MAR 90	1825	155	10	5011	7.0	1001
30	55	55 59.8 S	174 10.1 W	12 MAR 90	2212	171	12	4970	7.0	5030
31	56	53 56.9 S	176 9.5 W	13 MAR 90	1304	270	24	5289	9.3	5025
31	57	53 54.2 S	176 3.3 W	13 MAR 90	1643	280	22	5310	9.2	1250
32	58	50 30.3 S	179 23.7 W	15 MAR 90	620	270	18	4448	10.2	1753
33	59	49 29.9 S	179 44.7 E	15 MAR 90	1420	337	18	2012	8.8	1987
34	60	49 43.5 S	179 59.9 W	16 MAR 90	724	267	16	3111	8.5	3088
35	61	49 50.9 S	179 52.7 W	16 MAR 90	1146	284	21	4030	9.8	4056
36	62	50 29.0 S	179 21.4 W	18 MAR 90	704	285	22	4458	10.0	4531
37	63	46 20.0 S	179 28.9 E	20 MAR 90	5	145	14	3317	15.0	3004
38	65	34 38.9 S	178 38.2 W	29 MAR 90	948	144	23	6556	21.2	3000
39	66	32 29.8 S	178 18.8 W	28 MAR 90	2141	124	20	4994	21.9	5061
40	67	32 30.6 S	178 31.4 W	29 MAR 90	237	94	7	-	22.1	4219
41	68	32 29.8 S	178 44.6 W	29 MAR 90	704	93	10	3080	22.1	999
41	69	32 29.3 S	178 46.0 W	29 MAR 90	1000	100	11	2828	22.1	2973
42	70	32 29.0 S	178 30.1 W	29 MAR 90	1257	123	8	4211	22.0	1498
43	71	32 29.6 S	178 17.8 W	29 MAR 90	1554	157	8	5004	22.2	1500
44	72	32 29.5 S	178 0.2 W	29 MAR 90	2008	114	8	5722	21.9	1499
44	73	32 30.6 S	177 59.9 W	30 MAR 90	29	155	6	5898	22.0	5975
45	74	32 29.0 S	175 29.0 W	30 MAR 90	1229	125	4	5574	22.2	1498
45	75	32 29.4 S	175 30.1 W	30 MAR 90	1642	-	-	5462	22.3	5526
46	76	32 28.8 S	171 28.7 W	31 MAR 90	1104	218	3	5182	21.6	5229
47	77	30 0.0 S	170 0.4 W	1 APR 90	233	134	12	5414	24.1	5502
48	78	24 58.6 S	170 1.3 W	2 APR 90	206	114	24	5689	25.4	399
48	79	24 58.9 S	170 1.0 W	2 APR 90	506	100	20	5784	25.4	2253
48	80	25 1.2 S	170 1.8 W	2 APR 90	857	122	21	5740	25.3	5804
49	81	22 29.8 S	170 0.4 W	2 APR 90	2222	135	25	5468	25.4	500
49	82	22 30.4 S	170 0.5 W	3 APR 90	42	126	20	5645	25.4	2999
50	83	20 0.4 S	170 0.4 W	3 APR 90	1333	125	22	5320	27.0	400
50	84	20 0.9 S	170 0.0 W	3 APR 90	1548	120	18	5351	27.2	2249
50	85	20 1.5 S	170 0.8 W	3 APR 90	1926	132	24	5502	27.2	5472
51	86	17 29.5 S	170 0.3 W	4 APR 90	841	117	25	4848	27.6	600
52	87	15 0.2 S	170 0.6 W	4 APR 90	2202	168	8	4686	28.5	399
52	88	14 58.7 S	170 2.9 W	5 APR 90	12	85	4	4771	28.5	2016
52	89	15 0.3 S	170 0.4 W	5 APR 90	438	105	14	4833	28.5	4873
53	90	11 26.4 S	169 36.5 W	5 APR 90	2237	329	10	5216	28.8	1250
54	91	10 6.1 S	169 30.2 W	6 APR 90	700	38	14	5249	28.9	5302
55	92	10 5.4 S	169 59.5 W	6 APR 90	1137	53	6	5161	28.8	1500
55	93	10 5.5 S	170 0.0 W	6 APR 90	1546	60	8	5163	28.7	5230
56	94	10 5.3 S	170 14.9 W	6 APR 90	2053	56	14	5929	28.7	5111
57	95	9 29.5 S	170 12.8 W	7 APR 90	238	75	16	4515	29.0	1499
58	96	5 0.1 S	170 0.8 W	7 APR 90	2307	64	20	5413	29.1	400
58	97	5 1.5 S	170 3.7 W	8 APR 90	139	93	19	5436	29.2	1998
58	98	5 0.8 S	170 1.2 W	8 APR 90	526	80	18	5280	29.2	5481
59	99	2 0.3 S	170 0.4 W	8 APR 90	2116	66	21	5214	28.4	998
60	100	0 59.7 S	170 1.2 W	9 APR 90	244	80	18	5435	28.3	1001

STN #	Cast #	Latitude	Longitude	Date (GMT)	Time (°T)	W/D (kts)	W/S (m)	Depth (°C)	SST (db)	Cast
61	101	0 29.9 S	170 0.4 W	9 APR 90	605	90	16	5698	28.3	999
62	102	0 0.0 S	170 1.2 W	9 APR 90	931	78	15	5342	28.1	1999
62	103	0 0.7 N	170 0.3 W	9 APR 90	1149	69	10	5324	27.8	399
63	104	0 2.0 S	169 32.3 W	11 APR 90	916	72	13	5181	28.0	501
64	105	0 0.0 S	170 0.2 W	11 APR 90	1400	105	12	-	27.9	5582
65	106	0 30.0 N	170 0.3 W	11 APR 90	1837	104	14	5285	27.8	1002
66	107	1 0.1 N	170 0.3 W	11 APR 90	2145	117	16	5316	27.8	999
67	108	2 0.3 N	170 0.9 W	12 APR 90	308	96	14	5357	27.8	1001
68	109	5 0.1 N	170 0.6 W	12 APR 90	1655	90	22	7161	28.0	1005
69	110	5 13.7 N	169 52.4 W	12 APR 90	1923	60	20	5496	28.2	1249

TABLE 2. Weather condition code used to describe each set of CTD measurements.

Code	Weather Condition
0	Clear (no cloud)
1	Partly cloudy
2	Continuous layer(s) of cloud(s)
3	Sandstorm, dust storm, or blowing snow
4	Fog, thick dust or haze
5	Drizzle
6	Rain
7	Snow, or rain and snow mixed
8	Shower(s)
9	Thunderstorms

TABLE 3. Sea state code used to describe each set of CTD measurements.

Code	Height (meters)	Description
0	0	Calm-glassy
1	0-0.1	Calm-rippled
2	0.1-0.5	Smooth-wavelet
3	0.5-1.25	Slight
4	1.25-2.5	Moderate
5	2.5-4	Rough
6	4-6	Very rough
7	6-9	High
8	9-14	Very high
9	>14	Phenomenal

TABLE 4. Visibility code used to describe each set of CTD measurements.

Code	Visibility
0	<50 meters
1	50-200 meters
2	200-500 meters
3	500-1000 meters
4	1-2 km
5	2-4 km
6	4-10 km
7	10-20 km
8	20-50 km
9	50 km or more

TABLE 5. Cloud type.

Code	Cloud Types
0	Cirrus
1	Cirrocumulus
2	Cirrostratus
3	Altocumulus
4	Altostratus
5	Nimbostratus
6	Stratocumulus
7	Stratus
8	Cumulus
9	Cumulonimbus
x	Clouds not visible

TABLE 6. Cloud Amount.

Code	Cloud Amount
0	0
1	1/10 or less but not zero
2	2/10-3/10
3	4/10
4	5/10
5	6/10
6	7/10-8/10
7	9/10
8	10/10
9	Sky obscured or not determined

ORNL/CDIAC-84
NDP-052

TOTAL CARBON DIOXIDE, HYDROGRAPHIC, AND NITRATE MEASUREMENTS IN THE SOUTHWEST PACIFIC DURING AUSTRAL AUTUMN, 1990: RESULTS FROM NOAA/PMEL CGC-90 CRUISE

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ABSTRACT

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In support of the National Oceanic and Atmospheric Administration (NOAA) Climate and Global Change (C&GC) Program, Pacific Marine Environmental Laboratory (PMEL) scientists have been measuring the growing burden of greenhouse gases in the thermocline waters of the Pacific Ocean since 1980. Collection of data at a series of hydrographic stations along longitude 170 W during austral autumn of 1990 was designed to enhance understanding of the increase in the column burden of chlorofluorocarbons and carbon dioxide in the thermocline waters since the last expedition in 1984.

This document presents the procedures and methods used to obtain total carbon dioxide (TCO_2), hydrographic, and nitrate data during the NOAA/PMEL research vessel (R/V) Malcolm Baldrige CGC-90 Cruise. Data were collected along two legs; sampling for Leg 1 began along 170 W from 15 S to 60 S, then angled northwest toward New Zealand across the Western Boundary Current. Leg 2 included a reoccupation of some stations between 30 S and 15 S on 170 W and measurements from 15 S to 5 N along 170 W. Along the cruise track 68 CTD stations were occupied for collection of chemical and hydrographic data. The following data report summarizes the TCO_2, salinity, temperature, and nitrate measurements from 63 stations. In addition, potential density and potential temperature were calculated from the measured variables.

The TCO_2 concentration in seawater samples was measured using a coulometric/extraction system (Models 5011 and 5030, respectively) originated by Ken Johnson (Johnson et al. 1985, 1987). Throughout the cruise, the accuracy was determined to be within 0.15%, and the precision was within 0.12%.

The NOAA/PMEL R/V Malcolm Baldrige CGC-90 Cruise data set is available without charge as a numeric data package (NDP) from the Carbon Dioxide Information Analysis Center. The NDP consists of two oceanographic data files, two FORTRAN 77 data retrieval routine files, a documentation file, and this printed documentation, which describes the contents and format of all files as well as the procedures and methods used to obtain the data.

Keywords: carbon dioxide; nitrate; hydrographic measurements; carbon cycle; Pacific Ocean

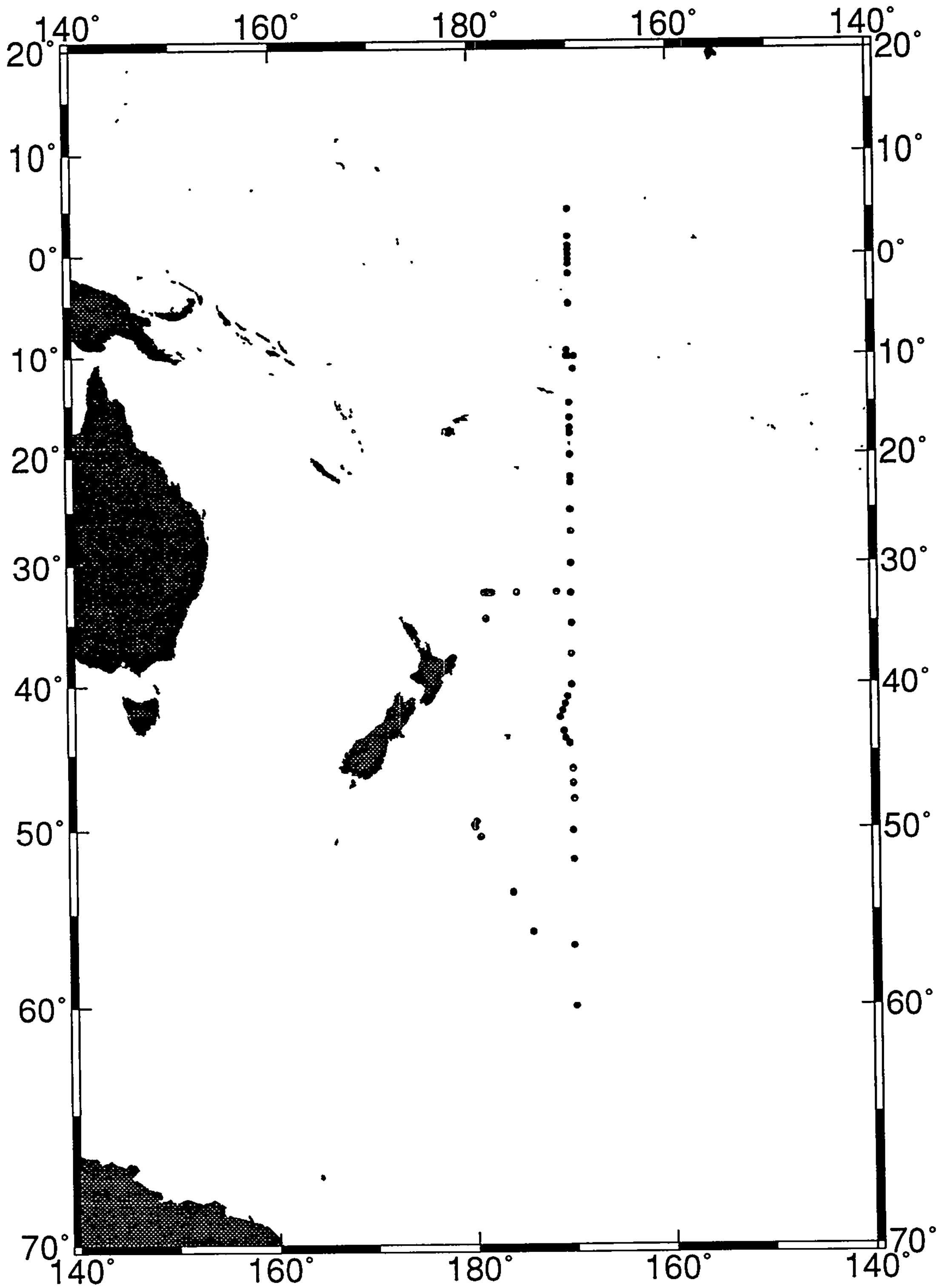

Figure 1. Station locations during R/V *Malcolm Baldrige* CGC-90 Cruise.

