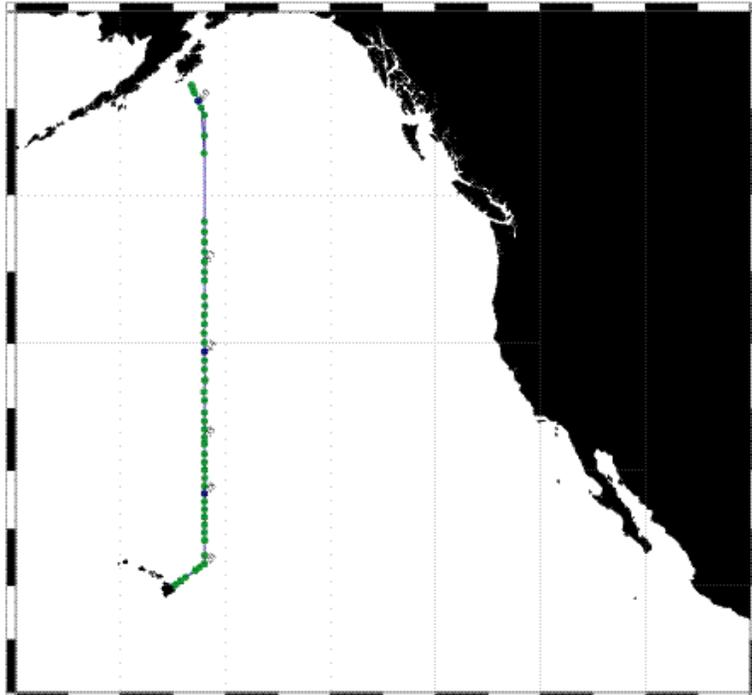


**A. Cruise Narrative: P16N**  
(Climate and Global Change 1991)



**A.1. Highlights**

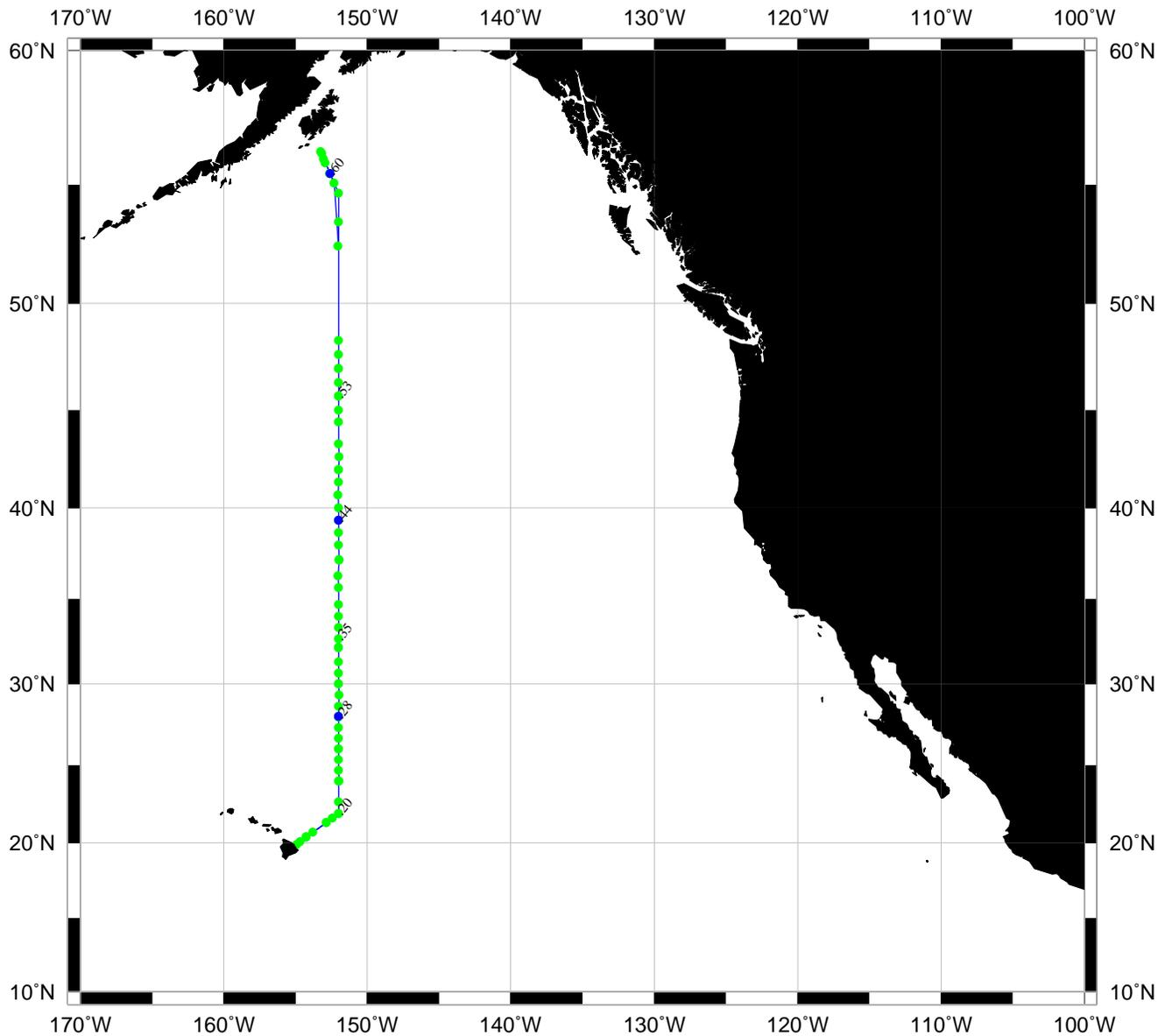
WOCE line designation	<b>P16N</b>
WOCE EXPCODE	<b>31DSCGC91_1-2</b>
Chief Scientist	<b>John L. Bullister</b>
	NOAA-PMEL
	7600 Sand Point Way, NE
	Seattle, WA 98115
	Tel: 206 526 6741
	FAX: 206 526 6744
	Email: <a href="mailto:bullister@noaapmel.gov">bullister@noaapmel.gov</a>
Dates	Leg 1 14 Feb 1991 - 28 Feb 1991
	Leg 2 07 Mar 1991 - 08 Apr 1991
Ship	NOAA R/V Discoverer
Ports of call	Leg 1 Seattle, WA - Hilo, Hawaii
	Leg 2 Hilo, Hawaii - Seattle, WA
Number of stations	64
Geographic boundaries (stations)	19°53.27'N 154°55.51'W 151°56.27'W 56°17.72'N
Floats and drifters deployed	0
Moorings deployed or recovered	0

## Table of Contents

Click on any heading to go to that text

A.	Cruise Narrative: P16N
A.1	Highlights
A.2	Cruise Summary
A.3	List of Principal Investigators
A.3.a	Participants
A.4	Results and Highlights
A.5	Major Problems
B.	Hydrographic Measurement Techniques and Calibrations
B.1	CTD Measurements
B.1.a	Standards and Calibrations
B.1.b	Data Acquisition
B.1.c	Data Acquisition Problems
B.1.d	Salinities
B.1.e	Post-Cruise Conductivity Calibrations
B.1.f	Conductivity Calibrations Programs and Plotting Command Files
B.1.g	Processing
B.2	Bottle Salinity Measurements
B.3	Dissolved Oxygen, Nutrients
B.3.a	STS/ODF Data Collection, Analyses, and Processing
B.3.a.1	Oxygen
B.3.a.2	Nutrients
B.3.a.3	Data Comparisons
B.4	Radiocarbon Results
B.4.a	General Comments on this Data Release(#92-15)
B.4.b	General Comments on C12 Data
B.5	CFC-11 and CFC-12 Measurements on WOCE Section P16N
B.6	DIC and pH
B.6.a	Total Dissolved Inorganic Carbon (TCO <sub>2</sub> )
B.6.b	pH
C.	Data Quality Evaluations
C.1	Data Quality Evaluation of hydrographic data
C.2	Data Quality Comments on CTD Data
C.3.a	CFC DQE Report
C.3.b	Final CFC Data Quality Evaluations
D.	Data Processing Notes

# Station locations for P16N



Produced from .sum file by WHPO-SIO

## A.2 Cruise Summary

Fig. 1 shows the station locations. A listing of station locations is given in the P16N.sea file.

Fig. 2 shows the sampling depths for the 10 liter bottles along the section.

## A.3 List of Principal Investigators

Measurement	PI	Institution
<b>LEG 2</b>		
CTD	S. Hayes	PMEL
CFCs	J. Bullister	PMEL
Helium-3	W. Jenkins	WHOI
	J. Lupton	UCSB
Tritium	W. Jenkins	WHOI
Oxygen	J. Swift	SIO-ODF
TCO <sub>2</sub>	R. Feely	PMEL
Alkalinity	R. Feely	PMEL
pH	R. Byrne	USF
DIC	P. Quay	UW
C-14 (AMS)	R. Key	Princeton
Nutrients	J. Swift	SIO-ODF
DON	P. Wheeler	OSU
ADCP	S. Hayes	PMEL

### A.3.a Participants

Measurement	PI	Institution
<b>LEG 2</b>		
John Bullister	PMEL	CFCs/Chief Scientist
David Wisegarver	PMEL	CFCs
Fred Menzia	PMEL	CFCs
Jeff Benson	PMEL	Rosette operations
Tiffany Vance	PMEL	CTD
Kristy McTaggart	PMEL	CTD
Dana Greely	PMEL	rosette operations, CO <sub>2</sub>
Paulette Murphy	PMEL	CO <sub>2</sub>
Susan Leftwich	AOML	CO <sub>2</sub>
Jiarong Zhang	UW	DIC
Mike Behrenfeld	OSU	Productivity
Pat Wheeler	OSU	Productivity/DON
Mary-Lynn Dickson	OSU	Productivity/DON
Leonard Lopez	SIO-ODF	Large Volume C-14
Art Hester	SIO-ODF	Oxygen, nutrients
Bob Key	Princeton	Large Volume C-14, AMS C-14
Tonya Clayton	USF	pH
Kim Kelly	PMEL	Underway dissolved gases
Kelly Roupe	PMEL	Helium-tritium
Dan Lee	PMEL	CFCs/data processing
Larry Murray	NOAA-PMC	CTD/salinity
Rex Long	NOAA-PMC	salinity
Clyde Kakazu	NOAA-PMC	CTD
Eric Noah	NOAA-PMC	CTD
John Nakamura	NOAA-PMC	CTD

### A.4 Results and Highlights

Leg 1 of the CGC91 expedition consisted of 14 stations occupied along the transit from Seattle to Hilo. These stations were re-occupations of stations previously sampled by PMEL investigators in 1985 for various parameters, and are not part of any WHP section. Only 1 of the stations on Leg 1 (Sta. 13 at 21 20 N, 152 50 W), made on the approach to Hilo, is included in this report

Leg 2 consisted of 52 stations (Sta. 15-66) on a line extending nominally along about 152 W from Hilo, Hawaii (20 N) to Kodiak Alaska (57 N). This section roughly follows the track from Honolulu to Kodiak made in 1984 during the Marathon II Expedition (Martin et al, 1987).

We obtained full water column CTD profiles at all stations. The CFC data have been submitted to the WHP Office. A detailed discussion of the CTD measurements, data acquisition techniques, post-cruise calibrations and processing is also given in McTaggart and Mangum (1995).

A 24 position 10 liter rosette with Neil Brown MARK III CTD (NBIS serial # 1111) was used at all stations. Due to limitations in ship time and endurance of the Discoverer, station spacing was nominally set at 40 nautical mile intervals, with closer spacing near boundaries and topographic features. To improve vertical resolution (within the available time), we planned to alternate between single cast (24 bottle) and 2 cast (48 bottle) stations along the line. Large volume Gerard Barrel casts (for C-14) were planned at a nominal spacing of 5 degrees along the line. No floats, drifters or moorings were deployed or recovered during the expedition. Continuous underway measurements of sea surface temperature and salinity were recorded along the cruise track. Approximately 44 XBTs were launched along the section.

### **A.5 Major Problems Encountered on the Cruise**

As anticipated for this region of the North Pacific in late winter, we encountered a series of storms along the cruise track. Bad weather caused the cancellation of several stations between about 20-48 N (see attached station listing and map). Severe weather caused us to skip all scheduled stations between 48-52 N on the northward transit along the line. We bypassed this region, and continued onward to complete the northern end of the line at Kodiak Island (57 N). We hoped to occupy the missed stations by re-tracing the track southward, but again experienced severe weather in this region, and were only partially successful in filling this gap. The center of this area (50 N, 152 W) was later crossed by a diagonal (SE-NW) section as part of WHP Line P17N in June 1993.

A number of water samples were lost due to problems with the 24 position General Oceanics Rosettes used to close the sample bottles. Although 2 new units were purchased for use on this cruise, and we were careful not to exceed lanyard tension specifications, we experienced a number of difficulties with the Rosettes. The problems included double-trips, failures to confirm firings, and failures in closing bottles. Typically, these problems resulted in losses of from one to several samples per cast, but at several stations only a few bottles were closed successfully. The mechanical components in the rosette required frequent disassembly and re-alignment, often resulting in delays in deploying the CTD/rosette package. After re-adjustment, performance of these units often deteriorated after only a few casts.

Most of the double trips and mis-firings were identified on board ship, and the correct closing depth determined from bottle salinity results. Additional mis-fires have been identified using other data, including dissolved nutrients, oxygen, CFCs and pH. We believe that most of the mis-fires have been identified, and that the bottle numbers (btlnbr) and corresponding ctd pressures (ctdprs) in the P16N.sea data file have been assigned correctly. After these checks were made, a bottle quality flag value of 2 has been assigned to these samples. As a result of the mechanical problems, bad weather, and

reduced ship speed, we were forced to reduce the number of 2 cast stations made along the section.

We experienced mechanical problems with some of the Gerard Barrels, especially during the first few stations attempted. This resulted in the loss of a number of large volume radiocarbon samples. Data from the Gerard Barrel casts has been processed by Robert Key at Princeton, and submitted to the WHP office in a separate file (.LVS format).

### **Summary:**

Despite the problems in fully completing the section as planned, we feel that the quality of the data at the stations sampled is generally good.

### **References:**

Martin, M., Talley, L.D., DeSzoeka, R.A. (1987). Physical, Chemical and CTD Data from the Marathon II Expedition. Data Report 131, Reference 87-15, College of Oceanography, Oregon State University, Corvallis, OR.

McTaggart, K.E., Mangum, L.J., (1995). CTD Measurements Collected on a Climate and Global Change Cruise (WOCE Section P16N) along 152 W during February-April, 1991. NOAA Data Report ERL PMEL-53, Pacific Marine Environmental Laboratory, Seattle, WA.

## **B. Hydrographic Measurement Techniques and Calibrations**

### **B.1 CTD Measurements**

(K. McTaggart)

#### **Introduction**

The Neil Brown Mark IIIb CTD profiler is designed to make precise, high resolution measurements of conductivity, temperature and depth 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 (the fast response thermistor was disabled). And a high performance, strain gage pressure transducer and associated electronics are used to determine pressure.

Data from the underwater unit is transmitted in real time to a shipboard data terminal through a single 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 via the same conductor.

#### **B.1.a Standards and Calibrations:**

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. And the Paine pressure sensor has a range of 0 to 6500 db, and accuracy of +/- 6.5 db, resolution of 0.1 db, and stability of 0.1%/month.

Both pre-cruise and post-cruise laboratory calibrations were done at Northwest Regional Calibration Center 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 is calculated for the platinum thermometer. A calibrated piston gauge was used to determine separate third order fits for the CTD pressure sensor at four temperatures for increasing pressure (over 7 pressure values from 0 to 6300 dbars) and decreasing pressure (over 6 values from 6300 to 0 dbars). Temperature and pressure calibrations are crudely checked at sea by comparing values with those from deep reversing thermometers, but the stability of the sensors is good enough (about 4 milli-degrees C for temperature and about .95 dbars for pressure over the 4-month period between pre- and post-cruise calibrations) that the CTD sensors are more accurate than the reversing thermometers. The conductivity sensor is not as stable relative to water sample values, and is more accurately calibrated using water samples collected in Niskin bottles mounted on the rosette sampler. Immediately prior to tripping the sampler, P, T, and C values are read from the deck unit. These values are then used to compare with the water sample values.