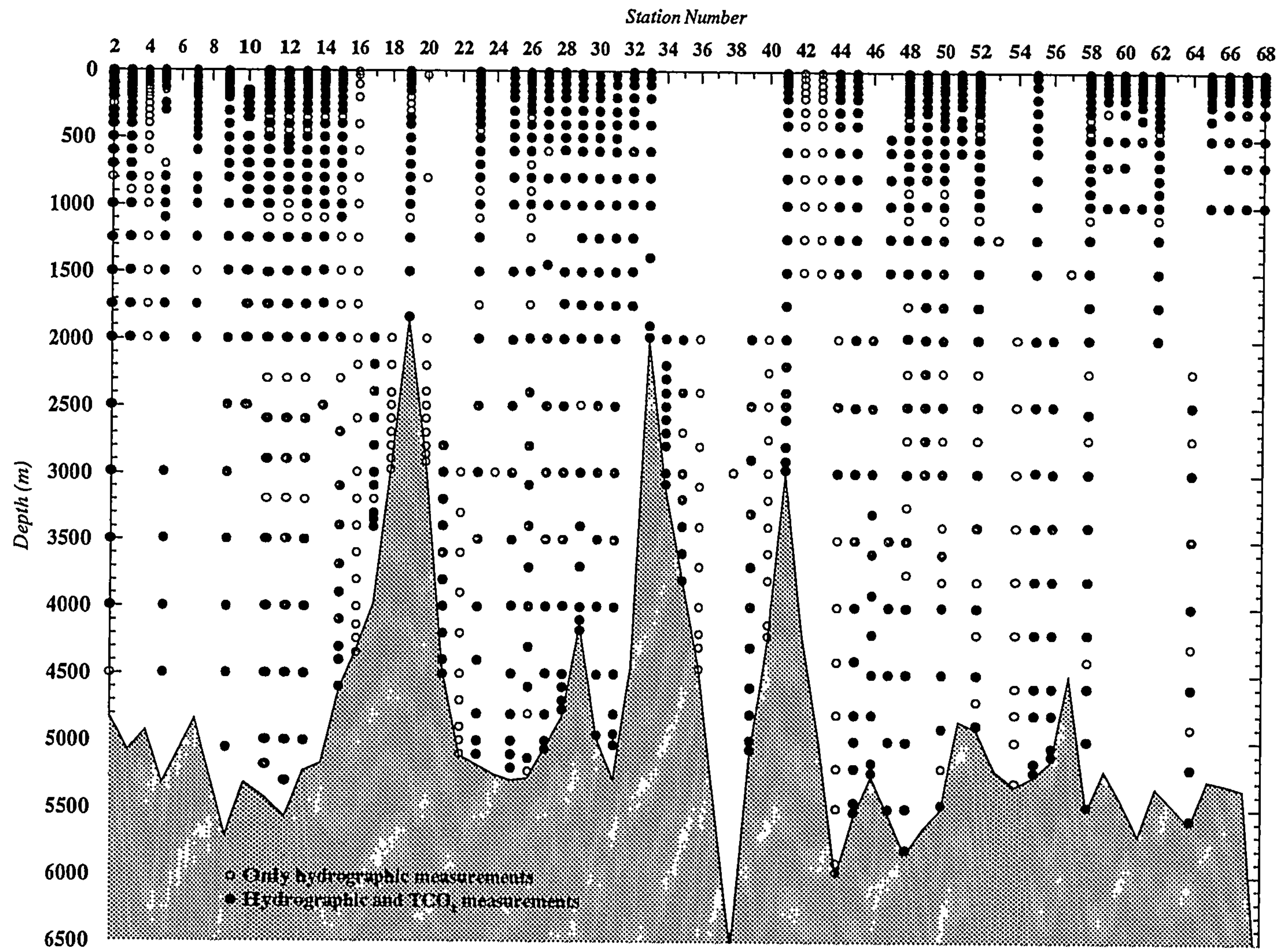

Figure 2. Sampling depths at the 63 hydrographic stations occupied during R/V *Malcolm Baldrige* CGC-90 Cruise.

PART 1:
OVERVIEW

1. BACKGROUND INFORMATION

Human activity is rapidly changing the composition of the earth's atmosphere, causing the greenhouse warming effect from excess carbon dioxide (CO_2) and other trace gas species such as chlorofluorocarbons, methane, and nitrous oxide. Combined, these gases play a critical role in controlling the earth's climate due to the increased trapping of outgoing infrared radiation. This mechanism has a large potential for significantly altering the world's climate.

Of all the anthropogenic CO_2 that has been released into the atmosphere, only about half still remains there; it is the missing CO_2 for which the global ocean is considered to be a dominant sink. Understanding the assimilation process is critical in determining the moderating role the oceans will play in delaying and damping the greenhouse warming predicted in the coming decades. Our goal is to help provide quantitative answers to the ways in which the oceans regulate and assimilate the excess CO_2, so that we can better predict the ocean's role in the natural climate cycle.

In response to these concerns, the Pacific Marine Environmental Laboratory (PMEL) conducted Cruise CGC-90 to the southwest Pacific onboard the research vessel (R/V) Malcolm Baldrige under the sponsorship of the Climate and Global Change Program (C&GC) of the National Oceanic and Atmospheric Administration (NOAA). Chemical and hydrographic data from 68 CTD stations were collected along the cruise track. Several tracers were measured during the cruise, including chlorofluorocarbons, helium, tritium, total carbon dioxide (TCO_2), ^{13}C, pH, nutrients, salinities and oxygens. The following data report summarizes the TCO_2, salinity, temperature, and nitrate data from 63 stations of this cruise.

2. DESCRIPTION OF THE EXPEDITION

2.1 R/V Malcolm Baldrige Technical Details

The R/V Malcolm Baldrige (previously Researcher r103) is owned by the U.S. Department of Commerce and operated by NOAA. The basic features of the vessel are described below.

Port of registration:	Miami, Florida
Call sign:	WTER
Operator:	NOAA
Launched:	October 1968
Delivered:	June 1970
Commissioned:	October 1970
Basic Dimensions:	
length	84.8 m
beam	15.5 m
draft	5.6 m
gross tons	2802
power	3200 hp

maximum speed	15.0 knots
cruise speed	13.0 knots
Personnel:	crew: 36; scientists: 14
Navigation Equipment:	Radar Loran SatNav Gyro DopLog
Hull:	welded steel (ice-strengthened)
Cranes:	Stern, Midships

2.2 NOAA/PMEL CGC-90 Cruise Information

The following is the cruise information:

Ship Name:	Malcolm Baldrige
Cruise/Leg:	CGC-90/1,2
Location:	Southwest Pacific Ocean
Dates:	February 22 - April 16, 1990

List of Participants:

Chief Scientist:	David Wisegarver, NOAA/PMEL
Project Manager:	Richard Feely
Total CO_2:	Marilyn Lamb-Roberts
	Paulette Murphy
CTD:	Linda Mangum
	Kristy McTaggart
	Marguerite McCarty
	Dana Greeley
	Jeff Benson
Salinity:	Survey Department of NOAA R/V Malcolm Baldrige
Nitrate:	Lloyd Moore
	Don Atwood
Computer Support:	Cathy Cosca
	Dan Lee
	Doug Wilson

2.3 Brief Cruise Summary

The cruise track for Leg 1 of CGC-90 started at 15 S/170 W and proceeded south along the meridional line; after reaching 60 S, it angled northwest, crossing the Western Boundary Current and ending in New Zealand. The cruise track for Leg 2 crossed the Kermadec Trench, included a reoccupation of selected stations between 30 S and 15 S on 170 W, and additional stations along the meridional line crossing the equator, to 5 N (Table A-1 in Appendix A).

Stations 2 through 7 were sampled using a 24-position rosette package equipped with 10-L Niskin bottles, and a Neil Brown (Mark III) CTD sampling system. While occupying Station 8, the CTD cable parted, and the equipment package was lost. Subsequently, the remaining stations (Stations 9 through 68) were sampled using a spare 12-position rosette with 10-L Niskin bottles and Neil Brown (Mark III) CTD sampling system. Multiple casts were performed at these stations to ensure high density sample profiles. Occasionally while at the most extreme latitudes, weather deteriorated and prevented the occupation of some stations. Several stations sampled during Leg 1 were reoccupied on Leg 2 for data quality checks.

Two moorings were retrieved, and two deployed at the equator.

3. DESCRIPTION OF VARIABLES AND METHODS

Each station consisted of the lowering of a CTD/rosette package, upon which 10-L standard Niskin bottles were suspended. Pressure, temperature, and CTD salinities for the tabulated data were taken from the calibrated CTD data. The discrete water samples were drawn from the Niskin bottles upon retrieval of the rosette on deck. Samples were collected for analyses of oxygen, chlorofluorocarbons (CFCs), helium, tritium (Leg 1 only), TCO_2, ^{13}C, pH (Leg 1 only), nutrients, and salinity. In addition, underway partial pressure of CO_2 (pCO_2) was measured throughout the cruise. This report addresses the temperature, salinity, TCO_2, and nitrate data.

CTD data were collected using a Neil Brown (Mark III) Instrument System. Pressure, temperature, and conductivity were recorded on the downtrace, and the discrete water samples were collected on the upcast with an electronically fired rosette sampler. The bottle salinity samples were analyzed with a Guideline Autosal, which was calibrated at the beginning of each day's run with a vial of Wormley standard seawater, and again after each case of samples was analyzed with another vial. An accuracy of 0.002 Practical Salinity Scale (PSS) and a precision of 0.001 PSS were achieved. A more detailed description of the CTD data processing has been published as a NOAA Data Report (McTaggart et al, 1993).

Nutrient analyses included nitrate, silicate, and phosphate. Due to accuracy and precision problems for silicate and phosphate, only nitrate data are included in this report.

Nitrate samples were collected from each Niskin bottle in aged 60-mL linear polyethylene bottles and analyzed for dissolved inorganic nitrate (NO_3--N). Analyses were performed on samples from all CTD casts with a five-channel Technicon Auto-Analyzer (AA-II) aboard ship. The analytical procedures and methodologies used in the analysis of nitrate are similar to those described by Armstrong et al. (1967), with modifications described in Atlas et al. (1971) and in a Technicon Corporation (1977) technical report. The detection limit for nitrate was 0.39 umol/kg with a standard deviation of 0.1 umol/kg. The precision of duplicate measurements was 0.25%, full scale. The accuracy was assumed to be 1% because no absolute standards were available. Nitrate measurements are reported in umol/kg at 1 atm and an assumed laboratory temperature of 25°C. Calibration standards ranged between 0 and 30 umol/kg; therefore, only samples within that concentration range are reported in Appendix B and data file.

Upon retrieval of the CTD-rosette package on deck, samples for TCO_2 were collected in 500-mL glass-stoppered bottles and poisoned with 0.5 mL of saturated $HgCl_2$ solution to decrease bacterial oxidation of organic matter prior to analysis. The samples were analyzed immediately when possible, but always within 24 h after collection.

The coulometric technique for TCO_2 analyses in seawater was originated by Ken Johnson (Johnson et al. 1985, 1987). UIC, Inc. supplied the coulometic/extraction system (Models 5011 and 5030, respectively). The following changes were made to the standard extraction system: 1. Both the pipet and seawater sample bottle were jacketed (the sample bottle was placed in a jacketed beaker) and were connected to a circulating bath set at 25°C. 2. Ultra-pure N_2 was used for both carrier gas and sample delivery; prior to hook-up to glassware, the N_2 was sent through an in-line NaOH (Malcosorb) scrubber to remove any CO_2. 3. The condensing column was connected to a circulating bath filled with antifreeze and run at 1°C. 4. An ORBO (activated Si gel from Supelco) tube was placed in-line between the glassware and titration cell to eliminate any excess moisture. 5. Standardization of instrumentation was modified (as described later in this section). The computer interfaced to the system was a Zenith ZBF-2339-BK. The program supplied by UIC was modified significantly, to accommodate our particular needs. In coulometric analysis of TCO_2, all carbonate species in seawater ($CO_{2(aq)}$, H_2CO_3, HCO_3- and CO_3^{2-}) are converted to CO_2 by addition of excess acid. The evolved CO_2 is then moved into the titration cell by N_2 carrier gas where it is titrated potentiometrically by reacting quantitatively with ethanolamine to form hydroxyethyl carbamic acid; this is titrated with OH- ions electrogenerated by the reduction of H_2O at a platinum cathode:

$$CO_2 + HO(CH_2)_2NH_2 \rightarrow HO(CH_2)_2NHCOO^- + H^+$$
$$Ag(s) \rightarrow Ag^+ + e^-$$
$$H_2O + e^- \rightarrow 0.5H_2(g) + OH^-$$
$$H^+ + OH^- \rightarrow H_2O$$

The equivalence point is detected photometrically with thymolphthalein as an indicator. The cell solution is blue at the equivalence point of 10.5 pH and colorless at pH 9.3 after the addition of CO_2 in aqueous solutions. CO_2 drives down the pH and raises percent transmittance. As the acid is titrated, pH increases (hence, the blue color returns) and percent transmittance decreases, thus causing the titration current to pass from high to low to zero as the equivalence point is approached and sensed by the optical detector. The CO_2 level is calculated based on the quantity of electricity required to reach the equivalence point and the time of passage. The entire sequence takes from 8 to 11 min.

The volume of the pipet was ~ 50 mL, and was calibrated in the laboratory before and after the cruise. The pipet was cleaned by drawing a 25% solution of NaOH into the cell and allowing it to soak overnight. This eliminated any organic film inside the pipet and ensured a clean delivery. Pipet calibrations were conducted to be within the measured pipet temperature range during the cruise (24.5°C-25.5°C) utilizing a circulating bath. Milli-Q water was drawn into the pipet in the exact manner that a liquid standard or seawater sample was handled. The water was delivered by N_2 (flow rate is 200 mL/min) into a tared, ground-glass stoppered mixing flask, and drained for an additional 5 s (monitored by a stop-watch) to allow the droplets of water to be delivered; the flask was then immediately stoppered and weighed on a Mettler AE240 balance. Approximately 15-20 samples were collected per experiment. The following references were used to correct the weighings: 1. Volume Properties of Ordinary Water. 2. Reductions of Weighings in Air to Vacuo for Brass Weights and a Water Density of 1.00. Density of air used was 0.0012. 3. Temperature Correction for Glass Volumetric Apparatus.

The corrected volumes were then linearly regressed with temperature, and a calibration curve was established (typical $r^2 = 0.80$).

Schott-Duran glass 500-mL bottles were annealed at 450°C for 1 h, then cleaned in a dishwasher with commercial grade dishwashing detergent. Prior to collection of samples, the solid ground-glass stoppers were coated with Type M Apiezon grease.

Acid used to convert carbonate species to CO_2 was a 1:10 solution of Baker reagent grade H3PO4. All coulometric chemicals (cathode solution, anode solution, and KI) were purchased from UIC, Inc.

Liquid standards were made up in a 0.7 M solution of KCl. The standards were treated just as a seawater sample and were delivered through the pipet under the same conditions. The standard used was $Na2CO_3$ (Ultrex, Lot 935113); the KCl was reagent grade from Mallinkrodt.

The $Na2CO_3$ was prepared in the laboratory by baking at 260 270°C for 0.5 h, and desiccated overnight. The standards were weighed into pre cleaned ground-glass stoppered vials with weights ranging from 0.20 to 0.25 g. They were immediately stored in an evacuated desiccator with fresh Si gel until prepared. The KCl was baked in a muffle furnace for 0.5 h at 260-270°C, and cooled in a desiccator overnight.

The KCl solution and liquid standards were prepared in the following manner: Milli-Q water was boiled in a 3-L boiling flask for 20 min to drive off CO_2, then cooled overnight with a NaOH column attached to the neck of the flask. A glove-box was purged with ultra-pure N_2 for about 20 min; in the glove box, the KCl was mixed with the CO_2-free water in a clean 2-L volumetric. Half of this solution was stored in a 1-L sample bottle with siphon tube and clamp and was used to determine blank values for the KCl (see following discussion). The other half was used to make the $Na2CO_3$ in a 1-L volumetric. After the standard equilibrated, it was poured into a 1-L bottle with siphon tube and clamp. This work was performed in an N_2 environment in the glove box.

The KCl solution was analyzed to determine a mean blank for the standard. Being careful not to expose the KCl solution to the atmosphere, it was drawn into the pipet in the same way as a sample. When handled in this way, the KCl blank was very constant, usually with a mean of around 6.0 ± 0.3 ug C for an individual batch and an over the cruise mean of 6 ± 1 ug C.

The standards yielded a mean calibration factor of 99.6588% +/- 0.0600 (n = 25).

A Certified Reference Material (CRM) was prepared and bottled by Dr. Andrew Dickson of the Scripps Institution of Oceanography (SIO). The TCO_2 concentration of the CRM was determined to be 2020 +/- 0.009 umol/kg by manometric technique in the laboratory of Dr. Charles Keeling of the SIO. Bottles of the CRM were taken on the cruise and analyzed frequently to determine the accuracy and precision of the coulometric method; the results are reported in Table 1. Throughout the cruise, the accuracy was determined to be within 0.15% and the precision was within 0.12%. Replicates analyzed at three different stations throughout the cruise yielded a precision of ≤ 0.05%. The reported TCO_2 data have been corrected to reflect the difference in accuracy to the CRM; the correction applied is +3 umol/kg TCO_2.

Samples were analyzed with the same method as standards, that is, 4.5 mLs of acid were dispensed into the reaction vessel, and 2-3 minutes were allowed to pass to purge CO_2 from the acid. Following that, the pipet was rinsed twice with the sample, and the third fill was isolated and used for analysis. The sample was emptied into the reaction vessel, and allowed to drain for an additional 5 seconds (monitored via stopwatch) to allow droplets of water to be delivered.

Table 1. Certified Reference Material (batch 1) analyzed for total CO_2 during R/V Malcolm Baldrige CGC-90 Cruise

Date	TCO_2 (umol/kg)
24 Feb. 1990	2012
25 Feb. 1990	2024
27 Feb. 1990	2014
2 Mar. 1990	2015
5 Mar. 1990	2012
5 Mar. 1990	2016
6 Mar. 1990	2019
7 Mar. 1990	2019
8 Mar. 1990	2019
10 Mar. 1990	2015
11 Mar. 1990	2016
12 Mar. 1990	2016
13 Mar. 1990	2017
15 Mar. 1990	2017
16 Mar. 1990	2017
20 Mar. 1990	2017
29 Mar. 1990	2017
30 Mar. 1990	2014
2 Apr. 1990	2018
3 Apr. 1990	2014
5 Apr. 1990	2016
6 Apr. 1990	2017
7 Apr. 1990	2018
7 Apr. 1990	2018
11 Apr. 1990	2020
12 Apr. 1990	2017
Mean	2017
Sta. Dev	2.5

Sigma-t and sigma-theta were calculated using standard UNESCO algorithms (Fofonoff and Millard 1983), and the CTD measured in situ temperature and bottle salinities. When no bottle salinities were available or when they were defined as a questionable or unacceptable measurements, CTD salinities were used in the calculation.

4. DATA CHECKS AND PROCESSING PERFORMED BY CDIAC

An important part of the NDP process at the Carbon Dioxide Information Analysis Center (CDIAC) involves the quality assurance (QA) of data before distribution. Data received at CDIAC are rarely in a condition that would permit immediate distribution, regardless of the source. To guarantee data of the highest possible quality, CDIAC conducts extensive QA reviews. Reviews involve examining the data for completeness, reasonableness, and accuracy. Although they have common objectives, these reviews are tailored to each data set, often requiring extensive programming efforts. In short, the QA process is a critical component in the value-added concept of supplying accurate, usable data for researchers.

The following summarizes the data QA checks and processing performed by CDIAC on the data obtained during the NOAA/PMEL R/V Malcolm Baldrige CGC-90 Cruise in the Southwest Pacific.

1. These data were provided to CDIAC as two ASCII-formatted files and accompanying printed documentation (NOAA Data Report ERL PMEL-42) (Lamb et al. 1993). A FORTRAN 77 retrieval code was written and used to reformat the original files.

2. To check for obvious outliers all data were plotted by use of a PLOTNEST.C program written by Stewart C. Sutherland, of the Lamont-Doherty Earth Observatory. The program plots a series of nested profiles, using the station number as an offset; the first station is defined at the beginning, and subsequent stations are offset by a fixed interval. Several outliers were identified and flagged after consultation with the principal investigators.

3. To generate a section profile plot of TCO_2 concentrations along the 170 W, the PLOTSECT.C program written by Stewart C. Sutherland, LDEO was used.

4. To identify noisy data and possible systematic methodological errors, property-property plots for all parameters were generated, carefully examined, and compared with plots from previous expeditions in the Southwest Pacific.

5. To identify possible instrumentation drifts and methodological errors, the data intercomparison for reoccupied stations was provided.

6. All variables were checked for values exceeding physical limits, such as sampling depth values that are greater than the given bottom depths.

7. Station locations (latitudes and longitudes) and sampling dates were examined for consistency with maps and with cruise information supplied by Lamb et al. (1993).

8. The designation for missing values, given as "-99.00" in the original files, was changed to "-999.90".

5. HOW TO OBTAIN THE DATA AND DOCUMENTATION

This data base is available upon request in machine-readable form, free-of-charge from CDIAC. CDIAC will also distribute subsets of the data base as needed. It can be acquired on 9-track magnetic tape; 8-mm tape; 150-mB, quarter-inch tape cartridge; IBM-formatted floppy diskettes; or from CDIAC's anonymous File Transfer Protocol (FTP) area via Internet (see FTP address below). Requests should include any specific media instructions (i.e., 1600 or 6250 BPI, labeled or nonlabeled, ASCII or EBCDIC characters, and variable- or fixed-length records; 3.5- or 5.25-inch floppy diskettes, high or low density; and 8200 or 8500 format 8-mm tape) required by the user to access the data. Magnetic tape requests not accompanied by specific instructions will be filled on 9-track, 6250 BPI, standard-labeled tapes with EBCDIC characters. Requests should be addressed to:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, Tennessee 37831-6335
U.S.A.

Telephone: (615) 574-0390 or (615) 574-3645
Fax: (615) 574-2232
Electronic Mail: INTERNET: CDIAC@ORNL.GOV

The data files can be also acquired from CDIAC's anonymous FTP account via Internet:

- FTP to cdiac.esd.ornl.gov (128.219.24.36)
- Enter "ftp" or "anonymous" as the user id
- Enter your electronic mail address as the password (e.g., alex@alex.esd.ornl.gov)
- Change to the directory "/pub/ndp052"
- Acquire the files using the FTP "get" or "mget" command

or World Wide Web URL:

- http://cdiac.esd.ornl.gov/cdiac/

6. REFERENCES

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Fofonoff, N. P., and R. C. Millard, Jr. 1983. Algorithms for computation of fundamental properties of seawater. UNESCO Technical Paper.

Johnson, K. M., A. E. King, and J. McN. Sieburth. 1985. Coulometric TCO_2 analyses for marine studies; an introduction. Mar. Chem. 16:61-82.

Johnson, K. M., P. J. Williams, L. Brandstrom, and J. McN. Sieburth. 1987. Coulometric total carbon analysis for marine studies: automation and calibration. Mar. Chem. 21:117-33.

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Lamb M. F., R. A. Feely, L. Moore, and D. K. Atwood. 1993. Total CO_2 and Nitrate Measurements In the Southwest Pacific During Austral Autumn, 1990. NOAA Data Report ERL PMEL-42. Pacific Marine Environmental Laboratory, Seattle, Wash.

Technicon Industrial Systems. 1977. Nitrate and nitrite in water and seawater. Technicon Auto- Analyzer II, Industrial Method No. 158 71W/A. Technicon Instrument Corporation, Tarrytown, N.Y.

UNESCO Technical Papers in Marine Science. 1991. Reference Materials for Oceanic Carbon Dioxide Measurements 60.