BIAS	SLOPE	COEF 1	COEF 2			
<b>Pre-cruise calibrations:</b>						
-32.7088	.9961159	0.188702E-5	-0.1999822E-09	P DN	S/N 1111	FEB 91
-35.0322	.9940687	0.293848E-5	-0.3073184E-09	P UP	S/N 1111	FEB 91
0.0534	1.0005530	0.000000E-6	0.0000000E-10	T 68	S/N 1111	FEB 91
0.0018	0.9997682	0.000000E-6	0.0000000E-10	C	S/N 1111	FEB 91
<b>Post-cruise calibrations:</b>						
-33.6641	.9963757	0.181537E-5	-0.1971429E-09	P DN	S/N 1111	JUN 91
-35.8913	.9941153	0.290680E-5	-0.3061199E-09	P UP	S/N 1111	JUN 91
0.0494	1.0006070	0.000000E-6	0.0000000E-10	T 68	S/N 1111	JUN 91
-0.0028	0.9996766	0.000000E-6	0.0000000E-10	C	S/N 1111	JUN 91

### B.1.b Data Acquisition

A total of 64 CTD casts were done by the ship's survey personnel under the supervision of PMEL CTD personnel. 54 casts were taken to within 50 meters of the bottom, although all of these were not deep (i.e. greater than 2000 meters). The remaining 12 casts were taken to 1000 meters or less. PMEL's Neil Brown Mark IIIb CTD, serial number 1111, and two new General Oceanics 24-bottle rosette pilons were used throughout the cruise. CTD 1111 was not equipped with an oxygen sensor. 10-liter Niskin bottles were used to collect water samples for salinity, oxygen, nutrients, CFCs, helium, tritium, C14, CO<sub>2</sub>, alkalinity, DIC, pH, chlorophyll, oxygen-18, DON, particulate nitrogen, and productivity.

Neil Brown Mark III deck units received the FSK signal from the underwater unit; displayed pressure, temperature, and conductivity values; sent an analog signal to an XY recorder which monitored the data acquisition in real time for signal spiking and problems with the electrical termination; sent any audio signal to a reel-to-reel or cassette recorder as a backup; and digitized the data before sending it to an IBM compatible 286-AT PC equipped with EG&G Oceansoft data acquisition software, version 2.02.

### B.1.c Data Acquisition Problems

Regarding the underwater unit and cable: Leg 2 started with cast 24. During cast 28, the CTD grounding strap parted and was fixed after the cast. Heavy surging produced 2 kinks in the cable during cast 32 and cast 33. The reel-to-reel audio recorder began failing as well. Cast 36 produced two bends in the cable within 3 meters of the underwater package but the cable was not reterminated. With cast 40 began major malfunctions in the rosette system including nonconfirmations on the deck unit and open bottles at the surface but not necessarily the same number. Water was found in the connectors after this cast and they were cleaned and resealed. Extensive, even creative, troubleshooting of the rosette system continued with nearly every cast. The XY analog plots monitoring the CTD signal were consistently of good quality. After cast 55, the y-cable was replaced with one from the ship so that the CTD and rosette would be on two different wires instead of one interrupted signal. Things did not improve however. The CTD was reterminated after cast 56. The ground strap parted again during cast 59 and was repaired. The conductivity

sensor was flushed with deionized water because of a noisier analog signal. Audio backups were made on cassette tapes after cast 59. By cast 72 the rosette was working better though not perfectly. After cast 77, all operations ceased for 2 days due to bad weather. The remaining casts were in rougher seas, the last being cast 87 at station 66.

Regarding data: Misfires were determined by a collaborative effort using the difference in CTD and bottle salinity, pH, oxygen, and nutrient data. The following is the general consensus at the end of the leg. Only misfired bottles are listed.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
26	1012	500	403.4	Sample bottles probably switched during analysis.
26	1013	400	498.3	
27	1026	1600	1302.4	Double trip at 1300m; no 1600m sample.
28	1036	4500	5079.2	Double trip at depth.
28	1031	4100	4516.6	Offset by one.
28	1025	3600	4001.7	Offset by one.
28	1029	3000	3613.9	Double trip at 3600m.
28	1038	2500	2985.6	Offset by one.
28	1007	2000	2501.6	Offset by one.
28	1012	1500	2001.6	Offset by one.
28	1013	1000	1500.4	Offset by one.
28	SI06	500	996.7	Offset by one.
28	1003	100	491.6	Offset by one.
28	1009	30	104.5	Offset by one.
28	1024	6	34.4	Offset by one; no 6m sample.
29	1025	100	67.2	Double trip at 70m; no 100m sample.
31	1040	1300	1095.8	Double trip at 1100m; no 1300m sample.
31	1036	800	698.9	Double trip at 700m; no 800m sample.
31	1025	600	497.7	Double trip at 500m; no 600m sample.
32	1036	200	147.3	Double trip at 150m; no 200m sample.
33	1036	2200	1901.4	Double trip at 1900m; no 2200m sample.
33	1025	1600	1298.9	Misfire; no 1600m sample.
33	1004	1300	1096.3	Double trip at 1100m; no 1300m sample.
35	1036	200	154.6	Double trip at 150m; no 200m sample.
38	1025	1000	1100.0	Double trip at 1100m.
38	1004	900	1001.0	Offset by one.
38	1026	800	898.0	Offset by one; no 800m sample.
39	1029	4500	4007.1	Double trip at 4000m; no 4500m sample.
39	1036	200	151.3	Double trip at 150m; no 200m sample.
39	1025	100	74.0	Double trip at 75m; no 100m sample.
40	1038	4000	1999.4	Double trip at 3000m; no 4000m sample.
41	1029	4600	4102.9	Double trip at 4100m; no 4600m sample.
41	1041	2100	1802.0	Double trip at 1800m; no 2100m sample.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
41	1036	800	701.3	Double trip at 700m; no 800m sample.
41	1025	600	494.0	Double trip at 500m; no 600m sample.
43	1017	5650	4542.8	Misfire.
43	1028	5000	3504.6	Misfire.
43	1029	4500	101.8	Misfire.
43	1038	4000	28.1	Misfire; only 4 bottles closed.
44	1038	4100	4607.0	Double trip at 4600m.
44	1007	3500	4104.1	Double trip at 4100m.
44	1012	3000	4104.1	
44	1013	2500	3508.8	Double trip at 3500m.
44	SI06	2000	3508.8	
44	1003	1700	3003.2	Offset by three.
44	1002	1400	2502.0	Offset by three.
44	1041	1150	2001.9	Offset by three.
44	1019	900	1698.4	Offset by three.
44	1033	700	1396.4	Offset by three.
44	SI04	600	1111.9	Offset by three.
44	1032	500	898.2	Offset by three.
44	1037	400	698.8	Offset by three.
44	SI26	300	600.0	Offset by three.
44	1036	200	498.5	Offset by three.
44	1031	150	400.3	Offset by three.
44	1025	100	300.9	Offset by three.
44	1004	75	202.0	Offset by three.
44	1026	50	150.4	Offset by three; no 50m sample.
44	1016	25	100.7	Offset by three; no 25m sample.
44	1027	6	75.7	Offset by three; no 6m sample.
46	1028	5105	298.5	Misfired.
46	1029	4400	5112.7	Offset by one.
46	1038	3900	4407.6	Offset by one.
46	1007	3400	3904.2	Offset by one.
46	1012	2900	3405.4	Offset by one.
46	1013	2400	2902.2	Offset by one.
46	SI06	1900	2902.2	Double trip at 2900m; no 2400m sample.
46	1003	1600	1900.0	Offset by one.
46	1002	1300	1900.0	Double trip at 1900m.
46	1041	1000	1599.8	Offset by two.
46	1019	900	1297.6	Offset by two.
46	1033	800	998.1	Offset by two.
46	1011	700	898.0	Offset by two.
46	1032	600	799.8	Offset by two.
46	1037	500	700.3	Offset by two.
46	SI26	400	601.1	Offset by two.
46	1036	300	498.8	Offset by two.
46	1031	200	398.9	Offset by two.
46	1025	150	298.5	Offset by two.
46	1004	100	199.9	Offset by two.
46	1026	50	151.8	Offset by two.
46	1016	25	99.7	Offset by two; no 25m sample.
46	1027	6	51.3	Offset by two; no 6m sample.
47	SI06	2750	3251.0	Double trip at 3250m.
47	1003	2500	2752.7	Offset by one.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
47	1002	2250	2500.8	Offset by one.
47	1041	2100	2250.0	Offset by one.
47	1019	1750	2250.0	Double trip at 2250m.
47	1033	1500	2098.4	Offset by two.
47	1011	1250	1750.8	Offset by two.
47	1032	900	1500.0	Offset by two.
47	1037	800	1246.4	Offset by two.
47	SI26	650	899.7	Offset by two.
47	1036	500	800.0	Offset by two.
47	1031	400	649.6	Offset by two.
47	1025	300	501.1	Offset by two.
47	1004	200	399.6	Offset by two.
47	1026	100	302.1	Offset by two.
47	1016	30	200.9	Offset by two; no 30m sample.
47	1027	6	100.9	Offset by two; no 6m sample.
48	1013	1000	749.6	Misfire.
49	SI06	2800	3101.2	Double trip at 3100m.
49	1003	2500	2802.4	Offset by one.
49	1002	2300	2502.2	Offset by one; no 2300m sample.
49	1019	1900	2100.9	Double trip at 2100m.
49	1033	1600	1897.8	Offset by one; no 1600m sample.
49	1032	1100	1298.1	Double trip at 1300m.
49	1037	1000	1098.8	Offset by one.
49	SI26	900	999.0	Offset by one.
49	1036	800	899.1	Offset by one.
49	1031	700	798.8	Offset by one.
49	1025	650	699.2	Offset by one.
49	1004	600	650.8	Offset by one.
49	1026	550	599.5	Offset by one.
49	1016	500	550.6	Offset by one.
49	1027	450	499.0	Offset by one; no 450m sample.
51	1003	2500	2752.7	Triple trip at 2750m; no 2500m sample.
51	1002	2250	2752.7	
51	1041	2100	2250.6	Offset by one.
51	1019	1750	2250.6	Double trip at 2250m; no 1750m sample.
51	1033	1500	2100.9	Offset by two.
51	1011	1250	1499.2	Offset by one.
51	1032	900	1499.2	Double trip at 1500m.
51	1037	800	1246.7	Offset by two.
51	SI26	650	898.4	Offset by two.
51	1036	500	799.7	Offset by two.
51	1031	400	640.9	Offset by two.
51	1025	300	502.3	Offset by two.
51	1004	200	400.4	Offset by two.
51	1026	100	297.4	Offset by two.
51	1016	30	201.5	Offset by two; no 30m sample.
51	1027	6	102.2	Offset by two; no 6m sample.
52	1029	4000	5008.2	Double trip at 5000m.
52	1038	3000	4007.4	Offset by one.
52	1007	2000	3002.5	Offset by one.
52	1012	1500	1999.3	Offset by one.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
52	SI06	1250	1372.8	Double trip at 1375m.
52	1003	1175	1246.5	Offset by one; no 1175m sample.
52	1002	1000	1246.5	Double trip at 1250m.
52	1041	850	1000.7	Offset by one.
52	1019	750	1000.7	Double trip at 1000m.
52	1033	650	849.7	Offset by two.
52	1011	550	750.7	Offset by two.
52	1032	450	550.2	Offset by one; no 650m sample.
52	1037	350	550.2	Double trip at 550m.
52	SI26	300	450.6	Offset by two.
52	1036	200	350.5	Offset by two.
52	1031	175	298.8	Offset by two.
52	1025	150	175.6	Offset by one; no 200m sample.
52	1004	125	175.6	Double trip at 175m.
52	1026	75	152.2	Offset by two; no 75m sample.
52	1016	30	126.8	Offset by two.
52	1027	6	31.6	Offset by one; no 6m sample.
53	1033	5000	5632.4	Double trip at depth.
53	1011	4750	5004.3	Offset by one.
53	1032	4500	4758.5	Offset by one.
53	1037	4250	4503.3	Offset by one.
53	SI26	3750	4254.5	Offset by one.
53	1036	3500	3755.9	Offset by one.
53	1031	3250	3507.9	Offset by one.
53	1025	2750	3252.5	Offset by one.
53	1004	2500	2753.8	Offset by one.
53	1026	2250	2500.2	Offset by one.
53	1016	1750	2251.8	Offset by one; no 1750m sample.
53	1017	1250	1498.6	Double trip at 1500m; no 1250m sample.
53	1029	800	1000.2	Double trip at 1000m.
53	1038	700	803.4	Offset by one.
53	1007	600	699.7	Offset by one.
53	1012	500	598.0	Offset by one.
53	SI06	250	402.0	Double trip at 400m.
53	1003	100	251.3	Offset by one; no 100m sample.
55	1007	3000	1175.4	Misfire.
55	1012	2000	1073.0	Offset by one.
55	1013	1500	847.2	Misfire.
55	SI06	1175	747.9	Offset by one.
55	1003	1075	646.7	Offset by one.
55	1002	925	547.0	Offset by one.
55	1041	850	453.2	Offset by one.
55	1019	750	351.0	Offset by one.
55	1033	650	301.5	Offset by one.
55	1011	550	199.7	Offset by one.
55	1032	450	176.1	Offset by one.
55	1037	350	151.0	Offset by one.
55	SI26	300	123.4	Offset by one.
55	1036	200	75.6	Offset by one.
55	1031	175	6.0	Offset by one.
56	1028	5650	4759.2	Misfire.
56	1029	4750	3502.0	Misfire.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
56	1038	4500	2251.5	Misfire.
56	1007	4250	601.4	Misfire.
56	1012	3750	403.5	Misfire.
56	1013	3500	52.9	Misfire.
56	SI06	3250	52.9	Double trip at 50m.
56	1003	2750	7.4	Misfire.
57	1013	3250	2752.2	Double trip at 2750m; no 3250m sample.
58	1013	125	101.6	Double trip at 100m; no 125m sample.
59	1013	1375	1173.6	Triple trip at 1175m; no 1375m sample.
59	1003	1075	1173.6	
59	1002	925	1075.3	Offset by one.
59	1041	850	924.1	Offset by one.
59	1019	750	850.9	Offset by one.
59	1033	650	749.4	Offset by one.
59	1011	550	648.7	Offset by one.
59	1032	450	548.8	Offset by one.
59	1037	350	449.7	Offset by one.
59	SI26	300	348.0	Offset by one.
59	1036	200	298.8	Offset by one.
59	1031	175	201.0	Offset by one.
59	1025	150	176.0	Offset by one.
59	1004	125	150.9	Offset by one.
59	1026	75	125.6	Offset by one.
59	1016	6	75.8	Offset by one.
59	1027	6	8.3	Offset by one; no second 6m sample.
60	1037	800	699.2	Double trip at 700m; no 800m sample.
61	1013	1375	1074.9	Double trip at 1075m; no 1375m sample.
61	SI06	1175	1074.9	No 1175m sample either.
61	1003	1075	924.4	Offset by one.
61	1002	925	819.4	Offset by one.
61	1041	850	651.8	Double trip at 650m; no 750m sample.
61	1019	750	651.8	Offset by one.
61	1033	650	450.2	Misfire.
61	1011	550	349.4	Double trip at 350m; no 550m sample.
61	1032	450	349.4	Offset by one.
61	1037	350	201.5	Double trip at 200m; no 300m sample.
61	SI26	300	201.5	Offset by one.
61	1036	200	177.0	Offset by one.
61	1021	175	151.5	Offset by one.
61	1025	150	127.0	Offset by one.
61	1004	125	77.2	Offset by one.
61	1026	75	32.8	Offset by one.
61	1016	30	8.6	Offset by one.
62	1003	2750	3252.1	Double trip at 3250m.
62	1002	2500	2749.4	Offset by one.
62	1019	1750	2249.6	Double trip at 2250m; no 2500m sample.
62	1033	1500	1748.5	Offset by one; no 1500m sample.
62	1037	800	701.4	Double trip at 700m; no 800m sample.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
63	1029	5000	4007.1	Double trip at 4000m; no 5000m sample.
63	SI06	1375	1502.2	Double trip at 1500m.
63	1003	1175	1375.9	Offset by one.
63	1002	1075	1175.5	Offset by one.
63	1041	925	1072.5	Offset by one.
63	1019	850	923.1	Offset by one.
63	1033	750	849.2	Offset by one.
63	1011	650	749.5	Offset by one.
63	1032	550	648.0	Offset by one.
63	1037	450	548.9	Offset by one.
63	SI36	350	449.1	Offset by one.
63	1036	300	350.7	Offset by one.
63	1031	200	300.3	Offset by one.
63	1025	150	199.6	Offset by one.
63	1004	125	150.0	Offset by one.
63	1026	75	126.7	Offset by one.
63	1027	6	31.8	Offset by two; no 75m or 6m sample.
64	1013	3500	3254.0	Double trip at 3250m; no 3500m sample.
65	1007	3500	4007.1	Double trip at 4000m.
65	1012	3250	3503.2	Offset by one; no 3250m sample.
65	SI06	2500	2750.2	Double trip at 2750m.
65	1003	2250	2499.0	Offset by one.
65	1002	2000	2249.2	Offset by one; no 2000m sample.
65	1019	1500	1747.9	Double trip at 1750m.
65	1033	1250	1499.5	Offset by one.
65	1011	1000	1247.6	Offset by one.
65	1032	900	997.7	Offset by one.
65	1037	850	900.1	Offset by one.
65	SI26	800	849.4	Offset by one.
65	1036	750	798.3	Offset by one.
65	1027	6	41.7	Misfire.
66	1025	40	22.7	Misfire.
66	1004	20	7.9	Offset by one.
68	1017	5033	5008.8	Misfire; no sample at depth.
68	1028	5000	4756.8	Offset by one.
68	1029	4750	4504.1	Offset by one.
68	1038	4500	4255.1	Offset by one.
68	1007	4250	3753.4	Offset by one.
68	1012	3750	2750.7	Offset by one.
68	1013	3500	2499.6	Misfire; no 3500m sample.
68	SI06	3250	2499.6	Double trip at 2500m; no 3250m sample.
68	1003	2750	1749.6	Misfire; no 2750m sample.
68	1002	2500	1749.6	Triple trip at 1750m.
68	1041	2250	1749.6	No 2250m sample.
68	1019	1750	1498.6	Offset by one.
68	1033	1500	1247.8	Offset by one.
68	1011	1250	998.3	Offset by one.
68	1032	1000	797.0	Offset by one.
68	1037	800	697.6	Offset by one.
68	SI26	700	597.4	Offset by one.
68	1036	600	499.7	Offset by one.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
68	1031	500	399.6	Offset by one.
68	1025	400	249.7	Offset by one.
68	1004	250	100.1	Offset by one.
68	1026	100	50.0	Offset by one.
68	1016	50	7.8	Offset by one.
69	1028	5250	4008.1	Misfire; no 5250m sample.
69	1029	4000	3002.2	Offset by one.
69	1038	3000	1998.9	Offset by one.
69	1007	2000	1498.5	Offset by one.
69	1012	1500	1374.9	Offset by one.
69	1013	1375	1172.9	Offset by one.
69	SI06	1175	1073.0	Offset by one.
69	1003	1075	922.6	Offset by one.
69	1002	925	847.6	Offset by one.
69	1041	850	749.1	Offset by one.
69	1019	750	648.7	Offset by one.
69	1033	650	548.8	Offset by one.
69	1011	550	349.4	Misfire; no 450m sample.
69	1032	450	202.4	Double trip at 200m; no 300m sample.
69	1037	350	202.4	Offset by two.
69	SI26	300	176.6	Offset by two.
69	1036	200	152.6	Offset by two.
69	1031	175	126.7	Offset by two.
69	1025	150	78.8	Offset by two.
69	1004	125	31.3	Offset by two.
69	1026	75	8.4	Offset by two.
70	1017	5330	4762.8	Misfire; no 5330m sample.
70	1028	5000	4506.4	Offset by two; no 5000m sample.
70	1029	4750	4257.4	Offset by two.
70	1038	4500	3756.1	Offset by two.
70	1007	4250	3253.1	Misfire; no 3500m sample.
70	1012	3750	2750.6	Offset by three.
70	1013	3500	1499.6	Misfire.
70	SI06	3250	799.4	Misfire.
70	1003	2750	699.1	Offset by eight.
70	1002	2500	600.3	Offset by eight; no 2500m sample.
70	1041	2250	499.6	Offset by eight; no 2250m sample.
70	1019	1750	400.3	Offset by eight; no 1750m sample.
70	1033	1500	252.1	Offset by eight; no 1500m sample.
70	1011	1250	101.6	Offset by eight; no 1250m sample.
70	1032	1000	50.4	Offset by eight; no 1000m sample.
70	1037	800	9.1	Offset by eight; no 150m sample.
73	1019	3250	2753.1	Double trip at 2750m; no 3250m sample.
74	1013	60	42.2	Misfire; no 60m sample.
74	1017	40	5.2	Misfire; no 40m sample.
74	1033	20	5.2	Tripped at the surface.
75	1026	3500	3254.2	Double trip at 3250m; no 3500m sample.
76	1029	4000	5004.4	Double trip at 5000m.
76	SI06	3000	4006.3	Offset by one.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
76	1026	2000	3002.2	Offset by one.
76	1002	1500	1999.7	Offset by one.
76	1004	1375	1495.3	Offset by one.
76	1019	1175	1371.1	Offset by one.
76	SI26	1075	1174.6	Offset by one.
76	1011	925	1076.1	Offset by one.
76	1003	850	923.2	Offset by one.
76	1037	750	848.2	Offset by one.
76	1013	650	746.1	Offset by one.
76	1036	550	648.1	Offset by one.
76	1017	450	546.6	Offset by one.
76	1025	350	452.2	Offset by one.
76	1033	300	351.6	Offset by one.
76	1041	200	300.0	Offset by one.
76	1007	175	199.8	Offset by one.
76	1027	150	174.4	Offset by one.
76	1032	125	149.4	Offset by one.
76	1028	75	123.1	Offset by one.
76	1023	30	76.3	Offset by one.
76	1031	6	29.7	Offset by one; no 6m sample.
77	1016	5105	6.0	Misfire.
77	1029	4750	5119.2	Offset by one.
77	SI06	4500	4758.3	Offset by one.
77	1026	4250	4506.4	Offset by one.
77	1002	3750	4255.1	Offset by one.
77	1004	3500	3755.4	Offset by one.
77	1019	3250	3501.3	Offset by one.
77	SI26	2750	3253.8	Offset by one.
77	1011	2500	2751.4	Offset by one.
77	1003	2250	2500.2	Offset by one.
77	1013	1500	2248.9	Offset by one.
77	1036	1250	1750.6	Offset by one.
77	1017	1000	1497.7	Misfire; no 1000m sample.
77	1025	800	1250.6	Offset by two.
77	1033	700	798.6	Offset by one.
77	1041	600	701.7	Offset by one.
77	1007	500	599.9	Offset by one.
77	1027	400	498.6	Offset by one.
77	1032	250	400.9	Offset by one.
77	1028	100	242.5	Offset by one.
77	1023	50	102.6	Offset by one.
77	1031	6	52.1	Offset by one; no 6m sample.
79	SI06	3500	3003.7	Double trip at 3000m; no 3500m sample.
80	1026	4000	3502.4	Double trip at 3500m; no 4000m sample.
81	1016	400	350.0	Double trip at 350m; no 400m sample.
82	1016	4175	3502.2	Double trip at 3500m; no 4175m sample.
82	1026	2000	1697.7	Double trip at 1700m; no 2000m sample.
82	1027	125	149.1	Double trip at 150m; no 125m sample.
83	1002	1200	1096.3	Double trip at 1100m; no 1200m sample.