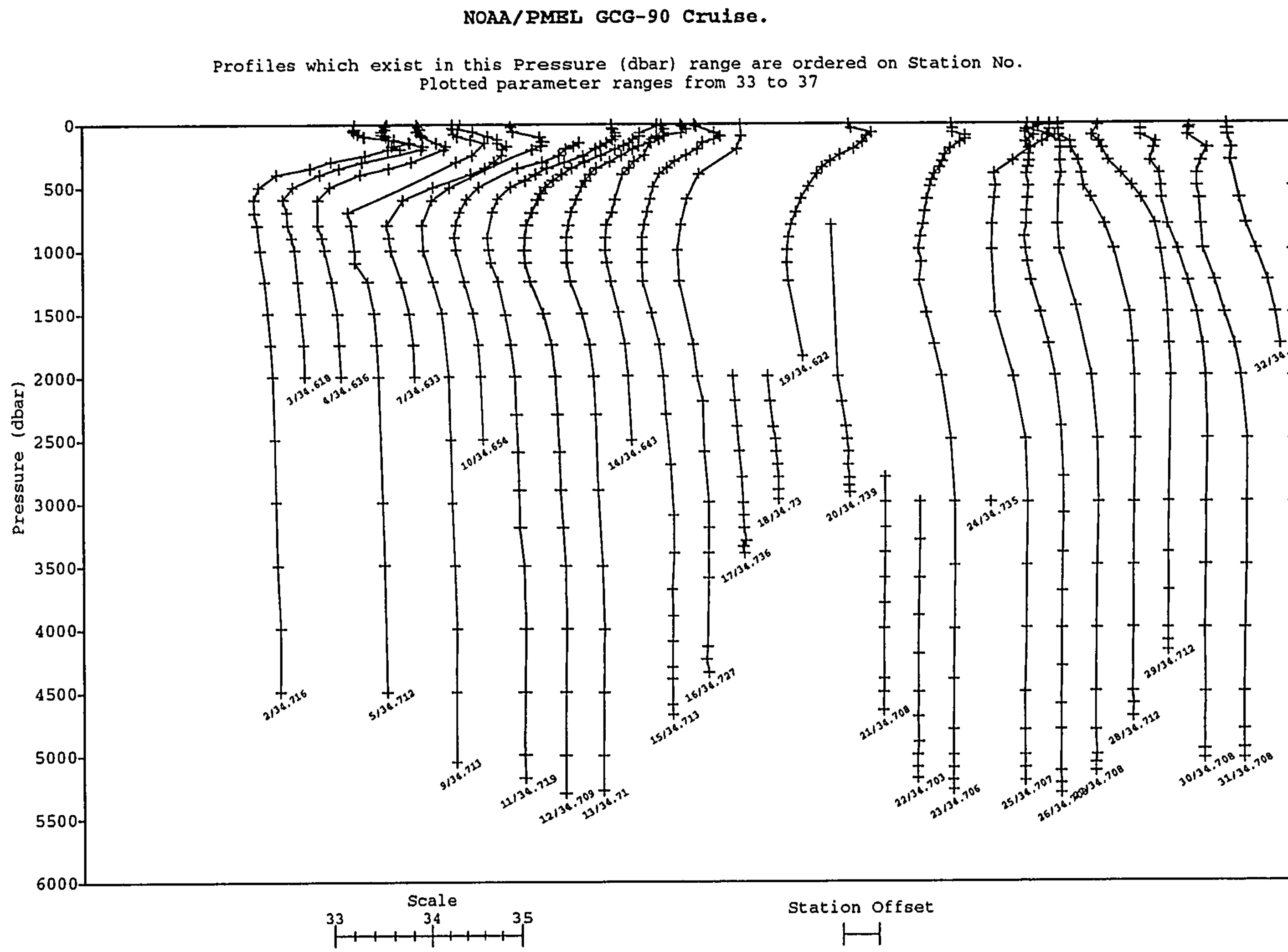

Figure 3. Nested profiles: bottle salinity (PSS) vs pressure (dbar) for stations 2–32.

NOAA/PMEL GCG-90 Cruise.

Profiles which exist in this Pressure (dbar) range are ordered on Station No.
Plotted parameter ranges from 33 to 37

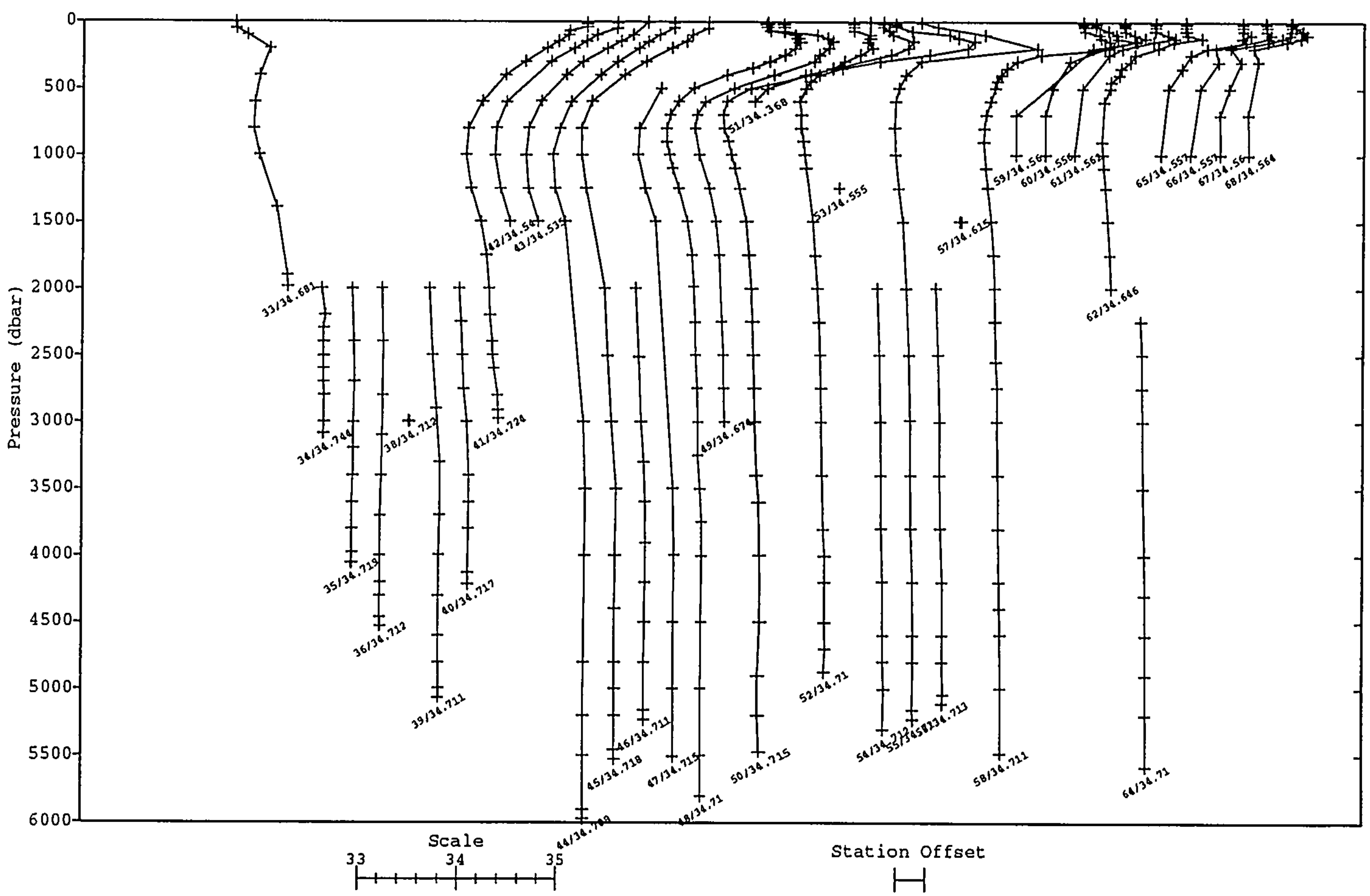

Figure 4. Nested profiles: bottle salinity (PSS) vs pressure (dbar) for stations 33–68.

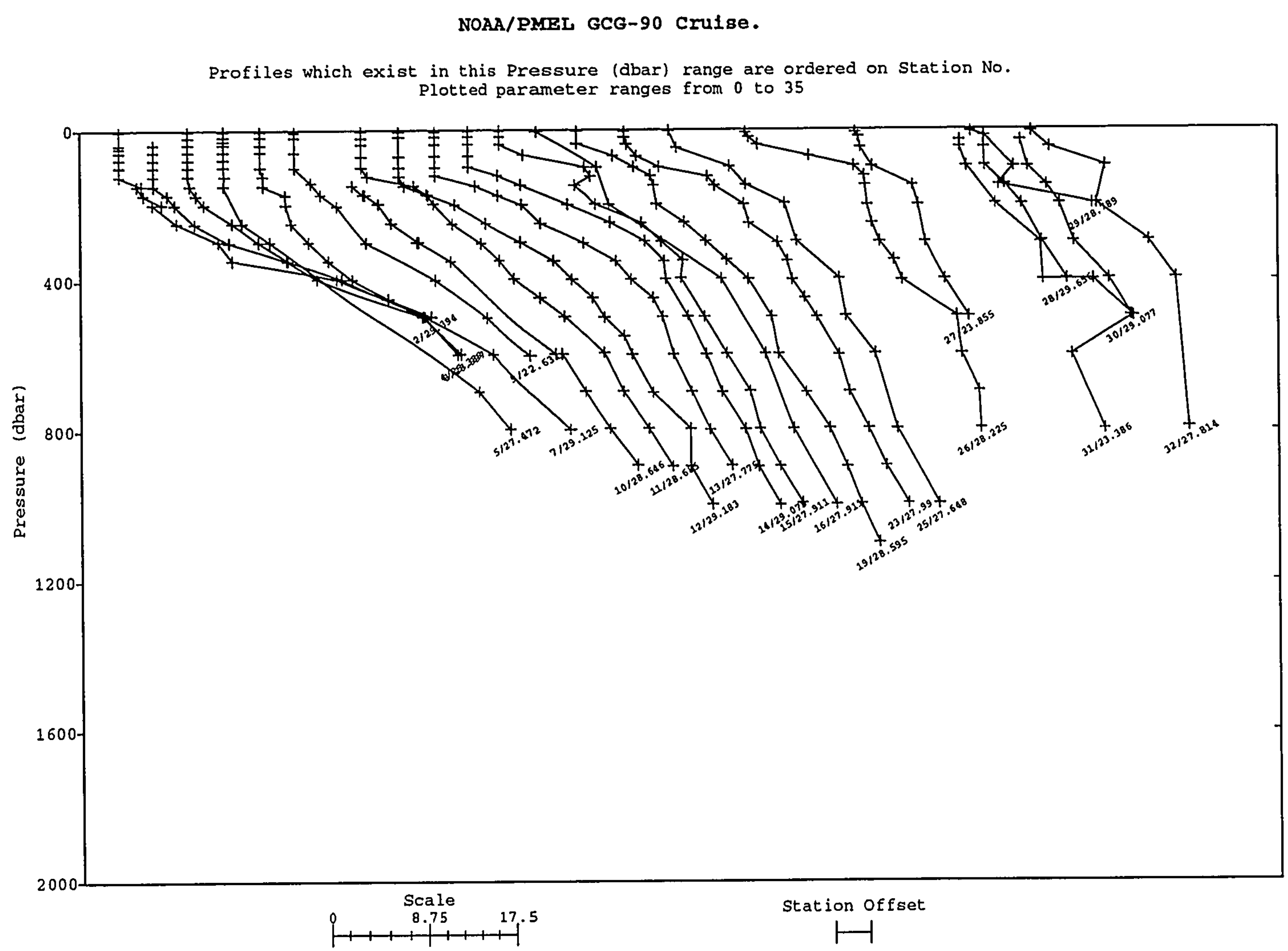

Figure 5. Nested profiles: NO_3 (μmol/kg) vs pressure (dbar) for stations 2–32.

NOAA/PMEL GCG-90 Cruise.