CAST	NISKIN	NOM Z	ACTUAL P	COMMENTS
84	1012	900	932.6	Double trip at 935m.
84	1029	800	898.5	Offset by one.
84	SI06	700	798.0	Offset by one.
84	1026	600	699.2	Offset by one.
84	1002	500	699.2	Double trip at 700m.
84	1004	400	598.6	Offset by two.
84	1019	300	499.7	Offset by two.
84	SI26	200	399.9	Offset by two.
84	1011	150	300.6	Offset by two.
84	1003	100	201.4	Offset by two.
84	1037	60	152.1	Offset by two.
84	1013	30	101.4	Offset by two; no 30m sample.
84	1036	6	61.7	Offset by two; no 6m sample.
85	1026	150	125.5	Double trip at 125m; no 150m sample.
85	1003	30	21.2	Misfire.
85	1037	20	7.1	Offset by one.
86	1026	2500	2000.7	Double trip at 2000m; no 2500m sample.
86	1027	125	101.1	Double trip at 100m; no 125m sample.
87	1002	2000	2501.8	Double trip at 2500m.
87	1004	1700	1998.9	Offset by one.
87	1019	1450	1697.9	Offset by one.
87	SI26	1200	1447.8	Offset by one.
87	1011	1000	1201.2	Offset by one.
87	1003	900	1003.2	Offset by one.
87	1037	800	898.9	Offset by one.
87	1013	700	803.2	Offset by one.
87	1036	600	701.2	Offset by one.
87	1017	500	600.1	Offset by one.
87	1025	400	499.0	Offset by one.
87	1033	300	399.0	Offset by one.
87	1041	200	298.8	Offset by one.
87	1007	150	203.3	Offset by one.
87	1027	125	151.7	Offset by one.
87	1032	100	131.4	Offset by one.
87	1028	60	105.7	Offset by one.
87	1023	30	61.6	Offset by one.
87	1031	6	31.9	Offset by one; no 6m sample.

#### B.1.d Salinities

Guildline Autosal 56.118, last calibrated at NRCC 1/15/91, was used to run salinities for all casts by SST Rex Long. IAPSO standard seawater used was lot #P110. Operating temperature was 21C while running samples from casts 38-38, and 24C for all others. This did not seem to affect the quality of the salinities. Drift corrections were applied by survey before being transcribed to the CTD cast logs.

### B.1.e Post-Cruise Conductivity Calibrations

Final calibrations were done at PMEL using the composite bottle data set called COMBINE.CAL produced by COMBINE.FOR of CG191 (casts 1-23), CG291 (casts 24-87), and PSI91 (casts 88-116). CALMSTRW was run with pre-cruise calibrations, then LINCALW for an overall least squares fit, and then CALMSTRW again with the overall fit applied. Plots of cast number, P, T, C, and bottle salinity verses the difference in conductivity between CTD and bottle data (CALMCONW.PPC) for bottles greater than 2000 meters showed cast breaks between casts 2 and 3 where the cable was first reterminated, and between casts 16 and 17 where the conductivity cell had been cleaned on CG191. The PSI data had no deep bottle data to look at and so was calibrated along with the last group which included the whole of CG291 data.

LINCALW was run on each of the 3 groups of casts. CALMCONW plots looked good but the pressure verses delta-conductivity showed an offset of approximately .002 psu in the deepest bottles. Fitting each group using only deep bottles (>2000 meters) remedied the deep pressure offset but skewed the surface bottles.

Fitting each group using only bottles greater than 500 meters decreased the pressure offset at depth somewhat but there was still some skew in the surface bottles. Because DEEPCTD plots of CTD salinity verses potential temperature with bottle salinities overplotted did not show any difference between using a fit calculated from all the bottle depths and a fit calculated from those bottles deeper than 500 meters (still in 3 groups), it was decided to go with the conductivity coefficients calculated from all bottle depths for no skew in the surface bottles.

Results of LINCALW:

		<b>BIAS</b>	<b>SLOPE</b>	<b>MAX RESIDUAL</b>	<b>STD ERROR</b>
Group 1:	(casts 1 & 2):	-0.03930474	1.000857	0.0033	0.0014
Group 2:	(casts 3-16):	0.01242658	0.999319	-0.0048	0.0017
Group 3:	(casts 17-118):	-0.00262318	0.999693	-0.0061	0.0022
Group 1:	1 value discarded from 35 in 2 repetitions.				
Group 2:	26 values discarded from 282 in 7 repetitions.				
Group 3:	242 values discarded from 1640 in 11 repetitions.				

### DEEPCTD

plots with the above calibrations applied showed that the majority of deep CTD traces were slightly fresher than the bottles implying that the linear fit calibrations were not enough. An average of the delta-conductivity values for bottles deeper than 5000 meters was computed (0.0015), added to the bias of group 3, and applied to only casts of CG291 (casts 24-87). Adding this additional conductivity offset to CG191 casts of group 3 made things worse or made no difference.

## **B.1.f Conductivity Calibration Programs and Plotting Command Files:**

### **CALEGGW**

creates .CAL uncalibrated bottle data file.

### **CALMSTRW**

inputs .CAL uncalibrated bottle file, and outputs .CLB calibrated bottle file and WOCE .SEA bottle file with unedited quality flags.

### **LINCALW**

inputs .CAL uncalibrated bottle file (which may be broken into groups) and calculates a least squares fit between CTD and water sample conductivity. When the difference between CTD and water sample conductivity is greater than 2.8 times the standard deviation of the calculated fit, that calibration point is thrown out. Another fit is then calculated without these points and the process is iterated until no calibration pairs are discarded. LINCALW outputs a .COEF file containing the final least squares fit coefficients and a .LOG file of fit iterations.

### **CALMCONW.PPC**

reads .CLB calibrated bottle data and makes five separate scatter plots: P, T, C, S, and cast number verses delta-C (CTD-bottle). These are examined for cast breaks and drifts in the CTD.

### **CALMDEEPW.PPC**

reads .CLB calibrated bottle file and make two separate scatter plots: CTD salinity and bottle salinity verses potential temperature from theta=0.6 to 2.2 degrees C.

### **DEEPCTD.PPC**

reads processed CTD and bottle data files of deep casts only and overplots the bottle salinity data and CTD salinity trace from theta=0.8 to 2.4 degrees C for each deep cast.

### **WOCE .SEA SUBMISSION:**

Programmer/chemist Dan Lee was manager of a collective data base of water sample data during the cruise and at the lab for this project. Each group (e.g. CTD, pH, freon, etc.) would give their results to Dan and he would incorporate them into a master data file which would be submitted to the WOCE Programme Office following the guidelines set forth in the WOCE Operations Manual Part 3.1.2: Requirements for WHP Data Reporting (July, 1991). CALMSTRW was modified to create this same .SEA file but containing only CTD and salinity parameters.

The International Temperature Scale of 1990 (ITS-90) is now a standard variable in PMEL CTD data files. Temperatures reported to the WHP office will have been converted to this scale. Salinities are still computed using PSS-78 and the 1968 temperature scale. WOCE quality flags are assigned to each bottle, each salinity value, and each bottle salinity value for every cast.

The bottle quality flag was assigned a value of 2 (no problems noted), 3 (leaking as noted on the sampling logs and CTD cast logs), or 4 (did not trip correctly i.e. if the nominal pressure differed from the actual pressure). The quality flag associated with the CTD salinity measurement was 2 (acceptable measurement). An in-house criteria was set up to distinguish between acceptable, questionable, and bad quality flags for bottle salinity measurements: For the highly variable upper water column (0-1000 db), if the difference between the CTD salinity and bottle salinity was greater than .04 psu, the quality flag was assigned a value of 4 (bad); if the difference was between .01 and .04 psu, it was assigned a value of 3 (questionable); and if the difference was less than .01, it was considered an acceptable bottle salinity. For the more stable deep water (potential temperature less than 2.4 degrees C), the quality flag for bottle salinity was 4 if the difference in salinities was greater than .008 psu, 3 if delta-S was between .003 and .008 psu, and 2 if less than .003 psu. For mid-column water, the assignment of quality flag values was subjective.

### B.1.g Processing

Data was restored to the PMEL VAX system from TK50 tape. The following standard processing programs and plotting command files were used to process the data:

DPDNZ	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 the ship rolling and pitching, a fall rate is computed between samples approximately 2 seconds apart and is recorded along with the original unprocessed data. DPDNZ inputs EG&G CTDACQ raw data files (.EDT) and outputs a binary file of raw data including computed fall rates (.DPZ) and an ASCII file (.RECZ) from which a record range for the downcast are selected.
DLAGZ	inputs the .DPZ file, applies pre-cruise calibrations (read from CALIB.DAT), edits the data for window outliers and first differencing outliers (according to WINDOW.DAT), fills these gaps by linear interpolation, corrects for the time-constant mismatch between temperature and conductivity sensors, edits data exceeding the fall rate criteria (default minimum fall rate acceptable is .8 db/60 scans or 25 meters per minute) and pressure interval of 1.5 db; computes 1-meter averages, and applies cell dependence to final conductivity values. DLAGZ outputs an error log file (CTDERR.DAT) of outlier flags, interpolated values, and fall rate criteria failures, and an ASCII .CTD data file including computed salinity.

Windowing and first differencing: After reading in a buffer of data DLAGZ applies appropriate transfer functions to convert the data to engineering units and checks for obviously bad values. If a value falls outside preset windows it is flagged as bad. The windows used on this data set were -12 to 6500 dbar for pressure, -2 to 33 C for temperature, and 24 to 68 mmho/cm for conductivity. The first two data scans after the user supplied starting record number which pass this window test are considered the first two good scans. Subsequent data points are then edited by calculating the difference between the scan under consideration and the previous scan. If this difference is greater than a certain preset value (1 for P, .07 for T, and .1 for C) it is tentatively rejected. The difference between the next scan and the last good scan is then calculated. If this value exceeds twice the maximum allowable difference between scans, it too is considered bad. If five scans in a row fail in this manner it is assumed that there is a gap in the data record and all scans are retained as good. If the next, third, fourth or fifth scan has a value close enough to the last good scan, then the scan in question is flagged as bad and is rejected.

Lagging conductivity: A filter is applied to conductivity data to account for the response time difference between the conductivity sensor and the slower platinum thermometer. This filter was developed using the techniques discussed in Horne and Toole (1980). The conductivity is slowed down as follows:

$$C(n) = (1-A) CM(n) + A*C(n-1)$$

where C is the lagged conductivity, CM is the measured conductivity, n is the scan number, and A is a constant which has been determined to best match temperature and conductivity (A=0.87).

Fall rate editing: We have found that the CTD/rosette package seems to entrap water and drag that water down with it as it falls downward. If the fall rate reverses or slows due to the ship's roll, the CTD sensors measure water that has been contaminated by the package. The contamination appears to extend below the level through which the CTD started its reversal or slowdown. So when the CTD starts downward again through this water, it is necessary to disregard data collected for a small interval past the pressure at which the reversal started. The lagged conductivity and measured temperature values are accepted and placed in 1 dbar bins unless the fall rate calculated by DPDNZ falls below the user specified minimum rate. Data are then rejected until the CTD is once again moving downward past the pressure at which it slowed below the minimum fall rate plus a user specified pressure interval to account for further contamination.

EPCTDW	<p>inputs .CTD calibrated P, T, and raw conductivity data; applies any additional P and T calibrations, corrects raw conductivity for cell factor, and applies conductivity calibrations; computes salinity; deals with oxygen if there was an oxygen sensor; eliminates 1-point spikes according to the gradients hardwired into the source code; omits any values specified by the processor, fills by linear interpolation for a value to exist every whole meter; recalculates conductivity (inverted from S, T, and P); and calculates potential temperature, sigma-t, sigma-theta, and dynamic height according to the subroutines supplied in Fofonoff and Millard (1974). EPCTDW outputs final .CTD data file in PMEL's EPIC (Equatorial Pacific Information Collection) format (Soreide and Hayes, 1988) and a log file listing the edited and filled data points.</p> <p>Single-point despiking and filling: A data scan is removed if the value of the point itself are both greater than a predetermined gradient and have opposite signs. Maximum allowable gradients are .05, .025 for T and S above 200 dbar and .01, .01 for T and S below 200 dbar. The data array is then filled to obtain one value for each 1 dbar interval. When the uppermost pressure is not equal to 0 dbar, surface values of T and S are filled with the values associated with the shallowest pressure for which values do exist (provided this pressure is less than 20 dbar). Data points are linearly interpolated to fill the gaps resulting in an even 1 dbar pressure spacing of the final data array.</p>
EPICBOMSTRW	inputs .CLB calibrated bottle data file and .CTD EPIC data files (for header information), and outputs .BOT bottle data files in EPIC format.
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 (from SIGMA.DAT). Use TSPLTB.PPC to include oxygen data.
TEXTNOX	inputs .CTD EPIC pointer file and constructs plotting subcommand file and outputs TXT*.PPC file for each cast. Use TEXTEP to include oxygen data.
3PLTNOX.PPC	reads TXT*.PPC subcommand files and .CTD EPIC pointer file and overplots vertical profiles of temperature, salinity, and sigma-t verses pressure to 1000 db on left hand side of page; and lists data in table form on right hand side of page. Use 4PLT1DB.PPC to include oxygen data.

Casts 27, 30, 31, 34, 39, and 47 theta-salinity plots showed obvious looping in the CTD trace, historically determined to be the result of fall rate inconsistencies of the package. The worse cast (cast 27) was used to determine a better criteria for this package. It turned out to be a minimum acceptable fall rate of .8 db/60 scans (approximately 25 meters per minute) and a pressure interval of 5.0 db to skip after a fall rate failure. However, this threw out around 50% of the original data! Alternatively, a group of casts were looked at with a more reasonable criteria (the default 0.8 db/60 scans and 1.5 db) but with a gradient despiking switch turned on in EPCTDW (default is off). This cleaned up the

traces remarkably well and without losing any structure. So all CGC92 casts were processed with the default fall rate criteria and automatic gradient despiking. Loops that got through this (as seen in TSPLTEP plots) were edited out using the subroutine NOMIT in EPCTDW). These were casts 5 (leg 1), 26, 27, 28, and 48. Small temperature inversions were neglected since they are very fine scale work.

TSPLTEP and DEEPCTD plots were looked at for any additional spiking that needed to be taken out using NOMIT of EPCTDW. Spikes were removed from casts 25, 27, 29, 32, 33, 36, 40, 41, 46, 48, 49, 52, 55, 58, 59, 61, 62, 65, 70, and 77; and the data replaced by linear interpolation.

N.B. Approximately 600 meters of data from cast 65 were lost during acquisition when the PC hard disk became full and the program aborted. The operator didn't realize this for several minutes and the data had to be restored from audio reel-to-reel tape later. As mentioned earlier, these tapes were badly oxidized and the replay was very poor. The majority of data between 1350 and 2100 meters is linearly interpolated in patches.

Also, a memo was received from Captain Smart of the DISCOVERER explaining that an error had been made in the bottle salinity calculations run aboard the ship between January 15, 1991 and October 28, 1991. In March, 1992 a program was written (FIXSAL) to read in the .BOT files, correct for this error, and write all the variables back out. Calibrations and CTD data files were left alone. Dan Lee also wrote a program to go through the master bottle file and make the corrections. Bottle data was resubmitted to WOCE.

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## **B.2 Bottle Salinity Measurements**

Bottle salinity analyses were performed in a climate-controlled lab using two Guildline Autosal Model 8400A inductive salinometers and IAPSO Standard Seawater from Wormley Batch P110. The commonly accepted precision of the Autosal is 0.001 psu, with an accuracy of 0.003 psu. Salinity samples were collected from each sample bottle at all stations by ship's personnel. Two samples were drawn from the deepest bottle at each station to monitor the drift of the Autosal instrument. The first deep sample was run that day, the second was run the following day. The autosals were standardized at the beginning of each day using one vial of standard seawater, and again at the end of each case of sample bottles. 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 saltness to identify leaking bottles, as well as to monitor the conductivity sensor performance and drift.

## **B.3 Dissolved Oxygen, Nutrients**

(Kristin Sanborn at SIO-ODF)

### **B.3.a STS/ODF Data Collection, Analyses, and Processing**

Gerard casts were carried out with ~270 liter stainless steel Gerard barrels on which were mounted 2-liter Niskin bottles with reversing thermometers. The Gerard barrels were numbered 81 through 94 and the piggy-back Niskin were numbered 61 through 71. Salinity check samples were analyzed by PMEL from the Niskin bottles for comparison with the Gerard barrel salinities to verify the integrity of the Gerard sample. Gerard pressures and temperatures were calculated from Deep-Sea Reversing Thermometer (DSRT) readings. Each DSRT rack normally held 2 protected (temperature) thermometers and 1 unprotected (pressure) thermometer. Thermometers were read by two people, each attempting to read a precision equal to one tenth of the thermometer etching interval. Thus, a thermometer etched at 0.05 degree intervals would be read to the nearest 0.005 degrees. Each temperature value is therefore calculated from the average of four readings.

#### **B.3.a.1 Oxygen**

Samples were collected for dissolved oxygen analyses soon after the sampler was brought on board and after CFC and Helium were drawn. Nominal 100 ml volume iodine flasks were rinsed carefully with minimal agitation, then filled via a drawing tube, and allowed to overflow for at least 2 flask volumes. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice; immediately, and after 20 minutes, to assure thorough dispersion of the Mn(OH)<sub>2</sub> precipitate. The samples were analyzed within 4-36 hours except for Station 13, Casts 21 and 22, which were analyzed ten (10) days after they were drawn.

Dissolved oxygen samples were titrated in the volume-calibrated iodine flasks with a 1 ml microburet, using the whole-bottle Winkler titration following the technique of Carpenter

(1965). Standardizations were performed with 0.01N potassium iodate solutions prepared from pre-weighed potassium iodate crystals. Standards were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Several standards were made up and compared to assure that the results were reproducible, and to preclude basing the entire cruise on one standard, with the possibility of a weighing error. A correction (-0.014 ml/l) was made for the amount of oxygen added with the reagents. Combined reagent/seawater blanks were determined to account for oxidizing or reducing materials in the reagents, and for a nominal level of natural iodate (Brewer and Wong, 1974) or other oxidizers/reducers in the seawater.

The assay of the finest quality KIO<sub>3</sub> available to ODF is 100%, +/-0.05%, but the true limit in the quality of the bottle oxygen data lies in the practical limitations of the present sampling and analytical methodology, from the time the bottle is closed through the calculation of oxygen concentration from titration data. Overall precision within a group of samples has been determined from replicates on numerous occasions, and for the system as employed on this expedition, one may expect +/-0.1 to 0.2%. The overall accuracy of the data is estimated to be +/-0.5%.

Oxygens were converted from milliliters per liter to micromoles per kilogram using the equation:

$$O_2[\mu\text{m/kg}] = O_2[\text{ml/l}] / (.022392 * (1.0 + \sigma_{\theta} / 1000.0))$$

The potential density anomaly,  $\sigma_{\theta}$ , is the potential density in kg/m<sup>3</sup> referenced to pressure=0, from which 1000 has been subtracted.

### **B.3.a.2 Nutrients**

Nutrients (phosphate, silicate, nitrate and nitrite) analyses, reported in micromoles/kilogram, were performed on a Technicon AutoAnalyzer. The procedures used are described in Hager et al. (1972) and Atlas et al. (1971). Standardizations were performed with solutions prepared aboard ship from pre-weighed standards; these solutions were used as working standards before and after each cast (approximately 24 samples) to correct for instrumental drift during analyses. Sets of 4-6 different concentrations of shipboard standards were analyzed periodically to determine the linearity of colorimeter response and the resulting correction factors. Phosphate was analyzed using hydrazine reduction of phosphomolybdic acid as described by Bernhardt & Wilhelms (1967). Silicate was analyzed using stannous chloride reduction of silicomolybdic acid. Nitrite was analyzed using diazotization and coupling to form dye; nitrate was reduced by copperized cadmium and then analyzed as nitrite. These three analyses use the methods of Armstrong et al. (1967).

Sampling for nutrients followed that for the tracer gases, CFCs, He, Tritium, and dissolved oxygen. Samples were drawn into ~45 cc high density polyethylene, narrow mouth, screw-capped bottles which were rinsed twice before filling. The samples may have been refrigerated at 2 to 6 deg C for a maximum of 15 hours.

Nutrients were converted from micromoles per liter to micro- moles per kilogram by dividing by sample density calculated at an assumed laboratory temperature of 25 deg C.

### **B.3.a.3 Data Comparisons**

The oxygen and nutrient data were compared not only with the adjacent station, but also with historical data from Marathon II and Trans-Pacific Section 47N. The agreement was within normal analytical error.

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## **B.4 Radiocarbon Results**

Small volume (AMS) samples were collected by Robert Key and processed at the AMS facility at WHOI. Information on processing and calibration of these samples is not included in this report. Results from several Large-Volume C-14 stations are included in the P16N.LVS file. These results have been provided by the University of Miami Tritium Laboratory, in Data Release #92-15, H. Gote Ostlund, Head. The following text is excerpted from this report:

### **B.4.a General Comments on this Data Release (#92-15)**

As part of the WOCE Hydrographic Programme, the NOAA R/V Discoverer CGC91 Cruise was undertaken during 7 March- 8 April 1991. The cruise track followed the 152 W meridian from 20-57 N., during which time six stations were sampled for radiocarbon using large volume casts. The University of Washington Quaternary Research Lab received samples from three of those stations and the University of Miami Tritium Lab received samples from the remaining stations. Hydrographic data for the large volume stations were received from Scripps Ocean Data Facility and Bob Key, Princeton University. Total CO<sub>2</sub> is in progress of being measured by Richard Feely, PMEL

### **B.4.b General Comments on C12 Data**

Both C14 and C13 measurements were performed on CO<sub>2</sub> gas prepared from the sample material. The standard for C14 measurements is the NBS oxalic acid standard or radiocarbon dating. R-value is the ratio between the measured specific activity of the sample CO<sub>2</sub> to a C13 value of -9 per mille and age-corrected from today to AD1950, all according to international agreement. Delta C14 is the deviation, (in per mil) from unity, of the activity ratio, isotope-corrected to a sample C13 value of -25 per mil. If ages are reported, they are in 'C14 years' (before AD1950), based on a "best" C14 half-life of 5730 years. Multiply the ages by 0.9721 to obtain ages based on the 'official' half-life of 5570. The quoted errors are 1 sigma, the uncertainty of the half-life (+-40y) not included. For further information on standards, etc, cf. preface to each issue of Radiocarbon, and papers by Broecker and Olson (1961), Stuiver and Robinson (1974) and by Stuiver (1980).

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## **B.5 CFC-11 and CFC-12 Measurements on WOCE Section P16N**

Specially designed 10 liter water sample bottles were used on the expedition to reduce CFC contamination. These bottles have the same outer dimensions as standard 10 liter Niskin bottles, but use a modified end-cap design to minimize the contact of the water sample with the end-cap O-rings after closing. The O-rings used in these water sample bottles were vacuum-baked prior to the first station. Stainless steel springs covered with a nylon powder coat were substituted in place of the standard internal elastic tubing used to close Niskin bottles.

Water samples for CFC analysis were usually the first samples collected from the 10 liter bottles. Care was taken to co-ordinate the sampling of CFCs with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. In most cases, dissolved oxygen, helium-tritium, total CO<sub>2</sub> and pH samples were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC samples were drawn directly through the stopcocks of the 10 liter bottles into 100 ml precision glass syringes equipped with 2-way metal stopcocks. The syringes were immersed in a holding tank of clean surface seawater until analyses.

To reduce the possibility of contamination from high levels of CFCs frequently present in the air inside research vessels, the CFC extraction/analysis system and syringe holding tank were housed in a modified 20' laboratory van on the deck of the ship.