Profiles which exist in this Pressure (dbar) range are ordered on Station No.
Plotted parameter ranges from 0 to 35

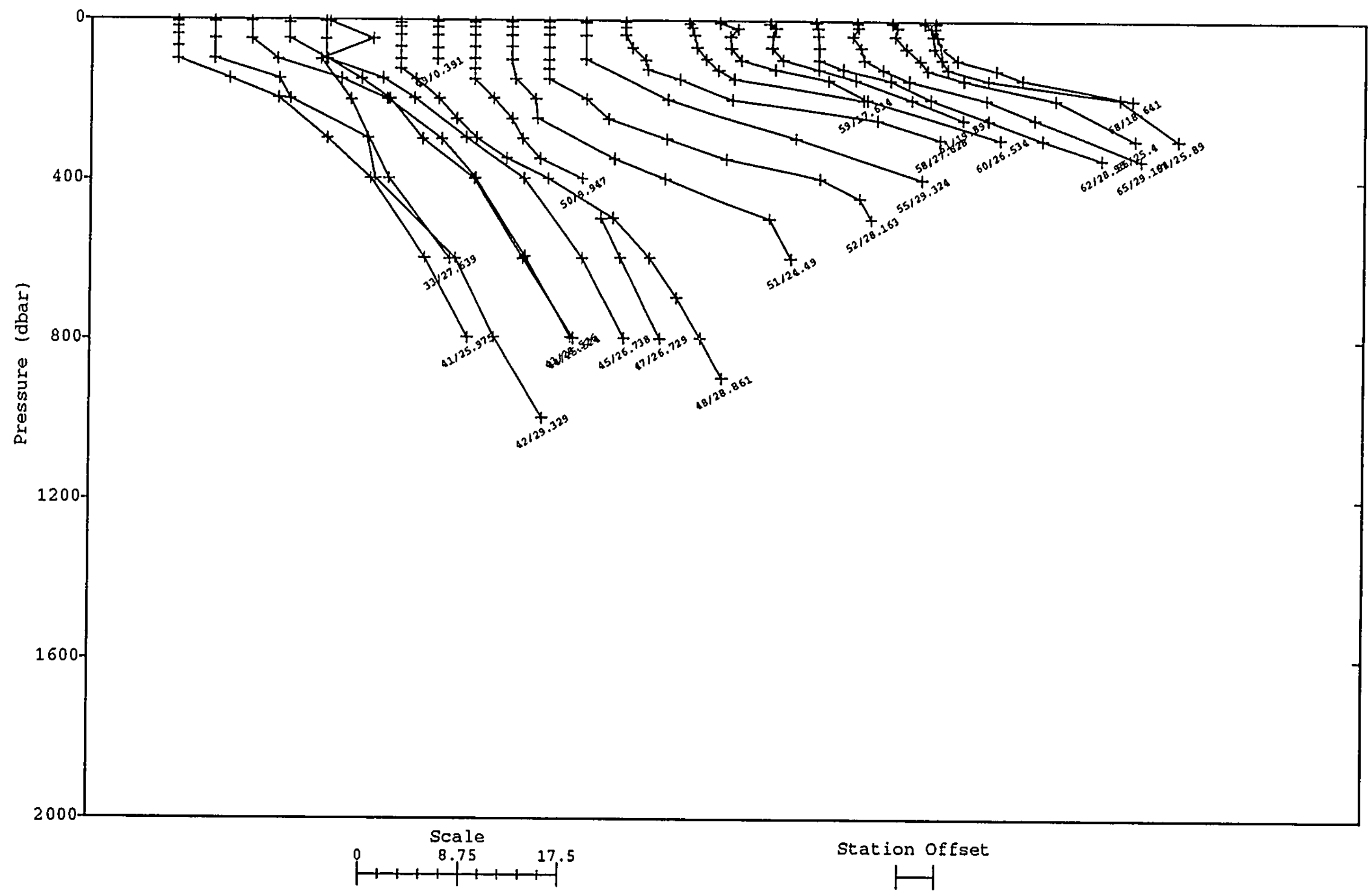

Figure 6. Nested profiles: NO_3 (μmol/kg) vs pressure (dbar) for stations 33–68.

NOAA/PMEL GCG-90 Cruise.

Profiles which exist in this Pressure (dbar) range are ordered on Station No.
Plotted parameter ranges from 1900 to 2400

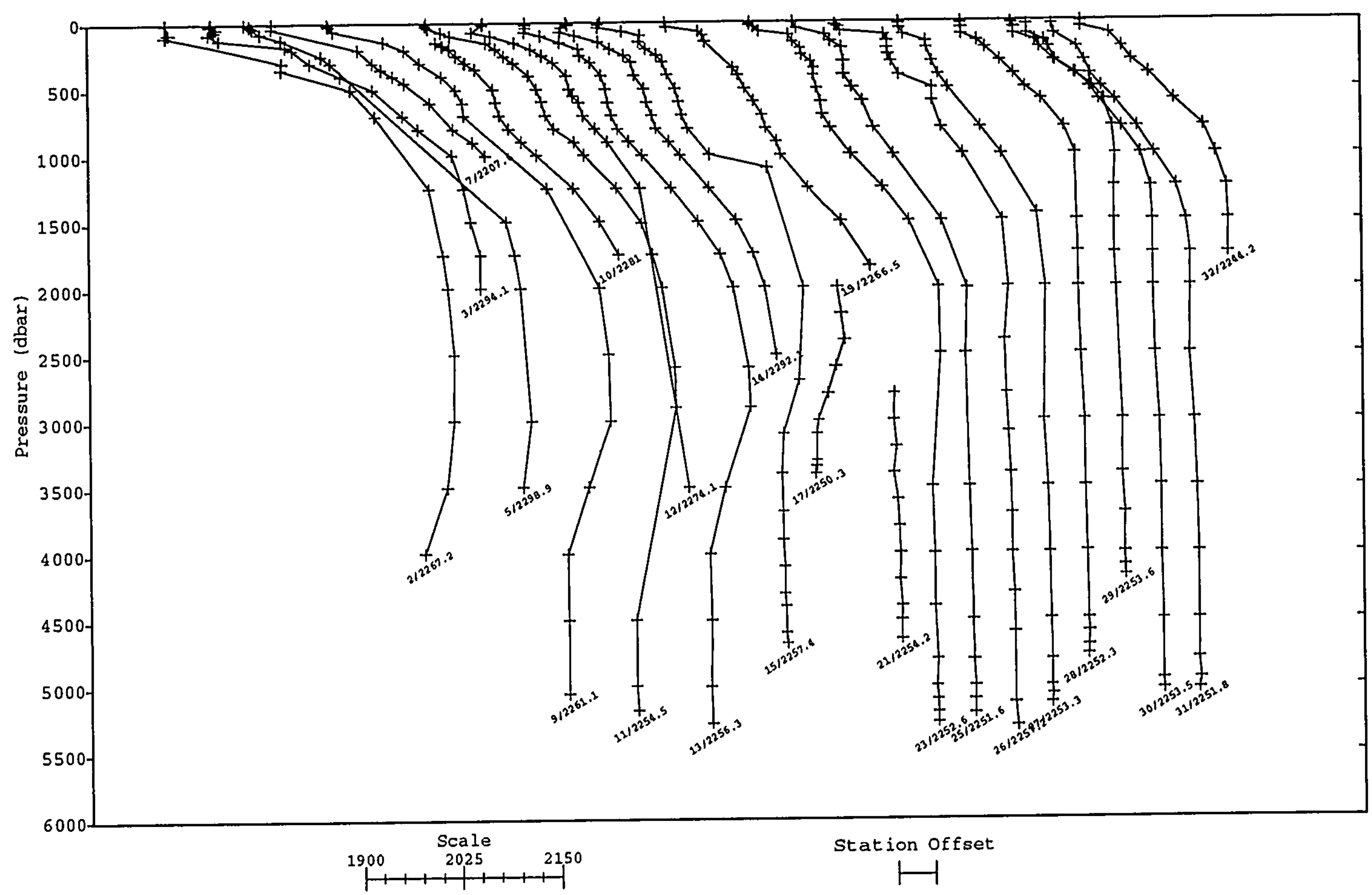

Figure 7. **Nested profiles: total CO_2 (μmol/kg) vs pressure (dbar) for stations 2–32.**

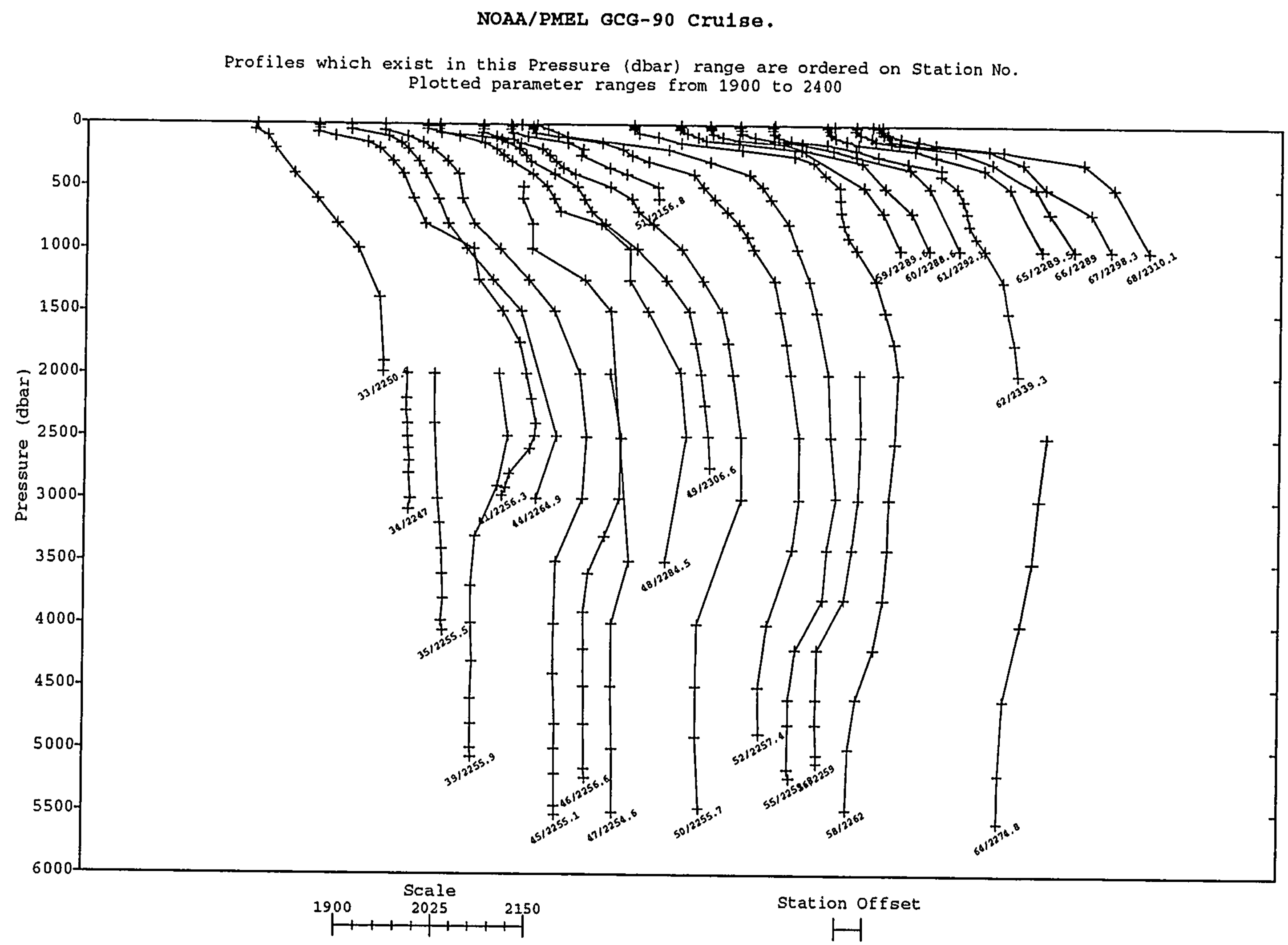

Figure 8. Nested profiles: total CO_2 (µmol/kg) vs pressure (dbar) for stations 33–68.

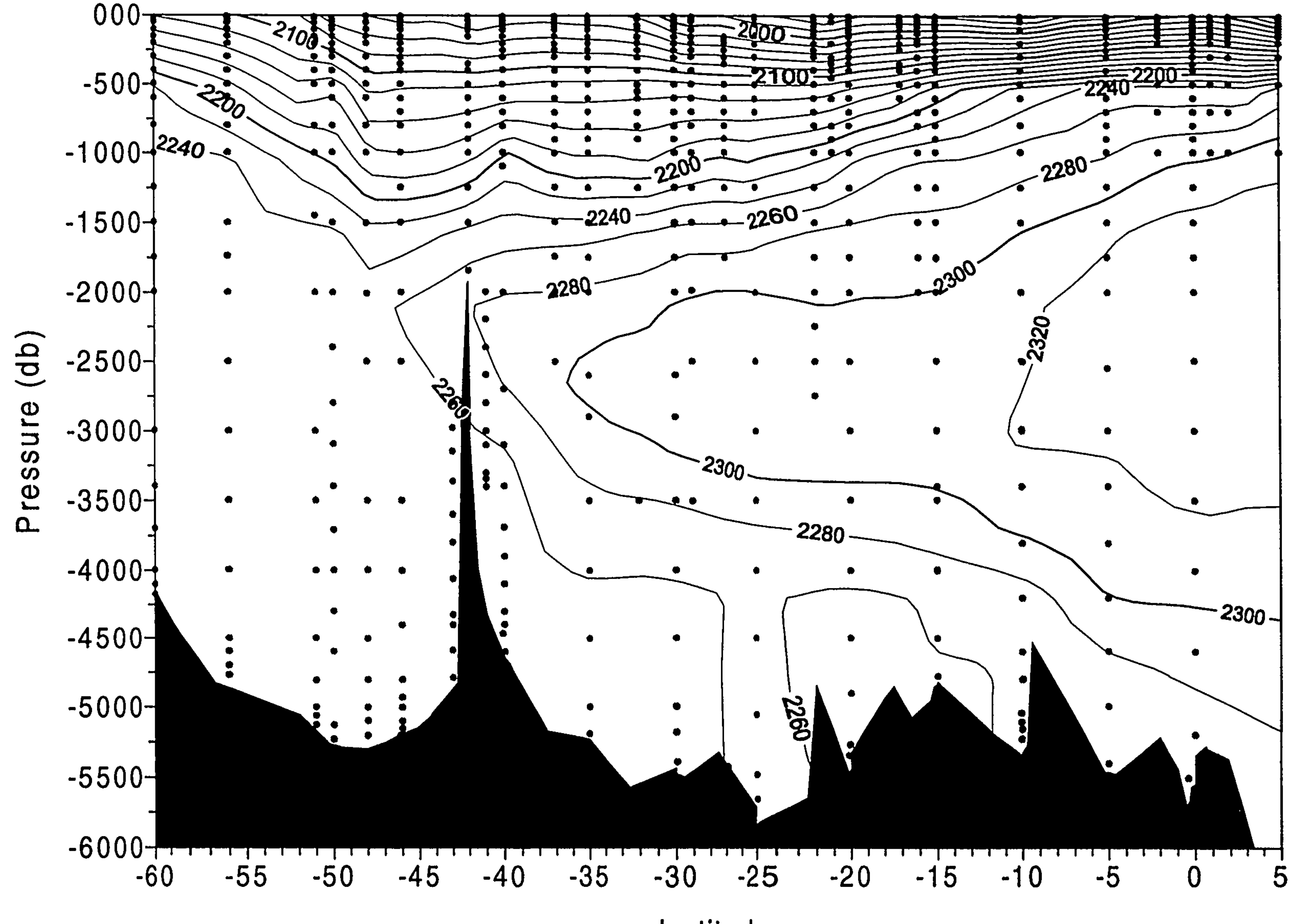

Figure 9. Total CO_2 concentrations along the 170° W during R/V *Malcolm Baldrige* CGC-90 Cruise.