For air sampling, a ~100 meter length of 3/8" OD Dekaron tubing was run from the CFC lab van to the bow of the ship. Air was sucked through this line into the CFC van using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at about 1.5 atm using a back-pressure regulator. A tee allowed a flow (~100 cc/min) of the compressed air to be directed to the gas sample valves, while the bulk flow of the air (>7 liter/minute) was vented through the back pressure regulator.

Concentrations of CFC-11 and CFC-12 in air samples, seawater and gas standards on the cruise were measured by shipboard electron capture gas chromatography (EC-GC), using techniques similar to those described by Bullister and Weiss (1988). For seawater analyses, a ~30-ml aliquot of seawater from the glass syringe was transferred into the glass sparging chamber. The dissolved CFCs in the seawater sample were extracted by passing a supply of CFC-free purge gas through the sparging chamber for a period of 4 minutes at ~70 cc/min. Water vapor was removed from the purge gas while passing through a short tube of magnesium perchlorate dessicant. The sample gases were concentrated on a cold-trap consisting of a 3-inch section of 1/8-inch stainless steel tubing packed with Porapak C and Porapak T (60-80 mesh) immersed in a bath of isopropanol held at -20 degrees C. After 4 minutes of purging the seawater sample, the sparging chamber was closed and the trap isolated. The trap was then heated to 100 degrees C. The sample gases held in the trap were then injected onto a precolumn (12 inches of 1/8-inch O.D. stainless steel tubing packed with 80-100 mesh Porasil C, held at 90 degrees C), for the initial separation of the CFCs and other rapidly eluting gases from more slowly eluting compounds. The CFCs then passed into the main analytical column (10 feet, 1/8-

inch stainless steel tubing packed with Porasil C 80-100 mesh, held at 90 degrees C), and then into the EC detector.

The CFC analytical system was calibrated frequently using standard gas of known CFC composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, precolumn, main chromatographic column and EC detector were similar to those used for analyzing water samples. Two sizes of gas sample loops were present in the analytical system. Multiple injections of these loop volumes could be done to allow the system to be calibrated over a relatively wide range of CFC concentrations. Air samples and system blanks (injections of loops of CFC-free gas) were injected and analyzed in a similar manner. The typical analysis time for a seawater, air, standard or blank sample was about 12 minutes.

Concentrations of CFC-11 and CFC-12 in air, seawater samples and gas standards are reported relative to the SIO93 calibration scale (Cunnold, et. al., 1994). CFC concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts-per-trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles of CFC per kg seawater (pmol/kg). CFC concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a CFC working standard (PMEL cylinder CC9944) into the analytical instrument. The concentrations of CFC-11 and CFC-12 in this working standard were calibrated before and after the cruise versus a primary standard (36743) (Bullister, 1984). No measurable drift in the concentrations of CFC-11 and CFC-12 in the working standard could be detected during this interval. Full range calibration curves were run at intervals of 1-2 days during the cruise. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of 1 to 2 hours) to monitor short term changes in detector sensitivity. Sample loops filled with CFC-free gas, and syringe samples of CFC-free water (degassed in a specially designed glass chamber) were also run to check sampling and analytical blanks.

Previous studies of time-dependent tracers in this region of the North Pacific indicate that water at density  $\sigma_0 > 27.4$  should have near-zero CFC concentrations during the time of the expedition. CFC-12 concentrations measured in deep samples along the section were typically at or near the detection limit ( $< 0.005$  pmol/kg) of the analytical system. Blank corrections have been applied to the dissolved CFC-12 concentrations at 3 of the stations reported in the P16N.sea file (see table below). Typical CFC-11 concentrations measured in deep samples along the section had a median value of about 0.007 pmol/kg.

The following table summarizes the blank corrections applied to the CFC measurements made during the expedition.

Station	CFC-11 blank correction (pmol/kg)	CFC-12 blank correction (pmol/kg)
15	0.015	0
16	0.006	0.005
17-20	0.006	0
21-22	0.010	0
23-25	0.006	0
26-27	0.000	0
28-31	0.007	0
32-38	0.000	0
39-42	0.004	0
43	0.007	-0.003
44-55	0.004	0
56-57	0.006	0
58	0.016	0
59-64	0.004	0
65	0.004	-0.002

We attribute the persistent non-zero CFC-11 blank signal to a combination of slow release of CFC-11 from the walls and O-rings of the 10 liter bottles into the seawater samples, contamination during the transfer and storage of the seawater samples in glass syringes prior to analysis and, most importantly, from contamination events due to the discharges from the ship.

A number of water samples had unexpectedly high CFC-11 and/or CFC-12 concentrations relative to adjacent samples. These anomalous samples appeared to occur more or less randomly during the cruise, and were not clearly associated with other features in the water column (e.g. elevated oxygen concentrations, salinity or temperature features, etc.). This suggests that the high values were due to individual, isolated CFC contamination events. A number of seawater samples were severely contaminated with CFC-11 during the first (non-WHP) leg of this expedition, especially at Stations 6-8. The sudden appearance of high and variable CFC-11 concentrations in deep samples at Sta. 8 may have been due to the inadvertent discharge of wastewater from the ship which occurred at the start of the hydrocast at this station. At several stations along Leg 2, CFC-11 concentrations significantly higher than the mean blank values were measured in some deep samples. We attribute this to sporadic CFC-11 contamination of the 10 liter bottles, possibly due to contact of the bottles with an oil slick from the ship at the start of the casts. Throughout the cruise, the exhaust stacks of R/V Discoverer emitted a large amount of soot and oil onto the working area of the ship's fantail. Although precautions were taken to shield the rosette and bottles from direct deposition of this material, an oily surface film was sometimes observed in the water as the rosette was lowered on station. Some of the

sporadic CFC-11 contamination observed during Leg 2 could have resulted from deposition of trace amounts of material on the inside of the bottles as the rosette descended through the surface layer. Measured concentrations for these anomalously high samples are included in this report, but are given a quality flag of 4 (bad measurement). The CFC-11/CFC-12 ratio for each sample was checked for consistency, and compared to CFC-11/CFC-12 ratios from samples above and below it in the profile, and to samples from adjacent stations. A quality flag of 3 (questionable) was applied to some CFC-11 and/or CFC-12 measurements which had an anomalous CFC-11/CFC-12 ratios and/or concentrations relative to surrounding samples. If one of the two gases was clearly anomalous, that gas was given the questionable flag. In some cases both gases were flagged as questionable.

A total ~208 analyses of CFC-11 were assigned a flag of 3 and ~120 analyses of CFC-12 were assigned a flag of 3. A total of ~215 analyses of CFC-11 were assigned a flag of 4 and 59 CFC-12 samples assigned a flag of 4. On this expedition, we estimate overall precisions (1 standard deviation) of about 1% or 0.005 pmol/kg (whichever is greater) for dissolved CFC-11 and 2% or 0.005 pmol/kg (whichever is greater) for dissolved CFC-12 measurements (see listing of replicate samples given at the end of this report).

CFC samples from stations 1-13 and Sta 15 are not included in this report. A value of -9.0 is used for missing values in the listings.

In addition to the file of mean CFC concentrations included in the P16N.sea file, tables of the following are included in this report:

Table 1a. P16N Replicate dissolved CFC-11 analyses

Table 1b. P16N Replicate dissolved CFC-12 analyses

Table 2. P16N CFC air measurements

Table 3. P16N CFC air measurements interpolated to station locations

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Table 1a P16N Replicate dissolved CFC-11 Analyses

STN #	SAMP NO.	F11 pM/kg	F11 Stdev
8	1106	3.900	0.004
10	1518	3.152	0.034
13	2206	-0.001	0.003
17	2616	1.988	0.001
19	2917	2.390	0.027
21	3218	2.252	0.021
22	3412	2.368	0.004
23	3523	2.169	0.010
24	3621	2.151	0.009
30	4416	0.177	0.010
32	4724	2.555	0.011
34	5001	2.222	0.019
35	5120	1.406	0.014
37	5308	2.398	0.023
42	5919	3.091	0.081
43	6018	0.689	0.003
43	6019	1.444	0.013
44	6114	2.762	0.006
44	6115	2.777	0.024
45	6218	0.789	0.003
48	6604	0.480	0.008
49	6714	0.664	0.015
50	6816	0.210	0.005
50	6822	3.973	0.014
51	6913	0.657	0.004
51	6922	4.209	0.012
52	7010	0.528	0.002
54	7324	4.396	0.067
56	7613	0.144	0.008
57	7721	1.310	0.001
58	7820	1.666	0.057
59	7914	0.053	0.004
59	7924	5.273	0.048
60	8101	0.316	0.004
60	8107	1.136	0.013
65	8616	0.282	0.001
66	8719	1.064	0.001

Table 1b P16N Replicate dissolved CFC-12 Analyses

STN #	SAMP NO.	F12 pM/kg	F12 Stdev
8	1106	1.831	0.000
10	1518	1.642	0.046
11	1814	0.001	0.003
12	1902	0.095	0.002
13	2206	0.003	0.000
19	2917	1.192	0.009
21	3218	1.170	0.013
22	3401	0.003	0.005
22	3412	1.242	0.009
23	3523	1.150	0.017
24	3621	1.156	0.002
30	4416	0.088	0.003
32	4724	1.339	0.013
34	4907	0.000	0.000
34	5001	1.090	0.000
35	5120	0.686	0.002
37	5308	1.209	0.024
42	5919	1.546	0.015
43	6018	0.328	0.003
43	6019	0.678	0.009
44	6114	1.362	0.001
44	6115	1.376	0.007
45	6218	0.365	0.002
48	6604	0.217	0.005
49	6714	0.310	0.001
50	6816	0.098	0.006
50	6822	1.947	0.081
51	6913	0.300	0.003
51	6922	2.085	0.000
52	7010	0.246	0.004
54	7319	0.323	0.011
54	7324	2.165	0.006
56	7613	0.067	0.001
57	7721	0.610	0.003
58	7820	0.790	0.001
59	7914	0.029	0.002
59	7924	2.584	0.014
60	8101	0.151	0.000
60	8107	0.521	0.000
65	8616	0.143	0.004
66	8719	0.490	0.001

Table 2. P16N CFC Air Measurements:

Leg 1

Date	Time (hhmm)	Latitude	Longitude	F11 PPT	F12 PPT
17 Feb 91	1621	49 00.0 N	135 00.0 W	266.0	502.3
17 Feb 91	1631	49 00.0 N	135 00.0 W	266.0	499.1
17 Feb 91	1645	49 00.0 N	135 00.0 W	267.3	500.2
19 Feb 91	0535	46 55.8 N	135 26.9 W	265.1	501.6
19 Feb 91	0545	46 55.8 N	135 26.9 W	264.8	502.0
19 Feb 91	0601	46 55.8 N	135 26.9 W	264.6	500.5
19 Feb 91	0611	46 55.8 N	135 26.9 W	264.3	503.1
21 Feb 91	0516	44 34.0 N	135 02.0 W	263.4	499.2
21 Feb 91	0527	44 34.0 N	135 02.0 W	263.1	497.3
21 Feb 91	0538	44 34.0 N	135 02.0 W	263.0	499.6
21 Feb 91	0551	44 34.0 N	135 02.0 W	263.2	501.7
24 Feb 91	2138	32 22.7 N	138 36.6 W	262.4	501.0
24 Feb 91	2151	32 22.7 N	138 36.6 W	262.5	501.2
24 Feb 91	2204	32 22.7 N	138 36.6 W	262.6	498.1
24 Feb 91	2216	32 22.7 N	138 36.6 W	262.7	499.9
24 Feb 91	2229	32 22.7 N	138 36.6 W	263.0	500.1
25 Feb 91	0619	32 22.7 N	138 36.6 W	262.4	497.7
25 Feb 91	0703	32 22.7 N	138 36.6 W	261.1	496.6
25 Feb 91	0714	32 22.7 N	138 36.6 W	262.4	496.8
25 Feb 91	1712	29 31.2 N	142 20.8 W	262.2	503.3
25 Feb 91	1725	29 31.2 N	142 20.8 W	262.9	504.1
25 Feb 91	1738	29 31.2 N	142 20.8 W	263.3	503.7
25 Feb 91	1750	29 31.2 N	142 20.8 W	263.5	503.7
25 Feb 91	1802	29 31.2 N	142 20.8 W	263.8	503.7
26 Feb 91	0121	28 42.3 N	143 25.6 W	257.3	491.4
26 Feb 91	0133	28 42.3 N	143 25.6 W	259.6	491.6
26 Feb 91	0145	28 42.3 N	143 25.6 W	258.7	492.5
26 Feb 91	0157	28 42.3 N	143 25.6 W	262.2	491.3
26 Feb 91	0209	28 42.3 N	143 25.6 W	266.2	496.5
26 Feb 91	0820	27 51.0 N	144 30.0 W	263.3	503.3
26 Feb 91	0831	27 51.0 N	144 30.0 W	263.9	502.1
26 Feb 91	0843	27 51.0 N	144 30.0 W	263.3	502.1
26 Feb 91	0937	27 51.0 N	144 30.0 W	264.4	501.6
27 Feb 91	2254	27 51.0 N	144 30.0 W	262.1	500.6
27 Feb 91	2306	27 51.0 N	144 30.0 W	262.6	502.0
27 Feb 91	2319	27 51.0 N	144 30.0 W	261.6	500.6
27 Feb 91	2331	27 51.0 N	144 30.0 W	262.0	502.5
27 Feb 91	2343	27 51.0 N	144 30.0 W	262.2	501.9
11 Mar 91	0355	22 40.0 N	152 00.0 W	-9.0	-9.0
11 Mar 91	0439	22 40.0 N	152 00.0 W	265.9	-9.0
11 Mar 91	0451	22 40.0 N	152 00.0 W	268.7	-9.0
11 Mar 91	0503	22 40.0 N	152 00.0 W	268.0	-9.0
11 Mar 91	0546	22 40.0 N	152 00.0 W	262.1	497.8
14 Mar 91	1210	27 42.7 N	151 59.7 W	265.2	502.5
14 Mar 91	1221	27 42.7 N	151 59.7 W	264.0	502.2
14 Mar 91	1233	27 42.7 N	151 59.7 W	264.8	500.9
14 Mar 91	1245	27 42.7 N	151 59.7 W	264.4	501.6
14 Mar 91	1259	27 42.7 N	151 59.7 W	264.8	501.2
15 Mar 91	0733	28 40.0 N	152 00.0 W	261.8	500.2
15 Mar 91	0746	28 40.0 N	152 00.0 W	263.0	499.2

## Leg 1

Date	Time (hhmm)	Latitude	Longitude	F11 PPT	F12 PPT
15 Mar 91	0760	28 40.0 N	152 00.0 W	263.9	504.1
16 Mar 91	1700	28 40.0 N	152 00.0 W	262.4	503.0
16 Mar 91	1712	28 40.0 N	152 00.0 W	263.2	502.8
16 Mar 91	1724	28 40.0 N	152 00.0 W	263.7	503.2
16 Mar 91	1736	28 40.0 N	152 00.0 W	267.0	507.2
16 Mar 91	1748	28 40.0 N	152 00.0 W	265.7	502.4
17 Mar 91	1710	32 08.6 N	152 00.1 W	261.4	502.0
17 Mar 91	1721	32 08.6 N	152 00.1 W	264.4	501.6
17 Mar 91	1733	32 08.6 N	152 00.1 W	263.8	501.3
17 Mar 91	1745	32 08.6 N	152 00.1 W	263.2	500.2
17 Mar 91	1759	32 08.6 N	152 00.1 W	264.5	501.3
20 Mar 91	0633	32 08.6 N	152 00.1 W	265.2	502.7
20 Mar 91	0645	32 08.6 N	152 00.1 W	-9.0	-9.0
20 Mar 91	0657	32 08.6 N	152 00.1 W	264.4	501.9
20 Mar 91	0709	32 08.6 N	152 00.1 W	263.6	503.0
22 Mar 91	1205	40 16.9 N	152 00.7 W	263.4	500.5
22 Mar 91	1217	40 16.9 N	152 00.7 W	266.5	501.6
22 Mar 91	1233	40 16.9 N	152 00.7 W	264.5	500.9
22 Mar 91	1245	40 16.9 N	152 00.7 W	265.0	499.3
22 Mar 91	1257	40 16.9 N	152 00.7 W	266.2	499.1
23 Mar 91	1020	40 16.9 N	152 00.7 W	266.4	506.2
23 Mar 91	2039	41 59.9 N	151 59.5 W	264.7	503.7
23 Mar 91	2051	41 59.9 N	151 59.5 W	267.9	504.2
23 Mar 91	2103	41 59.9 N	151 59.5 W	267.4	504.5
23 Mar 91	2115	41 59.9 N	151 59.5 W	265.6	505.2
23 Mar 91	2127	41 59.9 N	151 59.5 W	267.6	507.3
24 Mar 91	1104	42 48.9 N	151 57.2 W	-9.0	504.0
24 Mar 91	1116	42 48.9 N	151 57.2 W	268.3	504.6
24 Mar 91	1805	43 20.0 N	152 00.0 W	268.4	503.4
24 Mar 91	1817	43 20.0 N	152 00.0 W	268.4	504.4
24 Mar 91	1828	43 20.0 N	152 00.0 W	-9.0	501.2
24 Mar 91	1840	43 20.0 N	152 00.0 W	269.5	500.6
27 Mar 91	0343	49 09.0 N	152 00.0 W	267.1	504.3
27 Mar 91	0356	49 09.0 N	152 00.0 W	269.0	503.8
27 Mar 91	0408	49 09.0 N	152 00.0 W	268.5	505.8
29 Mar 91	0804	53 10.0 N	150 29.0 W	266.4	503.0
29 Mar 91	0816	53 10.0 N	150 29.0 W	263.2	503.1
29 Mar 91	0833	53 10.0 N	150 29.0 W	262.4	504.1
29 Mar 91	0845	53 10.0 N	150 29.0 W	261.5	503.9
30 Mar 91	1718	55 26.7 N	152 35.9 W	267.1	504.5
30 Mar 91	1729	55 26.7 N	152 35.9 W	267.8	504.4
30 Mar 91	1741	55 26.7 N	152 35.9 W	268.4	506.7
30 Mar 91	1753	55 26.7 N	152 35.9 W	268.1	503.6
30 Mar 91	1804	55 26.7 N	152 35.9 W	268.0	505.1
1 Apr 91	1219	55 26.7 N	152 35.9 W	259.3	499.8
1 Apr 91	1232	55 26.7 N	152 35.9 W	262.4	503.7
1 Apr 91	1244	55 26.7 N	152 35.9 W	264.8	499.2
1 Apr 91	1300	55 26.7 N	152 35.9 W	264.5	498.5
2 Apr 91	1134	55 26.7 N	152 35.9 W	267.2	503.4
2 Apr 91	1146	55 26.7 N	152 35.9 W	267.9	504.9
2 Apr 91	1158	55 26.7 N	152 35.9 W	269.7	500.7
2 Apr 91	1210	55 26.7 N	152 35.9 W	267.9	502.2

Table 3. P16N CFC Air values (interpolated to station locations)

STN #	Latitude	Longitude	Date	F11 PPT	F12 PPT
1	48 50.0 N	127 39.4 W	16 Feb 91	265.4	501.3
2	50 00.2 N	134 59.8 W	17 Feb 91	265.4	501.3
3	48 59.7 N	134 59.5 W	17 Feb 91	265.4	501.3
4	47 59.6 N	134 59.4 W	18 Feb 91	265.4	501.3
5	46 59.3 N	134 59.8 W	19 Feb 91	264.6	500.6
6	46 00.0 N	134 59.9 W	20 Feb 91	263.9	500.6
7	45 00.2 N	135 00.2 W	20 Feb 91	263.9	500.6
8	43 59.4 N	134 59.4 W	21 Feb 91	263.9	500.6
9	42 00.3 N	134 59.7 W	22 Feb 91	263.9	500.6
10	39 59.8 N	134 59.9 W	23 Feb 91	263.9	500.6
11	36 59.4 N	134 59.4 W	23 Feb 91	262.4	498.9
12	35 00.1 N	135 00.1 W	24 Feb 91	262.4	498.9
13	21 20.1 N	152 50.5 W	28 Feb 91	262.8	501.8
14	20 55.4 N	153 47.9 W	1 Mar 91	262.8	501.8
15	19 53.3 N	154 55.3 W	8 Mar 91	265.3	501.0
16	20 04.0 N	154 40.5 W	8 Mar 91	265.0	500.9
17	20 23.8 N	154 14.2 W	8 Mar 91	265.3	501.0
18	20 42.5 N	153 46.0 W	9 Mar 91	265.3	501.0
19	21 36.8 N	152 26.2 W	10 Mar 91	265.3	501.0
20	21 54.9 N	151 60.0 W	10 Mar 91	265.3	501.0
21	22 40.6 N	151 59.5 W	11 Mar 91	264.6	502.0
22	24 00.2 N	151 58.0 W	12 Mar 91	265.3	501.0
23	24 39.9 N	152 00.2 W	12 Mar 91	265.3	501.0
24	25 20.2 N	151 59.7 W	13 Mar 91	265.3	501.0
25	26 00.2 N	151 60.0 W	13 Mar 91	264.2	502.3
26	26 39.9 N	152 00.0 W	14 Mar 91	264.2	502.3
27	27 20.0 N	151 59.9 W	14 Mar 91	264.2	502.3
28	27 60.0 N	151 59.7 W	15 Mar 91	264.2	502.3
29	28 39.8 N	151 59.9 W	15 Mar 91	264.2	502.3
30	29 20.7 N	151 58.3 W	16 Mar 91	263.8	502.8
31	29 60.0 N	152 00.5 W	16 Mar 91	263.8	502.8
32	30 39.9 N	151 59.5 W	17 Mar 91	263.8	502.3
33	31 20.1 N	152 00.1 W	17 Mar 91	263.8	501.8
34	32 10.5 N	152 00.6 W	18 Mar 91	263.8	501.8
35	32 40.0 N	152 00.1 W	18 Mar 91	263.8	501.8
36	33 20.0 N	152 00.0 W	18 Mar 91	263.8	501.8
37	34 00.1 N	152 00.1 W	19 Mar 91	263.8	501.8
39	35 36.5 N	152 00.4 W	20 Mar 91	263.8	501.8
40	36 17.7 N	152 02.7 W	20 Mar 91	265.4	501.3
41	37 09.9 N	151 57.6 W	21 Mar 91	265.4	501.3
42	37 59.9 N	152 00.0 W	21 Mar 91	265.4	501.3
43	38 40.2 N	151 59.9 W	22 Mar 91	265.4	501.3
44	39 21.0 N	151 59.2 W	22 Mar 91	265.4	501.3
45	40 00.9 N	151 59.6 W	22 Mar 91	265.4	501.3
46	40 40.5 N	152 01.3 W	23 Mar 91	265.4	501.3
47	41 21.0 N	152 00.3 W	23 Mar 91	266.7	503.0
48	41 59.6 N	151 59.1 W	24 Mar 91	266.9	504.8
49	42 40.8 N	151 58.5 W	24 Mar 91	267.5	503.9
50	43 20.0 N	151 59.6 W	24 Mar 91	267.5	503.9
51	44 25.1 N	151 59.8 W	25 Mar 91	267.5	503.9
52	45 00.1 N	151 59.0 W	25 Mar 91	267.5	503.9

STN				F11	F12
#	Latitude	Longitude	Date	PPT	PPT
---	-----	-----	-----	-----	-----
53	45 41.1 N	151 59.6 W	26 Mar 91	267.7	504.1
54	46 20.2 N	151 59.3 W	26 Mar 91	268.5	503.6
55	47 00.0 N	152 00.0 W	27 Mar 91	268.5	503.4
56	47 39.9 N	152 00.4 W	27 Mar 91	268.5	503.6
57	48 19.5 N	152 00.3 W	27 Mar 91	266.4	503.4
58	53 29.7 N	152 00.1 W	30 Mar 91	265.7	503.0
59	54 39.6 N	151 59.8 W	30 Mar 91	266.4	502.8
60	55 27.1 N	152 33.5 W	31 Mar 91	266.4	502.8
61	55 51.9 N	152 55.7 W	31 Mar 91	266.4	502.8
62	56 01.6 N	153 02.7 W	31 Mar 91	266.4	502.8
63	56 14.5 N	153 10.8 W	1 Apr 91	266.4	502.8
64	56 17.7 N	153 14.0 W	1 Apr 91	266.4	502.8
65	55 04.2 N	152 17.9 W	1 Apr 91	266.4	502.8
66	52 29.4 N	152 01.2 W	2 Apr 91	265.7	503.0

**B.6 DIC and pH:**  
(Marilyn F. Roberts)

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<http://www.pmel.noaa.gov/co2/co2-home.ht>

Additional details on the analytical techniques and data processing are available from the individual PIs, and from the Carbon Dioxide Information Analysis Center (CDIAC):  
<http://cdiac.esd.ornl.gov/about/intro.html>

**B.6.a Total dissolved inorganic carbon (TCO<sub>2</sub>)**

The TCO<sub>2</sub> concentration of seawater samples was determined by using the coulometric titration system (UIC Inc., Model 5011) described by Johnson et al. (1985, 1987). The standards used were Na<sub>2</sub>CO<sub>3</sub> in a matrix of 0.7M KCl, and were analyzed daily. The batch of CRMs (Dr. Andrew Dickson, SIO) that was shipped for our cruise was not stable and we were not able to use them as reference materials. Batch 1 CRMs had been used on a previous cruise by our group. We were therefore able to reference our cruise data to Batch 1 CRMs by means of a non-certified seawater standard that had been collected on both cruises which gave similar results. Batch 1 CRM shipboard measurements yielded a mean value of 2017.0 +/- 2.5 μmol/kg (n=25), which compares with 2020.2 +/- 0.8 μmol/kg (n=12) certified by SIO. Data reported for this cruise have been corrected to the Batch 1 CRM value by adding the difference between the certified value and the mean shipboard CRM value (certified value - shipboard analyses). Seawater samples for TCO<sub>2</sub> analysis were drawn from the Niskin-type samplers into 500mL borosilicate glass bottles and poisoned with 100uL of HgCl<sub>2</sub>. The samples were sealed with ground-glass stoppers coated with Type M Apiezon grease, and stored in a cooled environment before analysis (usually within 12 hours after collection). The sample was introduced into a calibrated, thermostated (25C) pipette (~50mL), and then transferred to the extraction vessel and acidified with 4.5 ml of 10% phosphoric acid (previously stripped of CO<sub>2</sub>). The evolved CO<sub>2</sub> gas passed through an Orbo-53 tube to remove volatile acids other than CO<sub>2</sub> and then into the titration cell of the coulometer by the N<sub>2</sub> carrier gas. In the coulometric analysis of TCO<sub>2</sub>, all carbonate species are converted to CO<sub>2</sub> (g) by addition of excess hydrogen to the seawater sample. The evolved CO<sub>2</sub> gas is carried into the titration cell of the coulometer, where it reacts quantitatively with a proprietary reagent based on ethanolamine to generate hydrogen ions. These are subsequently titrated with coulometrically generated OH<sup>-</sup>. CO<sub>2</sub> is thus measured by integrating the total charge required to achieve this. The entire sequence takes between 8 to 11 minutes. All reagents in the extraction/analytical system were renewed daily.

### **B.6.b pH**

Sample cells (10-cm pathlength spectrophotometric cells, 30-cm<sup>3</sup> volume) were filled directly from the Niskin<sup>TM</sup>-type bottle using a 20-cm length of silicone tubing. A flushing volume of approximately 300 mL was used. Care was taken to eliminate bubbles from the sampling system, and the sample cell was sealed with PTFE caps while ensuring that there was no head space. All spectrophotometric pH measurements were made using the indicator m-Cresol Purple. Spectrophotometric cells were warmed to 25°C within the water bath of a refrigerated thermocirculator. Subsequently cells were cleaned and placed in the thermostated sample compartment of the spectrophotometer. Absorbance measurements were made at three wavelengths: a non-absorbing wavelength (730 nm) and wavelengths corresponding to the absorbance maxima of the alkaline (I<sup>2</sup>-, 578 nm) and acidic (HI-, 434 nm) forms of the indicator. Subsequently, one of the cell caps was removed and 0.08 cm<sup>3</sup> of concentrated indicator (2 μmol/cm<sup>3</sup>) was injected into the cell. The cell was capped, rapidly mixed and returned to the thermostated cell. Absorbance measurements were again made at 730 nm, 578 nm and 434 nm. Sample pH was then calculated using the equations and procedures of Clayton and Byrne (1993). The "total" pH scale is used, and pHT is reported in mol/kg of seawater.

### **References**

- Clayton T. and Byrne, R. H., 1993. Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results., *Deep Sea Res.*, 40, 2115-2129.
- Johnson, K.M., A.E. King, and J. McN. Sieburth (1985): Coulometric DIC 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, 117-133.

**B.7 Tritium-helium data were not available at the time of this report.**

## **C. Data Quality Evaluations**

### **C.1 Data Quality Evaluation of Hydrographic Data**

(A. Mantyla)

5 April 1993

This report is an assessment of the hydrographic data taken along WOCE line P16N by the Discoverer Cr CGC91/2 in Feb.-Apr. 1991. The cruise essentially repeats the section done by the Marathon II Expedition in May-June 1984 (OSU Ref. 87-15). Unfortunately, neither cruise achieved WOCE goals for water column sampling either in the vertical or horizontally. Marathon had deep station spacing usually at 40 nm intervals and deep bottle spacing no closer than 500 m (but their planned objectives were accomplished). The Discoverer cruise was considerably less successful. Many stations were cancelled because of bad weather, and many other stations failed to collect sufficient water sample data due to frequent rosette trip failures. The cruise did tend to support some of the interesting abyssal silicate structure seen on Marathon, but did not add any new information or better confirmation that the WOCE sampling strategy of 200 to 300 m deep bottle spacing could have provided. The cruise must have been a disappointment to the PIs. They have clearly worked hard to sort out the mis-trips and to identify the correct trip depths for each of the rosette bottles. The analytical work was also good, I saw no significant systematic differences between this cruise and Marathon, nor with cruise TPS24 and TPS47.

A large number of bottle numbers were flagged "4" (did not trip correctly) due to mis-trips or double-trips causing subsequent planned trips to be off by one or more target depths. When this occurs, it becomes a data processing challenge to sort out the correct CTD pressure and temperature to assign to the rosette bottle water sample data. Comparisons of the water sample salinity and oxygen measurements with the CTD info is usually sufficient to match the correct CTD trip data to the water sample data with a reasonable degree of certainty, and the data originators have done that quite well for this cruise. I have not changed any of their '4' flags, although my own inclination would have been to flag far fewer bottles for the following reasons: the initial mis-trip or double-trip represents a missed planned sampling depth and could even be a trip between planned depths and should be flagged as a problem. However, the subsequent trips are usually routine or normal, except that the initial CTD information assigned to the trip is incorrect. Once the correct trip info has been aligned with the water sample data, there really is little question as to the correctness of the data, and my own preference would be to accept those levels as OK. However, I'll leave it up to the WHP office and the data originators to decide on what convention to use.

An unusual number of bottle salinities were flagged as questionable. Apparently any deep salinity that differed by more than .003 from the "corrected" CTD salinity was flagged. Since there was a slight bias between the corrected CTD and the salinometer salinities (CTD usually higher), an excessive number of measured salinities appeared to be too far off. I accepted most of the deep salts as OK, although there was some station to station

wobble that probably is not real, presumably due to slight differences in salinometer standardizations or vial to vial variations in Standard Seawater.