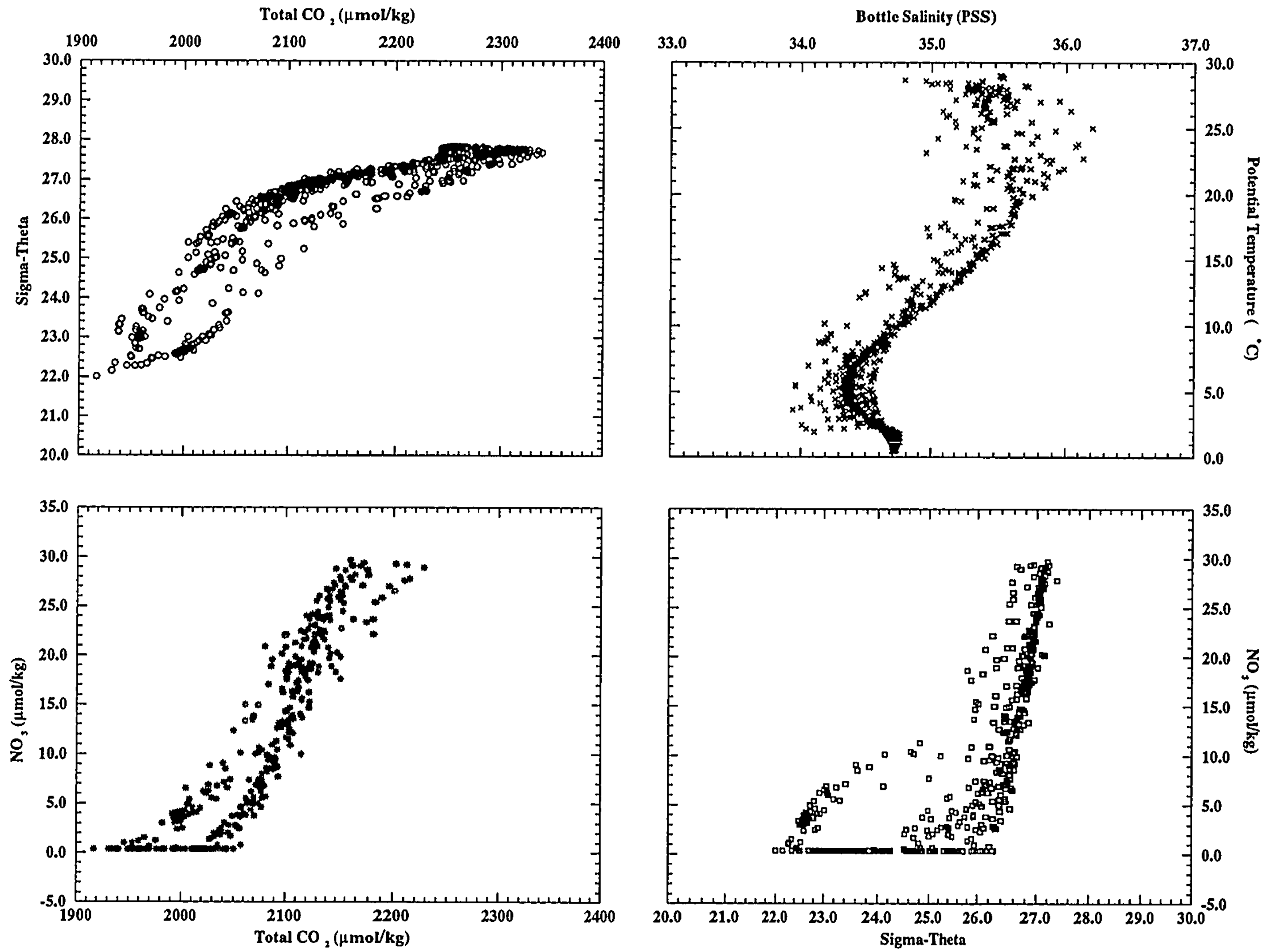

Figure 10. Property-property plots for all stations occupied during R/V *Malcolm Baldrige* CGC-90 Cruise.

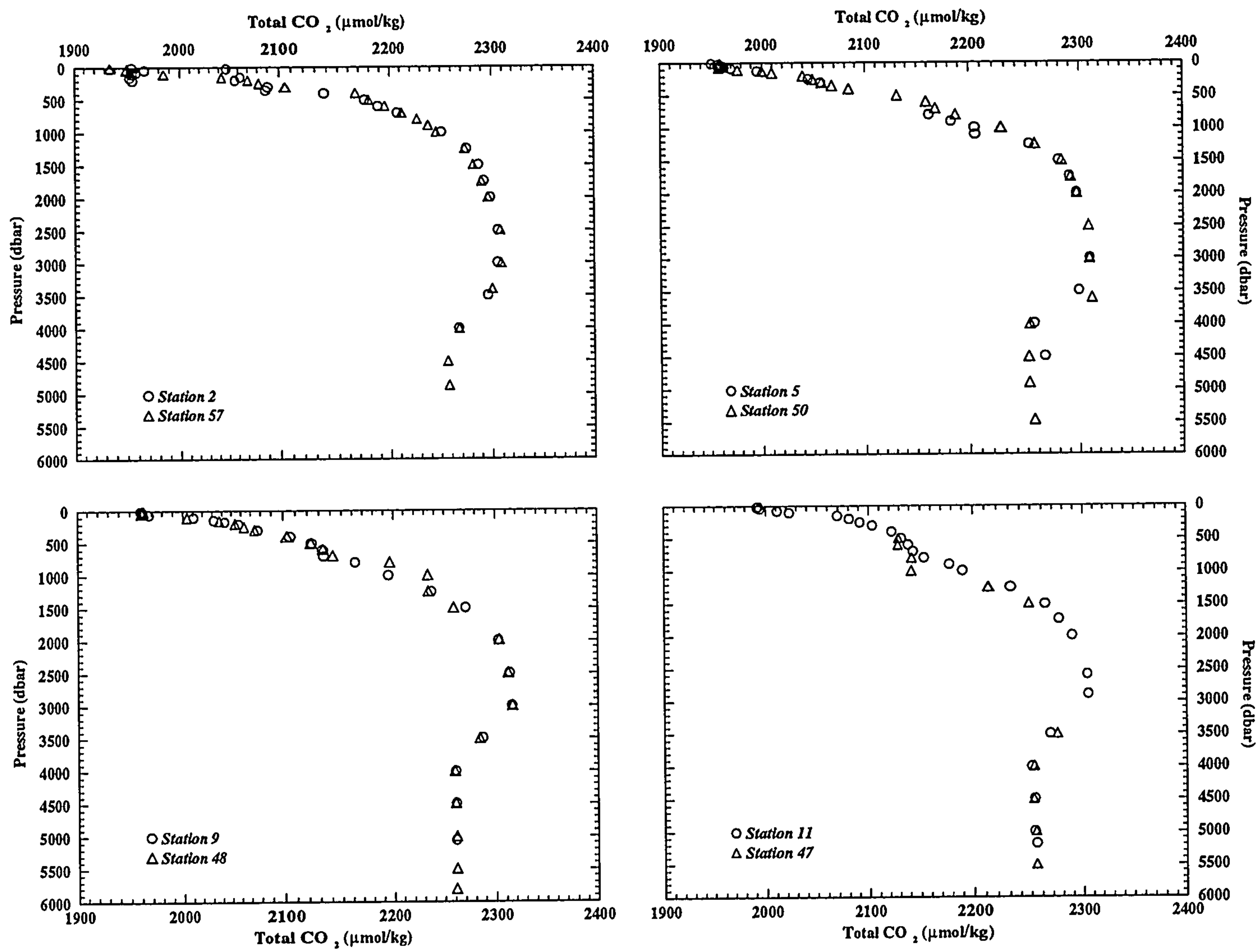

Figure 11. Total CO_2 data intercomparison for reoccupied stations during R/V *Malcolm Baldrige* CGC-90 Cruise.

PART 2:

CONTENT AND FORMAT OF DATA FILES

7. FILE DESCRIPTIONS

This section describes the content and format of each of the five files that comprise this NDP (Table 2). Because CDIAC distributes the data set in several ways (e.g., via anonymous FTP, floppy diskette, and on 9-track magnetic tape), each of the five files is referenced by both an ASCII file name, which is given in lower-case, bold-faced type (e.g., ndp052.txt), and a file number. The remainder of this section describes (or lists, where appropriate) the contents of each file. The files are discussed in the order in which they appear on the magnetic tapes.

Table 2. Content, size, and format of data files

	File number, name, and description	Logical records	File size in bytes	Block size	Record length
1.	**readme** a detailed description of the cruise network, the two FORTRAN 77 data retrieval routines, and the two oceanographic data files	954	50,859	8,000	80
2.	**stainv.for:** a FORTRAN 77 data retrieval routine to read and print cgc90sta.inv (File 4)	30	1,062	8,000	80
3.	**cgc90dat.for:** a FORTRAN 77 data retrieval routine to read and print cgc90.dat (File 5)	36	1,368	8,000	80
4.	**cgc90sta.inv:** a listing of the station locations, sampling dates, and sounding bottom depths for each station	63	3,906	4,100	41
5.	**cgc90.dat:** hydrographic, carbon dioxide, and nitrate data from 63 stations.	1,224	134,640	16,000	160
	Total	2,307	191,835		

7.1 readme (File 1)

This file contains a detailed description of the data set, the two FORTRAN 77 data retrieval routines, and the two oceanographic data files. It exists primarily for the benefit of individuals who acquire this database as machine-readable data files from CDIAC.