Larger salinity differences that are often seen in regions of strong vertical salinity gradients may be due to a different sort of problem. Each type of sampling bottle has its' own characteristic "flushing length" (Weiss, DSR 18:653-656) and requires a finite time to collect a sample representative of the intended sampling depths. CTD console operators often trip bottles nearly on the fly, hardly pausing at the desired sampling depth, so the rosette bottle is apt to have water entrained from deeper in the water column. The measured salinity can accurately represent the water contained by the rosette bottle, yet differ substantially from the instantaneous CTD measurement. Both measurements can be correct, though different when the water sample is smeared out somewhat in depth. The problem is only apparent in regions of strong salinity gradients, but can exist elsewhere in low salinity gradients that have high gradients of some other property. Since this is a problem common to rosette casts (wire casts have sufficient time to thoroughly flush before being tripped by messenger), I tend to be more accepting of halocline salinities and have flagged many then as OK. To be rigorously correct, if the incompletely flushed bottle salinity is flagged questionable, so should all of the other measurements for that depth. At any rate, it's a tough call.

I didn't notice any mention of which batch of IAPSO SSW was used. Post-cruise intercomparisons of different batches sometimes reveal systematic differences from the labeled values for the batch, which would result in systematic errors in the cruise salinities. That sort of error is correctable, if the SSW batch number used is known.

ODF noted the reported temperatures are in the IPTS-68 scale. If they haven't been converted to the ITS-90 scale yet, they should be.

There were a surprising number of odd oxygens. Some look like errors in flask identification (each has a different volume). I suspect station 23, deepest 4 is such a problem, perhaps a little detective work could salvage them.

I suspect that the oxygens below about 2500m on station 25 were listed one depth too shallow but without CTD oxygen probe data for verification, can't be sure. I have not flagged the data as doubtful, but if the data originator did, I would agree.

For future reference, oxygen analytical blanks should be done in distilled water, not seawater (Culberson, WOCE Rep. 68/91). Seawater blanks, to be done properly, would have to be run on every sample. The error is slight however, probably less than 1m m/kg.

The report indicates that the oxygen conversion to per kilogram units was done using sigma-theta, assuming that the oxygen sample was drawn at the potential temperature. Experience on a recent WOCE cruise where the oxygen draw temperature was measured and recorded indicated that the proper temperature for density of the sample at the time it was fixed is commonly several degrees warmer than the potential temperature. Use of the in-situ temperature would have been a better guess than the potential temperature.

However, not knowing the correct temperature for volume to mass conversion results is an error of only about 0.2% (twice the analytical sensitivity).

On station 18, salinity sample numbers 2807 to 2809 appear to belong one depth deeper. However, this station was a bust with no other water sample data reported, so it only matters if it affects the CTD calibration.

On Station 21, the 100db water sample data appears to belong one depth shallower. I have flagged all of the data questionable for that depth, but if they were moved up, they would look OK.

On Station 55, the first trip at 648db appears to belong to about 700db. Was there an attempt to trip this bottle at 700db? If so, the data would be acceptable at that level. I've tentatively flagged the bottle number and all water sample data as questionable.

On Station 57, there appears to be some serious sample drawing errors. The salinity samples at 500 and 600db definitely belong one depth shallower, but the O<sub>2</sub>'s and nutrients do not. The oxygen and nutrient samples at 1250, 1500, 1750 and 2250db (2nd trip) appear to belong one depth shallower (the 1250 at an unlisted pressure of about 1000db), but the salinity samples are OK as listed! Without outright data fudging I see no way to fix the problems, so I've flagged the doubtful data. Perhaps careful examination of the original data sheets could uncover the errors.

The nutrient data appears to be of uniformly high quality; what is lacking are good resolution profiles. The nutrient data can show features that are not seen by the continuous CTD traces, so it is sad so much nutrient data was lost, particularly for the northern part of the cruise.

As someone who has gotten beaten to hell trying to work in the Gulf of Alaska in February, I can commiserate with the Discoverer's scientific parties efforts to work in that region not just once, but twice without success in the winter. My last cruise also suffered because it was scheduled in the wrong season. P16S could only get to about 62S because sea ice was still near its maximum northern extent. Rosette trip problems also plagued our cruise, but we had sufficient ship time, people and spares to effect repairs as needed (one station lost). The rosette trip problems definitely need to be resolved to everyone's benefit.

## C.2 Data Quality Comments on CTD Data

(Robert Millard)

April 16, 1993

Two data sources have been looked at in quality controlling the CTD data of P16N (\_\_\_\_.HY2 and to a lesser degree the individual \_\_\_\_WTC files), The cruise report has good information on laboratory and at-sea calibrations performed on the CTD data set although a reference describing the calibration and standardization methods used by the Northwest Regional Calibration-Center would be helpful. It would also be useful to have a reference on the data processing methodology (i.e. converting the time series CTD data to a uniform pressure series, edit procedures both data glitches and pressure reversals). KO CTD oxygens were provided and therefore no assessment of CTD oxygens was performed.

The water sample data (\_\_\_\_.HY2)

The CTD and water sample salinity difference (CTD-WS) was calculated for all observation levels of the \_\_\_\_HY2 file and are plotted versus station in figure 1. In figure 1, several stations show salinity differences of .003-.004 psu (sta. 15,16,17,51, & 56) but this could be problems associated with water sample or CTD salinity. A histogram of salinity differences is shown in figure 2 with a mean difference of .0019 psu and a standard deviation of .0043 psu. A plot of the salt differences versus pressure (figure 3) shows that the scatter decreases with depth particularly below 2000 decibars. A few questionable salinities below 2000 dbars are indicated on figure 3 and the CTD salt is higher than the water sample most noticeable between 1500 and 3500 dbars. The

least squares linear fit shows that mean difference approaches the zero line at the bottom. A plot of the salt differences below 2000 decibars (figure 4) shows a smaller scatter as does the histogram for  $P > 2000$  dbars of figure 5. Again several stations (16,17,51, & 56) show salinity differences as noted earlier. The standard deviation below 2000 dbars is reduced to .0021 psu and the mean salt difference is 0.00083 psu. The CTD salinity appears to be slightly higher than the water sample salts at all depths. Aside from these small but systematic differences, the CTD conductivity (salinity) appears to be well matched to rosette water sample salinities for all stations.

The 1 decibar CTD profiles \_\_\_\_WCT

A mean profile was created on pressure surfaces for all stations and then individual profiles compared to the mean profile in order to identify questionable data values. Two edit criteria were used to flag questionable data: 1) T, S, O<sub>2</sub> variables whose difference from the mean profile exceeding 3.3 standard deviations (for all of the station data at that pressure level or density inversions where the stability parameter (E) exceeds  $-1.0 \times 10^{-4}$  per meter. Station 17 has a series of temperature values between 2675 & 280 dbars that just exceed the 3.3 standard deviation edit criteria and is probably a feature of interest. The

other questionable data involve a few slightly unstable regions (the E min = -1.0 E-04 edit criteria) A summary list stations with questionable data follows below:

File name	Pmax	E_Tot	T_err	S_err	02_err	E_err	Sd fact	E Min
0012AO01.WCT	698.0	0	0	0	0	0	3.30	-0.1000E-04
0012AO02.WCT	5269.0	0	0	0	0	0	3.30	-0.1000E-04
0015AO01.WCT	920.0	2	0	0	0	2	3.30	-0.1000E-04
0016AO01.WCT	2519.0	2	0	0	0	2	3.30	-0.1000E-04
0017AO01.WCT	1004.0	2	0	0	0	2	3.30	-0.1000E-04
0017AO02.WCT	5212.0	272	265	0	0	7	3.30	-0.1000E-04
0018AO01.WCT	5073.0	1	0	0	0	1	3.30	-0.1000E-04
0019AO01.WCT	5384.0	0	0	0	0	0	3.30	-0.1000E-04
0020AO01.WCT	307.0	2	0	0	0	2	3.30	-0.1000E-04
0020AO02.WCT	5753.0	2	0	0	0	2	3.30	-0.1000E-04
0021AO01.WCT	5489.0	4	0	0	0	4	3.30	-0.1000E-04
0022AO01.WCT	5466.0	3	0	0	0	3	3.30	-0.1000E-04
0022AO02.WCT	909.0	6	0	0	0	6	3.30	-0.1000E-04
0023AO01.WCT	5345.0	0	0	0	0	0	3.30	-0.1000E-04
0024AO01.WCT	5538.0	1	0	0	0	1	3.30	-0.1000E-04
0025AO01.WCT	603.0	3	0	0	0	3	3.30	-0.1000E-04
0025AO02.WCT	5414.0	1	0	0	0	1	3.30	-0.1000E-04
0026AO01.WCT	5486.0	2	0	0	0	2	3.30	-0.1000E-04
0027AO01.WCT	5550.0	1	0	0	0	1	3.30	-0.1000E-04
0028AO01.WCT	5530.0	2	0	0	0	2	3.30	-0.1000E-04
0028AO02.WCT	1002.0	3	0	0	0	3	3.30	-0.1000E-04
0029AO01.WCT	5645.0	4	0	0	0	4	3.30	-0.1000E-04
0030AO01.WCT	5430.0	0	0	0	0	0	3.30	-0.1000E-04
0031AO01.WCT	298.0	2	0	0	0	2	3.30	-0.1000E-04
0031AO02.WCT	5109.0	0	0	0	0	0	3.30	-0.1000E-04
0032AO01.WCT	5416.0	5	0	0	0	5	3.30	-0.1000E-04
0033AO01.WCT	5507.0	0	0	0	0	0	3.30	-0.1000E-04
0034AO01.WCT	5006.0	0	0	0	0	0	3.30	-0.1000E-04
0034AO02.WCT	393.0	1	0	0	0	1	3.30	-0.1000E-04
0035AO01.WCT	5598.0	1	0	0	0	1	3.30	-0.1000E-04
0036AO01.WCT	5516.0	1	0	0	0	1	3.30	-0.1000E-04
0037AO01.WCT	5627.0	1	0	0	0	1	3.30	-0.1000E-04
0038AO01.WCT	5724.0	0	0	0	0	0	3.30	-0.1000E-04
0039AO01.WCT	5747.0	0	0	0	0	0	3.30	-0.1000E-04
0040AO01.WCT	5651.0	0	0	0	0	0	3.30	-0.1000E-04
0041AO03.WCT	5618.0	0	0	0	0	0	3.30	-0.1000E-04
0041AO04.WCT	394.0	2	0	0	0	2	3.30	-0.1000E-04
0042AO01.WCT	5017.0	0	0	0	0	0	3.30	-0.1000E-04
0043AO01.WCT	5344.0	0	0	0	0	0	3.30	-0.1000E-04
0044AO01.WCT	5504.0	0	0	0	0	0	3.30	-0.1000E-04
0045AO01.WCT	5277.0	0	0	0	0	0	3.30	-0.1000E-04
0046AO01.WCT	5068.0	0	0	0	0	0	3.30	-0.1000E-04
0047AO01.WCT	5276.0	0	0	0	0	0	3.30	-0.1000E-04
0048AO01.WCT	5134.0	0	0	0	0	0	3.30	-0.1000E-04
0048AO04.WCT	753.0	0	0	0	0	0	3.30	-0.1000E-04
0049AO01.WCT	5206.0	0	0	0	0	0	3.30	-0.1000E-04
0050AO01.WCT	5039.0	0	0	0	0	0	3.30	-0.1000E-04
0051AO01.WCT	5254.0	0	0	0	0	0	3.30	-0.1000E-04
0052AO01.WCT	5337.0	0	0	0	0	0	3.30	-0.1000E-04
0053AO01.WCT	5333.0	0	0	0	0	0	3.30	-0.1000E-04
0053AO02.WCT	643.0	1	0	0	0	1	3.30	-0.1000E-04

File name	Pmax	E_Tot	T_err	S_err	O2_err	E_err	Sd fact	E Min
0054AO01.WCT	5454.0	0	0	0	0	0	3.30	-0.1000E-04
0055AO01.WCT	403.0	1	0	0	0	1	3.30	-0.1000E-04
0055AO04.WCT	5230.0	0	0	0	0	0	3.30	-0.1000E-04
0056AO01.WCT	5140.0	0	0	0	0	0	3.30	-0.1000E-04
0057AO01.WCT	5110.0	0	0	0	0	0	3.30	-0.1000E-04
0058AO01.WCT	4751.0	0	0	0	0	0	3.30	-0.1000E-04
0059AO01.WCT	4337.0	0	0	0	0	0	3.30	-0.1000E-04
0060A003.WCT	5244.0	1	0	0	0	1	3.30	-0.1000E-04
0060A004.WCT	402.0	0	0	0	0	0	3.30	-0.1000E-04
0061AO01.WCT	4075.0	0	0	0	0	0	3.30	-0.1000E-04
0062AO01.WCT	1941.0	0	0	0	0	0	3.30	-0.1000E-04
0053AO01.WCT	929.0	1	0	0	0	1	3.30	-0.1000E-04
0064AO01.WCT	215.0	1	0	0	0	1	3.30	-0.1000E-04
0065AO01.WCT	4167.0	0	0	0	0	0	3.30	-0.1000E-04
0066AO01.WCT	4501.0	2	0	0	0	2	3.30	-0.1000E-04

Very few questionable data were located and nearly all were slight density inversions which could be real. Station 17 has a series of temperature Values between 2700 to 2980 dbars which exceed the 3.3 std. deviation edit criteria.

Station 17 flagged temperature difference region is:

PRESS	TEMP	SALT	OXYGEN	Edit criteria			Sta. dif.			QU	E
				t-sd	S-sd		t-df	S-df			
2674.0	1.731	34.659	-9.00	0.076	0.023	0.17	0.076	0.010	0.00	2	-0.155E-06
2702.0	1.723	34.660	-9.00	0.076	0.023	0.17	0.076	0.010	0.00	2	-0.407E-06
2980.0	1.633	34.667	-9.00	0.063	0.020	0.17	0.063	0.006	0.00	2	0.282E-07

Qu error numbers: 2 = T  
4 = S 8= O2  
16 = E  
sum = combinations of errors E is the stability parameter

The mean profile shows a standard deviation of salinity of .002 psu or less below 3700 dbars indicating that the CTD data is very internally consistent in the deep water.

A spot check for down-UK salinity hysteresis was made on a couple of deeper stations (40,41, & 54). potential temperature versus salinity plot (figure 6) shows a hint that the up profile salinity (\_\_\_\_.HY2) is slightly (<0.002 psu) fresher than the down profile (\_\_\_\_.WCT).

Overall the CTD data of P16N both the water sample file and CTD data files, appears to be of good quality both with respect to calibration and removal of erroneous data.