7.2 stainv.for (File 2)

This file contains a FORTRAN 77 data retrieval routine to read and print cgc90sta.inv (File 4). The following is a listing of this program. For additional information regarding variable definitions, variable lengths, variable types, units, and codes, please see the description for the cgc90sta.inv file.

```
c*************************************************************
c* This is a FORTRAN 77 retrieval code to read and print the    *
c* file named "cgc90sta.inv" (File 4)                           *
c*************************************************************

        INTEGER  sta, cast, dep
        REAL lat, lon
        CHARACTER date*8, time*4
        OPEN (unit=1, file='cgc90sta.inv')
        OPEN (unit=2, file='pmel90sta.inv')
        write (2, 5)

  5     format (2X,'STANBR',1X,'CASTNBR',1X,'LATITUDE',1X,
     1  'LONGITUDE',6X,'DATE',4X,'TIME',3X,'DEPTH',/,18X,
     2  'DEC.DEG',3X,'DEC.DEG',5X,'D/M/Y',5X,'GMT',7X,'M',/)

  7     CONTINUE
        read (1, 10, end=999) sta, cast, lat, lon, date,
        time,
     1  dep
 10     format (6X, I2, 5X, I3, 2X, F7.3, 2X, F8.3, 2X, A8,
        4X,
     1  A4, 4X, I4)

        write (2, 20) sta, cast, lat, lon, date, time,
     1  dep  20
        format (6X, I2, 5X, I3, 2X, F7.3, 2X, F8.3, 2X, A8,
        4X,
     1  A4, 4X, I4)
        GOTO 7

999     close(unit=1)
        close(unit=2)
        stop
        end
```

7.3 cgc90dat.for (File 3)

This file contains a FORTRAN 77 data retrieval routine to read and print cgc90.dat (File 5). The following is a listing of this program. For additional information regarding variable definitions, variable lengths, variable types, units, and codes, please see the description for the cgc90.dat file.

```
c*****************************************************************
c*  This is a FORTRAN 77 data retrieval code to read and format *
c*  the file named "cgc90.dat" (File 5)                          *
c*****************************************************************

      INTEGER  sta, samp, qcfl
      REAL pres, temp, theta, ctdsal, botsal, sigma, sigmat
      REAL nO3, tcO2
      OPEN (unit=1, file='cgc90.dat')
      OPEN (unit=2, file='pmel90.dat')
      write (2, 5)   5

      format (3X,'STANBR',3X,'SAMPID',3X,'CTDPRS',2X,'CTDTEMP',4X,
     1 'THETA',3X,'CTDSAL',3X,'BOTSAL',4X,'SIGMA',2X,'SIGMA-T',2X,
     2 'NITRATE',4X,'TCARB',3X'QC_FLAG',/,23X'DBAR',3X,'DEG(C)',
     3 3X,'DEG(C)',6X,'PSS',6X,'PSS',4X,'THETA',11X,'UMOL/KG',2X,
     4 'UMOL/KG',/,56X,'*******',20X,'*******',2X,'*******')

7     CONTINUE
      read (1, 10,end=999) sta, samp, pres, temp, theta, ctdsal,
     1 botsal, sigma, sigmat, nO3, tcO2, qcfl

10    format (7X,I2,4X,I5,3X,F6.1,3X,F6.3,3X,F6.3,3X,F6.3,1X,F8.3,
     1 3X,F6.3,3X,F6.3,1X,F8.3,2X,F7.1,7X,I3)

      write (2, 20) sta, samp, pres, temp, theta, ctdsal,
     1 botsal, sigma, sigmat, nO3, tcO2, qcfl

20    format (7X,I2,4X,I5,3X,F6.1,3X,F6.3,3X,F6.3,3X,F6.3,1X,F8.3,
     1 3X,F6.3,3X,F6.3,1X,F8.3,2X,F7.1,7X,I3)
      GOTO 7

999   close(unit=1)
      close(unit=2)
      stop
      end
```

7.4 cgc90sta.inv (File 4)

This file provides station inventory information for each of 63 stations occupied during the R/V Malcolm Baldrige CGC-90 Cruise. There is one entry for each station. Each line contains a section number, cast number, latitude, longitude, sampling date (day/month/year), sampling time, and sounding depth of the station. The file is sorted by station number and can be read using the following FORTRAN 77 code (contained in stainv.for, which is File 2):

```
      INTEGER  sta, cast, dep
      REAL lat, lon
      CHARACTER date*8, time*4
      read (1, 10, end=999) sta, cast, lat, lon, date, time,
     1 dep
10    format (6X, I2, 5X, I3, 2X, F7.3, 2X, F8.3, 2X, A8, 4X,
     1 A4, 4X, I4)
```

Stated in tabular form, the contents include the following:

Variable	Variable type	Variable width	Starting column	Ending column
sta	Numeric	2	7	8
cast	Numeric	3	14	16
lat	Numeric	7	19	25
lon	Numeric	8	28	35
date	Character	8	38	45
time	Character	4	50	53
dep	Numeric	4	58	61

where

sta   is the station number;

cast   is the cast number;

lat   is the latitude of the station (in decimal degrees). Stations in the Southern Hemisphere have negative latitudes;

lon   is the longitude of the station (in decimal degrees). Stations in the Western Hemisphere have negative longitudes

date   is the date the station was sampled (day/month/year);

time   is the time the station was sampled (Greenwich Mean Time);

dep   is the sounding depth of the station (in m).

7.5 cgc90.dat (File 5)

This file provides hydrographic, carbon dioxide, and nitrate data for the 63 stations occupied during R/V Malcolm Baldrige CGC-90 Cruise in the Southwest Pacific. Each line of the file consists of a station number, sample ID, CTD pressure, CTD temperature, potential temperature, CTD salinity, bottle salinity, sigma-t, sigma-theta, nitrate, total CO_2, and data quality flags. The file is sorted by station number and pressure and can be read using the following FORTRAN 77 code (contained in cgc90dat.for, which is File 3):

```
      INTEGER  sta, samp, qcfl
      REAL pres, temp, theta, ctdsal, botsal, sigma, sigmat
      REAL nO3, tcO2
      read (1, 10,end=999) sta, samp, pres, temp, theta, ctdsal,
    1 botsal, sigma, sigmat, nO3, tcO2, qcfl
10    format (7X,I2,4X,I5,3X,F6.1,3X,F6.3,3X,F6.3,3X,F6.3,1X,F8.3,
    1 3X,F6.3,3X,F6.3,1X,F8.3,2X,F7.1,7X,I3)
```

Stated in tabular form, the contents include the following:

Variable	Variable type	Variable width	Starting column	Ending column
sta	Numeric	2	8	9
samp	Numeric	5	14	18
pres	Numeric	6	22	27
temp	Numeric	6	31	36
theta	Numeric	6	40	45
ctdsal	Numeric	6	49	54
botsal	Numeric	8	56	63
sigma	Numeric	6	67	72
sigmat	Numeric	6	76	81
nO_3	Numeric	8	83	90
tcO_2	Numeric	7	93	99
qcfl	Numeric	3	107	109

where

sta is the station number;

samp is the sample number;

pres is the CTD pressure (in dbar);

temp is the CTD temperature (in deg. C);

theta is the potential temperature (in deg. C);

ctdsal is the CTD salinity (in PSS);

botsal* is the bottle salinity (in PSS);

sigma is sigma-theta (in sigma units);

sigmat is sigma-t (in sigma units);

nO_3* is the nitrate concentration (in umol/kg);

tcO_2* is the total carbon dioxide concentration (in umol/kg);

qcfl is an 3-digit variable that contains data quality flag codes for parameters flagged by an asterisk in the output file.

Quality flags definitions:

2 = Acceptable measurement;
3 = Questionable measurement;
5 = Not reported;
9 = Sample not drown for this measurement from this bottle.

8. VERIFICATION OF DATA TRANSPORT

The data files contained in this numeric data package can be read by using the FORTRAN 77 data retrieval programs provided. Users should visually examine each data file to verify that the data were correctly transported to their systems. To facilitate the visual inspection process, partial listings of each data file are provided in Tables 3 and 4. Each of these tables contains the first and last five lines of a data file.

Table 3. Partial listing of cgc90sta.inv (File 4)

First five lines of the file:

2	2	-15.001	-170.005	24/02/90	0151	4817
3	3	-16.472	-169.993	24/02/90	1238	5073
4	4	-18.003	-170.007	24/02/90	2149	4929
5	7	-20.012	-169.993	25/02/90	2049	5320
7	10	-21.992	-169.997	26/02/90	1300	4839

Last five lines of the file:

64	105	0.000	-170.001	11/04/90	1400	5612
65	106	0.500	-170.005	11/04/90	1837	5285
66	107	1.001	-170.005	11/04/90	2145	5316
67	108	2.005	-170.015	12/04/90	0308	5357
68	109	5.001	-170.010	12/04/90	1655	7161

Table 4. Partial listing of cgc90.dat (File 5)

First five lines of the file:

2	222	3.0	28.197	28.196	35.525	35.527	22.729	22.729	-999.900	-999.9	259
2	110	3.6	28.214	28.213	35.531	-999.900	22.727	22.726	0.391	1954.7	522
2	109	18.2	28.152	28.147	35.531	-999.900	22.748	22.746	-999.900	2047.9	553
2	108	39.0	28.043	28.034	35.522	35.527	22.782	22.779	0.391	1966.5	223
2	219	47.7	27.715	27.704	35.521	35.513	22.879	22.876	0.391	-999.9	229

Last five lines of the file:

68	10945	196.6	14.442	14.413	34.595	34.613	25.801	25.795	18.641	2124.9	222
68	10953	295.9	9.985	9.951	34.668	34.661	26.696	26.690	-999.900	2222.9	252
68	10943	496.6	7.978	7.927	34.611	-999.900	26.979	26.972	-999.900	2263.0	552
68	10942	695.1	6.208	6.145	34.558	34.553	27.181	27.173	-999.900	2292.0	253
68	10941	996.9	4.493	4.413	34.568	34.564	27.396	27.387	-999.900	2310.1	252

APPENDIX A

STATION INVENTORY

This appendix lists station inventory information for the 63 sites occupied during R/V Malcolm Baldrige CGC-90 Cruise in the Southwest Pacific. The meanings of the column headings in Table A-1 are as follows.

STANBR is the station number;

CASTNBR is the cast number;

LATITUDE is the latitude of the station (in decimal degrees). Stations in the Southern Hemisphere have negative latitudes;

LONGITUDE is the longitude of the station (in decimal degrees). Stations in the Western Hemisphere have negative longitudes;

DATE is the sampling date (day/month/year);

TIME is the sampling time [Greenwich Mean Time (GMT)];

DEPTH is the sounding bottom depth of each station (in m).

Table A.1. Station inventory information for the 63 sites occupied during R/V Malcolm Baldrige CGC-90 Cruise

STANBR	CASTNBR	LATITUDE DEC.DEG	LONGITUDE DEC.DEG	DATE D/M/Y	TIME GMT	DEPTH M
2	1-2	-15.001	-170.005	24/02/90	0151	4817
3	3	-16.472	-169.993	24/02/90	1238	5073
4	4	-18.003	-170.007	24/02/90	2149	4929
5	5-7	-20.012	-169.993	25/02/90	2049	5320
7	9-10	-21.992	-169.997	26/02/90	1300	4839
9	11-13	-25.022	-170.015	27/02/90	1837	5712
10	14-15	-27.053	-170.015	28/02/90	0952	5316
11	16-18	-30.005	-170.043	01/03/90	0441	5429
12	19-21	-32.553	-170.052	02/03/90	0030	5568
13	22-24	-35.023	-170.010	02/03/90	2115	5225
14	25-26	-37.543	-170.037	03/03/90	1252	5170
15	27-29	-40.028	-170.028	04/03/90	0706	4626
16	30-31	-40.968	-170.483	04/03/90	1908	4323
17	32	-41.490	-170.723	05/03/90	0041	3984
18	33	-41.982	-170.983	05/03/90	0554	2974
19	34-35	-42.478	-171.208	05/03/90	1225	1857

20	36	-43.502	-170.853	05/03/90	1902	2904
21	37	-43.985	-170.693	06/03/90	0054	4473
22	38	-44.370	-170.328	06/03/90	0641	5108
23	39-41	-46.045	-170.001	06/03/90	2207	5190
24	42	-47.007	-170.013	07/03/90	0538	5252
25	43-44	-48.022	-169.915	07/03/90	1509	5294
26	45-47	-50.067	-170.070	08/03/90	0844	5279
27	48-49	-51.967	-169.985	09/03/90	0027	5054
28	50-51	-56.768	-170.068	10/03/90	0612	4822
29	52-53	-60.010	-169.883	11/03/90	0502	4139
30	54-55	-55.997	-174.168	12/03/90	2212	4970
31	56-57	-53.948	-176.158	13/03/90	1304	5289
32	58	-50.505	-179.395	15/03/90	0620	4448
33	59	-49.492	-179.745	15/03/90	1420	2012
34	60	-49.725	-179.998	16/03/90	0724	3111
35	61	-49.848	-179.878	16/03/90	1146	4030
36	62	-50.483	-179.357	18/03/90	0704	4458
38	65	-34.648	-178.637	28/03/90	0948	6556
39	66	-32.497	-178.313	28/03/90	2141	5091
40	67	-32.510	-178.523	29/03/90	0237	4249
41	68-69	-32.488	-178.767	29/03/90	1000	3003
42	70	-32.483	-178.502	29/03/90	1257	4211
43	71	-32.493	-178.297	29/03/90	1554	5004
44	72-73	-32.510	-177.998	30/03/90	0029	6005
45	74-75	-32.490	-175.502	30/03/90	1642	5556
46	76	-32.480	-171.478	31/03/90	1104	5259
47	77	-30.000	-170.007	01/04/90	0233	5532
48	78-80	-25.020	-170.030	02/04/90	0857	5834
49	81-82	-22.507	-170.008	03/04/90	0042	5645
50	83-85	-20.025	-170.013	03/04/90	1926	5502
51	86	-17.492	-170.005	04/04/90	0841	4848
52	87-89	-15.005	-170.007	05/04/90	0438	4903
53	90	-11.440	-169.608	05/04/90	2237	5216
54	91	-10.102	-169.503	06/04/90	0700	5332
55	92-93	-10.092	-170.000	06/04/90	1546	5260
56	94	-10.088	-170.248	06/04/90	2053	5141
57	95	-9.492	-170.213	07/04/90	0238	4515
58	96-98	-5.013	-170.020	08/04/90	0526	5511
59	99	-2.005	-170.007	08/04/90	2116	5214
60	100	-0.995	-170.020	09/04/90	0244	5435
61	101	-0.498	-170.007	09/04/90	0605	5698
62	102-104	0.000	-170.020	09/04/90	0931	5342
64	105	0.000	-170.001	11/04/90	1400	5612
65	106	0.500	-170.005	11/04/90	1837	5285
66	107	1.001	-170.005	11/04/90	2145	5316
67	108	2.005	-170.015	12/04/90	0308	5357
68	109	5.001	-170.010	12/04/90	1655	7161

CCHDO Data Processing Notes

Date	Person	Data Type	Action	Summary
1997-08-15	*David Wisegarver*	SUM	Submitted	Received 1997 August 15th.
2000-06-21	*John L. Bullister*	CTD	Submitted	None
2000-10-11	*Karla Uribe*	SUM	Admin.	Files found in incoming dir

Detailed Notes

Files were found in incoming directory under whp_reports. This directory was zipped, files were separated and placed under proper cruise. All of them are SUM files.

Date	Person	Data Type	Action	Summary
2002-05-22	*John L. Bullister*	BTL	Submitted	Submitted
2002-05-30	*John L. Bullister*	BTL	Reformatted by WHPO	Set flags to 2 (pre-WOCE cruise)

Detailed Notes

I checked with Kristy McTaggart, who did the CTD work on the cruise. This was a pre-WOCE cruise and no quality flags were assigned to these data. Assigning them a WOCE flag of 2 would imply they had undergone this type of quality evaluation.

I put this header on the original file: CGC90 (extracted 22 May 2002, J.Bullister) "f" is WOCE quality flag (set to 0 if not available) -9 represents missing value

If this doesn't work, I can re-extract the file and not include a flag column.

Date	Person	Data Type	Action	Summary
2002-05-30	*Sarilee Anderson*	BTL	Update Needed	Set flags to 2?

Detailed Notes

What do you want me to do about this. I think we could include a note in the documentation that we set the QUALT1 flags to 2 since this was a pre-WOCE cruise and no quality flags were assigned by the originator.

Date	Person	Data Type	Action	Summary
2002-05-31	*Lynne Talley*	BTL	Reformatted by WHPO	Set flags to 2

Detailed Notes

Sarilee - I agree - set the flags to 2 and include a note in the documentation. The doc file will be scanned from the pdf.

Date	Person	Data Type	Action	Summary
2002-06-13	*Sarilee Anderson*	BTL	Website Updated:	Reformatted data online

Detailed Notes

Took bottle data sent by Bullister to Lynne Talley and put into WOCE format.

There were zeroes for the QUALT1 flags for CTDSAL and SALNTY. Asked Bullister about this. See his e-mail below.

Talked to Lynne, and we decided they could be assigned a flag of 2.

See e-mails below.

File contains data for press, ctdtmp, ctdsal, salnty, tritum, triter, delhe3, delher, helium, helier, neon, and neoner.

There was a difference in the bottle and ctd cast summary for stations 0, 1, and 2. After comparing the depths I determined that the bottle file needed to be changed to agree with the summary file. Converted the CTD cast summary file retrieved from ftp site, ftp.pmel.noaa.gov to a WOCE formatted .sum file.

The cast numbers were sequential (0-110) throughout the file. Using the sum file I was able to determine (I hope) the correct cast number for each station.

Date	Person	Data Type	Action	Summary
2002-12-04	*Sarilee Anderson*	CTD	Website Updated:	Formatted CTD and added quality flags

Detailed Notes

Formatted and added QUALT flags to file received from Kristy McNicols.

Notes:

In June I received the ctd data from Kristy McNicols. I converted to WOCE format.

Since this was a pre-WOCE cruise there were no QUALT flags. I assigned a QUALT flag of 2 to all pressure, temperature and salinity values and since there were no oxygens a 9 for oxygen.

Many stations have more than one cast so I named the files

pr32a0011.wct - cast 1
pr32a0011_2.wct - cast 2
pr32a0011_3.wct - cast 3

The individual casts are every decibar instead of every other decibar.

Date	Person	Data Type	Action	Summary
2003-07-23	*Danie Bartolacci*	CTD	Website Updated:	Converted to exchange & netCDF, but need editing

Detailed Notes

I have converted the ctd files to both exchange and netcdf files, however the conversion was suspect. Files have not been checked with JOA yet.

Two ctd station station files needed editing:

station 13 cast 3 needed cast header edited from 2 to 3.
station 62 cast 2 needed cast header edited from 1 to 2.

All files had the name/date stamp removed.

In sumfile for purposes of conversion:

station 64 cast 1 needed depth changed from blank to ----
station 40 cast 1 needed depth changed from blank to ----

SECT ID was changed from PR15S to PR32. This sumfile replaced the current online sumfile (depths were left at -999 in online version)

Date	Person	Data Type	Action	Summary
2003-07-31	*Danie Bartolacci*	CTD	Website Updated:	Converted to exchange and netCDF, NO. OBS column removed

Detailed Notes

After much tinkering, the CTD files have been converted to both exchange and netCDF formats. Previously these files would not convert using current software (many errors, core dumps and JOA crashes). After different edits to the original ctd station files (*.wct files) It was found that the empty column for header NO. OBS was causing errors. This column was removed for the purposes of conversion (was retained in original .wct station files). Also previously online sumfile contained missing/wrong information had needed edits (see below).

Files now pass JOA and inventory files appear correct. These files have been zipped and added to the parent directory. Previous sumfile has been moved to the original directory. Web pages have been remade and link correctly.

Station track files have also been made and linked correctly.

This cruise does not come up on RCS at this time, therefore this readme file will be sent to document edits in lieu of RCS.

Date	Person	Data Type	Action	Summary
2003-07-31	*Danie Bartolacci*	CTD	Data Update:	Contacted Steve about remaking maps

Detailed Notes

Lynne- I wrote Steve et al. about remaking the maps to include this station track (and sent them the track image) so it should be up toward the top of his queue (I think he's crunching on some code for Jim before he gets back at the moment, so I'll ping again when he comes up for air).

Date	Person	Data Type	Action	Summary
2003-12-10	*Danie Bartolacci*	CTD/BTL/SUM	Data Update:	Changed line number and updated all files

Detailed Notes

At the direction and guidance of Lynne Talley, this cruise was moved from PR32 to the onetime directories and renamed P15S because it more closely follows the P15S onetime line than any repeat line.

A new directory for this cruise was created. All files have been edited to reflect change in line number and exchange, netcdf, and station track files have been remade. New web files have been generated also.

This cruise needs to be changed in the data base before it will link on the onetime site. Previous directory (pr32_a) has been zipped as an original copy of the data and it's file history and therefore will no longer link from the repeat site. A readme file will point users to new directory.

Date	Person	Data Type	Action	Summary
2007-04-04	*Robert Key*	BTL	Submitted	nitrate, cfc-11, cfc-12, tco2, c13 & flags

Detailed Notes

File: p15sahy1.csv Type: ascii, csv with unix line endings Status: Public
Name: Key, Bob
Institute: PU
Country: USA
Expo:3175CGC90_1 Line: P15Sa
Date: 02/1990
Action:Place Data Online

Notes:

This file is identical to the exchange file you have on-line except I've added: nitrate, cfc-11, cfc-12, tco2, c-13 and flags for each. These data were sent to me by J. Bullister on 3/30/07. Copy of my readme with additional details pasted below: You can cut and paste the extra columns from my file (p15sahy1.csv) into your file (p15sa_hy1.csv) or just swap as you see fit.

bob

3/12/99
Initialized README file for CGC 90
P15S line
Malcolm Baldridge EXPOCODE 3175CG90_1
2/24-4/12/1990
Ch. Sci. D.Wisegarver
64 stations; Sta 2-7 24 bottle Rosette; 12 bottle Rosette for remainder
For one-time WOCE survey, this cruise replaced by P14S15S
Hydro: Who - NOAA ; Status - final ; S Plus - up-to-date

Notes: Data from CCHDO 4/4/07

Nuts: Who - L. Moore, D. Atwood ; Status - final ; S Plus - up-to-date
Notes: only nitrate reported, probably nitrate+nitrite; only reported
values between 0-30umol/kg due to standard range. Silicate
and phosphate not reported due to poor precision/accuracy
No oxygen data
Data from Bullister 3/30/07

TCO2: Who - Roberts, Murphy; Status - final; S Plus - up-to-date
Notes: NDP-052; data from M.Roberts 7/22/94.

CRM used (value 2020+/-.009, Keeling; batch 1); +3umol/kg corrrection applied to data based on CRM analysis as suggested by A.Dickson

TA: Who - Feely; Status - Not Reported; S Plus - N/A
Notes: Poor Quality

pCO2: Who - none; Status - Not Measured; S Plus - N/A
Notes: underway sampling only

pH: Who - R.Byrne ; Status - no date; S Plus - N/A
Notes:serious problems with rented spectrophotometer, measurements of no value and not reported (Byrne e-mail 2/1/07)

CFC: Who - Wisegarver/Bullister; Status - final; S Plus - up to date
Notes: CFC data are reported on the SIO98 scale.

C-14: Who - none; Status - N/A; S Plus -
Notes:

C-13: Who - Quay; Status - final; S Plus - up to date

Notes:data from Bullister 3/30/07

H-3: Who - Jenkins ; Status - final ; S Plus - up-to-date

Notes:Data from CCHDO 4/4/07

References:

Wisegarver, D.P., J.L. Bullister, F.A. Van Woy, F.A. Menzia, R.F. Weiss, A.H. Orsi, and P.K. Salameh (1995): Chlorofluorocarbon measurements in the southwestern Pacific during the CGC-90 Expedition. NOAA Data Report ERL PMEL-57, 98 pp.

Lamb, M.F., R.A. Feely, L. Moore, and D.A. Atwood (1993): Total CO2 and nitrate measurements in the southwest Pacific during austral autumn, 1990. NOAA Data Report ERL PMEL-42, NTIS: PB93-188415, 62 pp.

McTaggart, K.E., D. Wilson, and L.J. Mangum (1993): CTD measurements collected on Climate and Global Change Cruise along 170°W during February^April 1990. NOAA Data Report ERL PMEL-44, NTIS: PB93-226041, 265 pp.

Upload directory: /incoming_data/20070404.132353_P15Sa_Key,_Bob

2007-04-23	*Dr. Lynne Talley*	TRITUM	Update Needed	fliers?

Detailed Notes

Hi Bill (Jenkins) - can you check on several tritium values for the southern ocean occupation of P15? (This is the 1990 NOAA Malcolm Baldridge CGC-90 cruise.) What I notice about these three is that they are very high for the given potential temperature. On the three stations, there are also no tritium samples at shallower bottles. If their temperatures were up around 27, which would be possible if the samples were actually from shallower bottles, then the values would fall in with all the other tritiums from this section.

So is it possible that these should have been assigned to shallower depths than 196 or 194?

Sta. tritium theta pressure

66 1.117 13.694 196.
67 1.259 12.962 194.
68 1.860 14.413 196.

Here are just these lines in the WHPO format file:

EXPOCODE 3175CG90_1, _2 WHP-ID PR32 CRUISE DATES 022290 TO 041690 20020529

WHPOSIOSA *

```
STNNBR CASTNO SAMPNO BTLNBR CTDPRS CTDTMP CTDSAL SALNTY TRITUM TRITER HELIUM HELIER DELHE3
DELHER NEON NEONER QUALT1 DBAR ITS-90 PSS-78 PSS-78 TU TU NMOL/KG N MOL/KG PERCNT PERCNT
NMOL/KG NMOL/KG
******* ******* ******* ******* ******* ******* ******* *
66 1 745 5 196.7 13.722 34.806 34.809 1.117 0.005 1.783 0.009 7.06 0.15 7.088 0.035 2222222
67 1 845 5 194.5 12.989 34.668 34.671 1.259 0.007 1.791 0.009 8.83 0.15 7.131 0.035 2222222
68 1 945 5 196.6 14.442 34.613 34.595 1.860 0.008 1.777 0.009 8.79 0.15 7.069 0.035 2222222
```

2007-04-24	*William J. Jenkins*	TRITUM	None	Values OK

Detailed Notes

The short answer is that those tritium results are definitely real! I've enclosed a few sections, including P15S for perspective. Those high values at ~200 m are the Fine/McPhaden tritium tongue from the northern subtropics.

2013-02-xx	*Jerry Kappa*	CrsRpt	Website Updated	Final PDF version online

I've placed a new PDF version of the cruise report:

p15sado.pdf

into the directory: onetime/pacific/p15/p15s/p15sa/ .

It includes both CTD and Carbon Parmeter reports, summary pages and CCHDO data processing notes, as well as a linked Table of Contents and links to figures, tables and appendices.