Figure 1

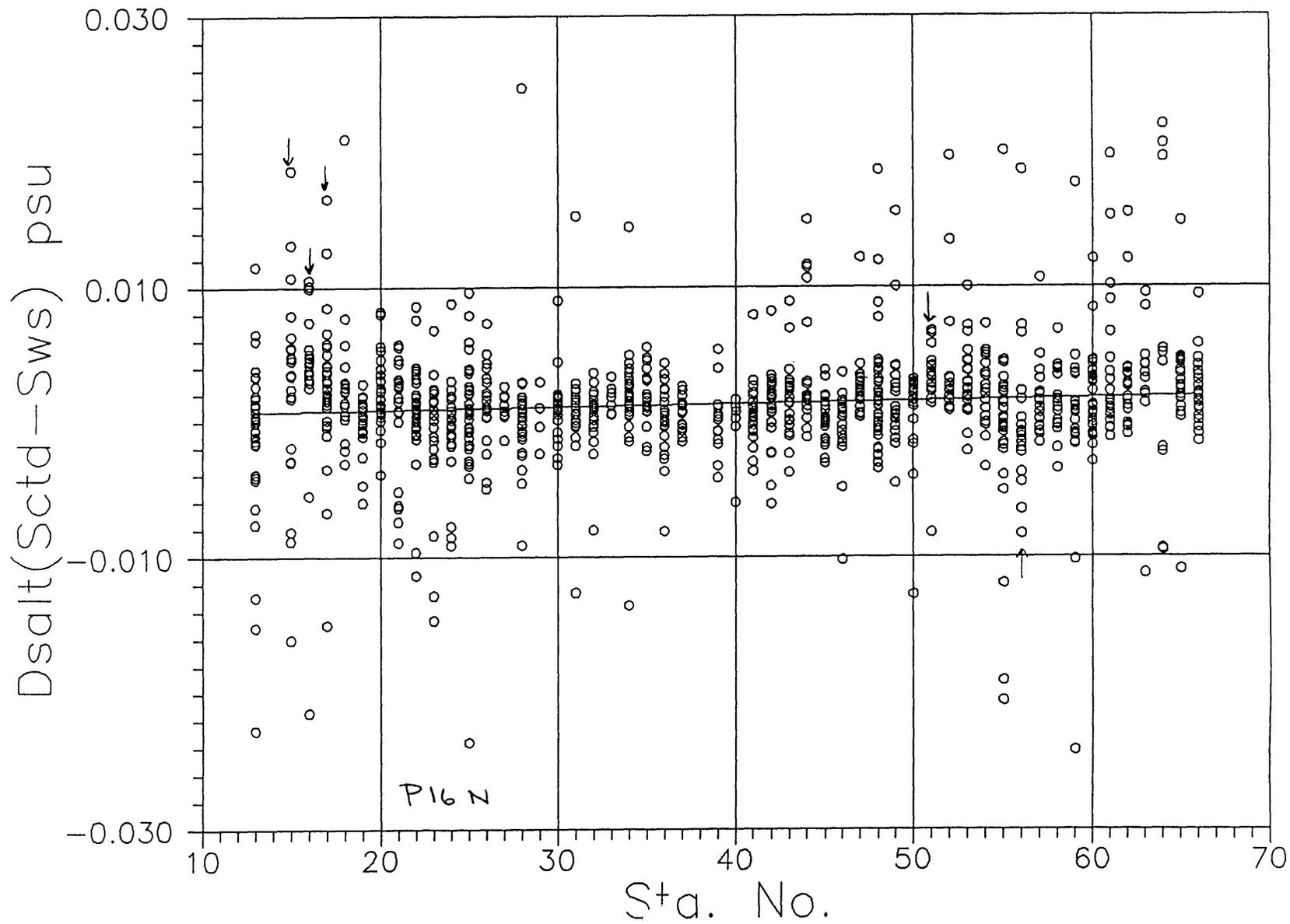


Figure 2

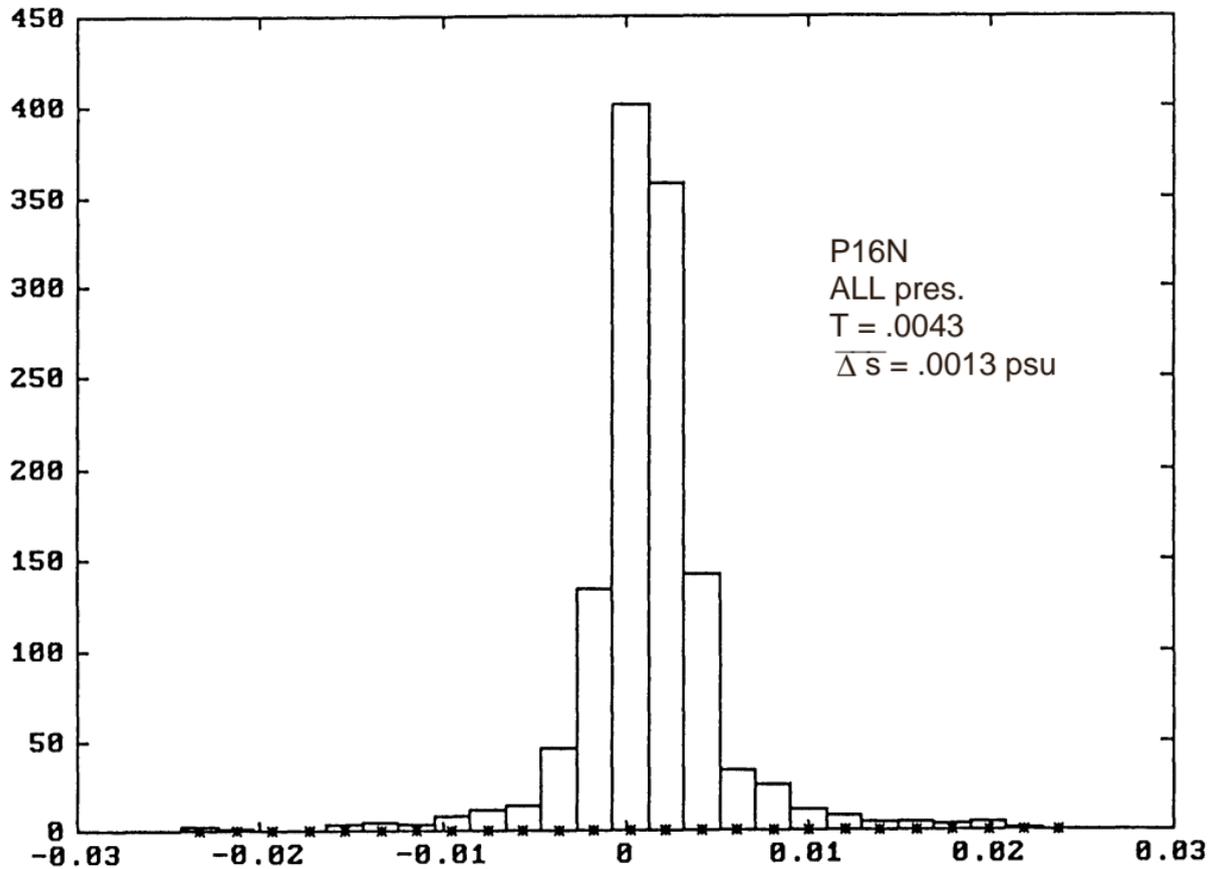
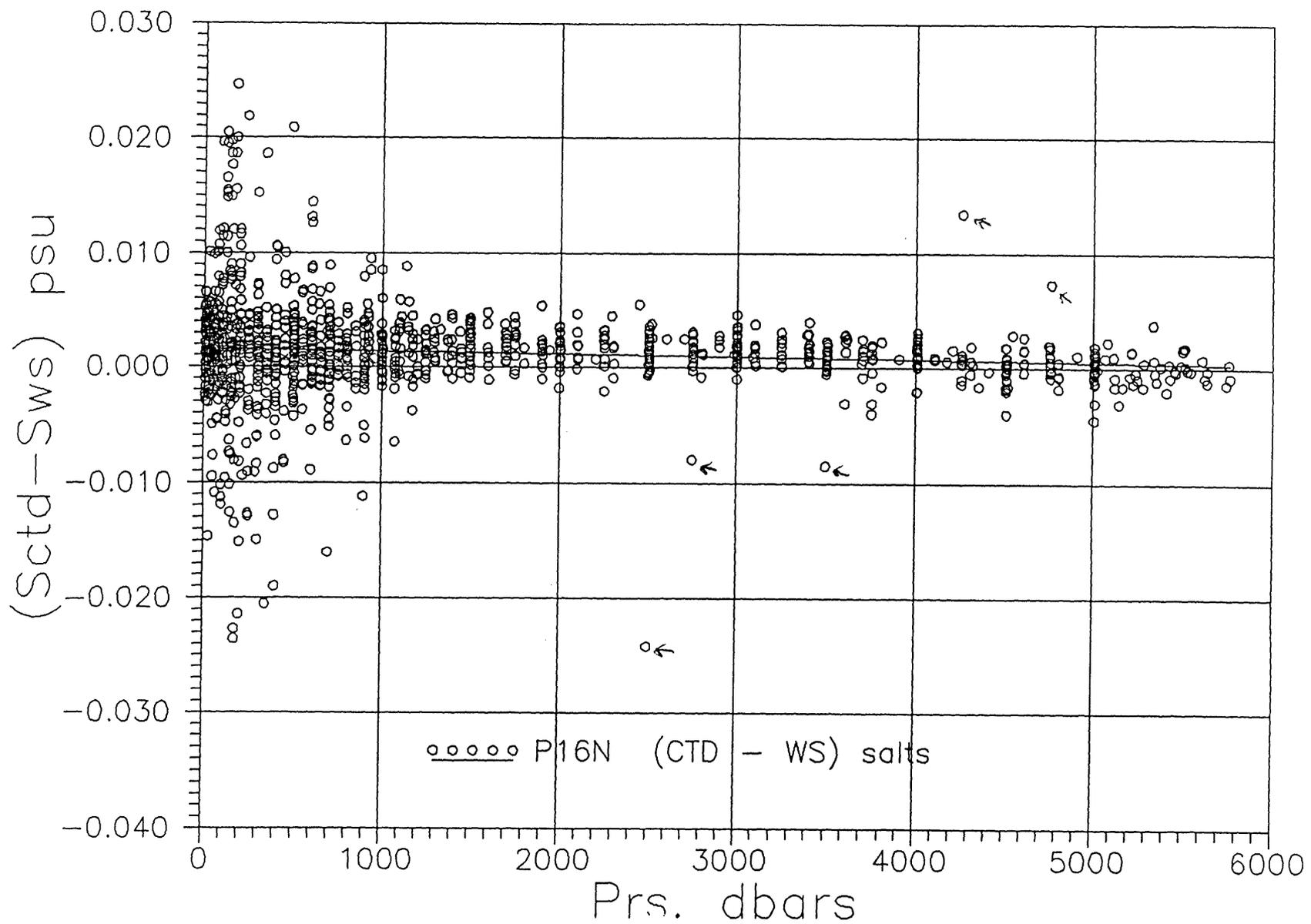


Figure 3



**Figure 4**

P16N deep P > 2000 dbars

STD = .0021

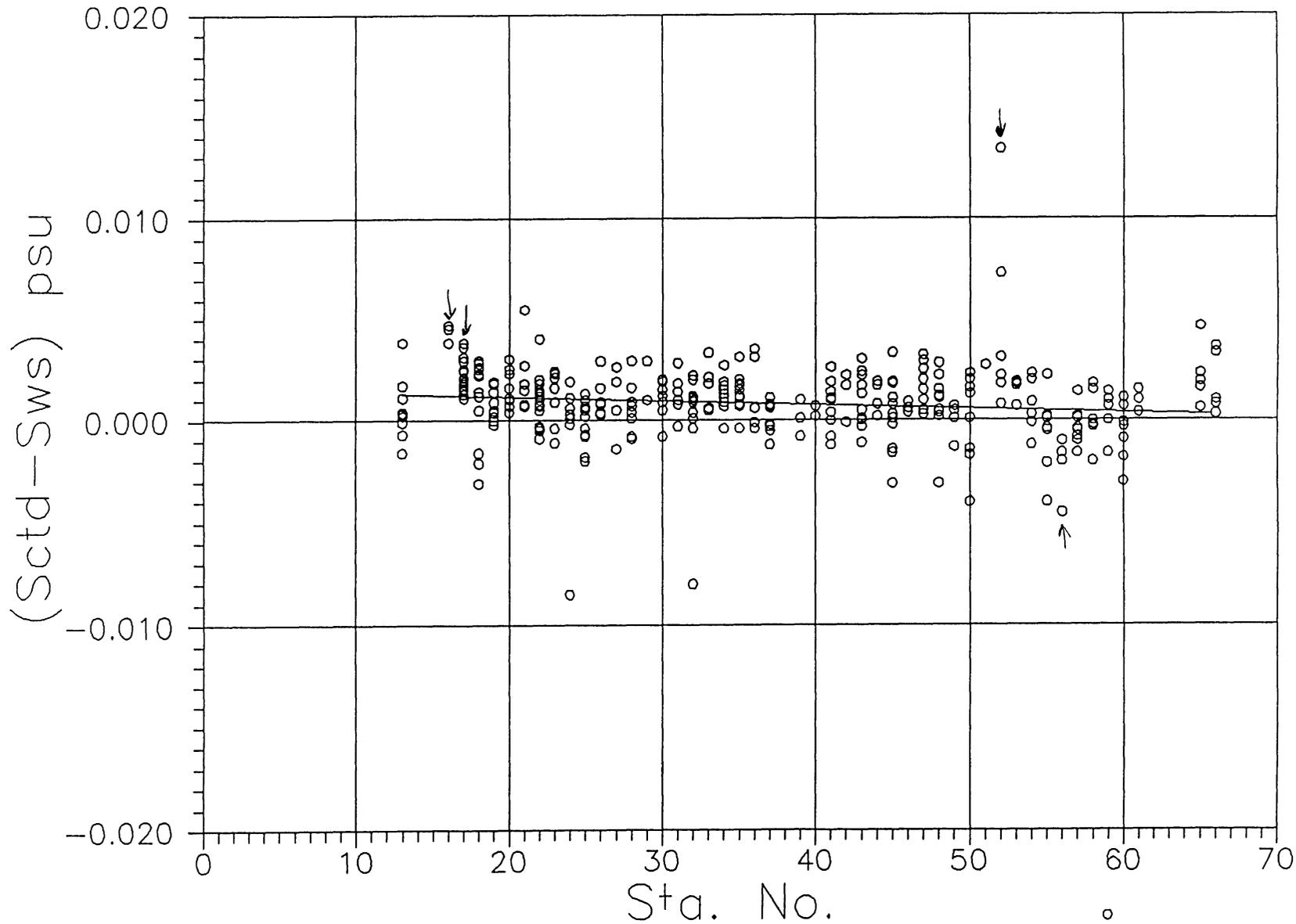


Figure 5

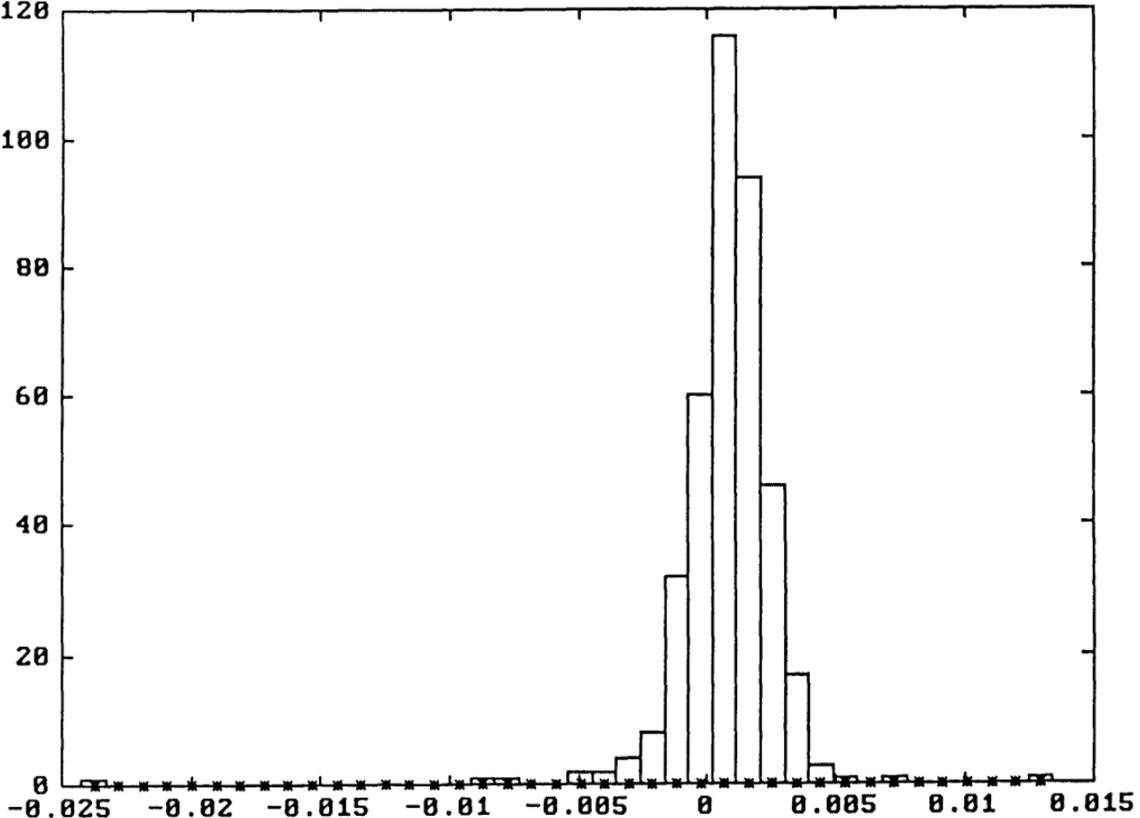
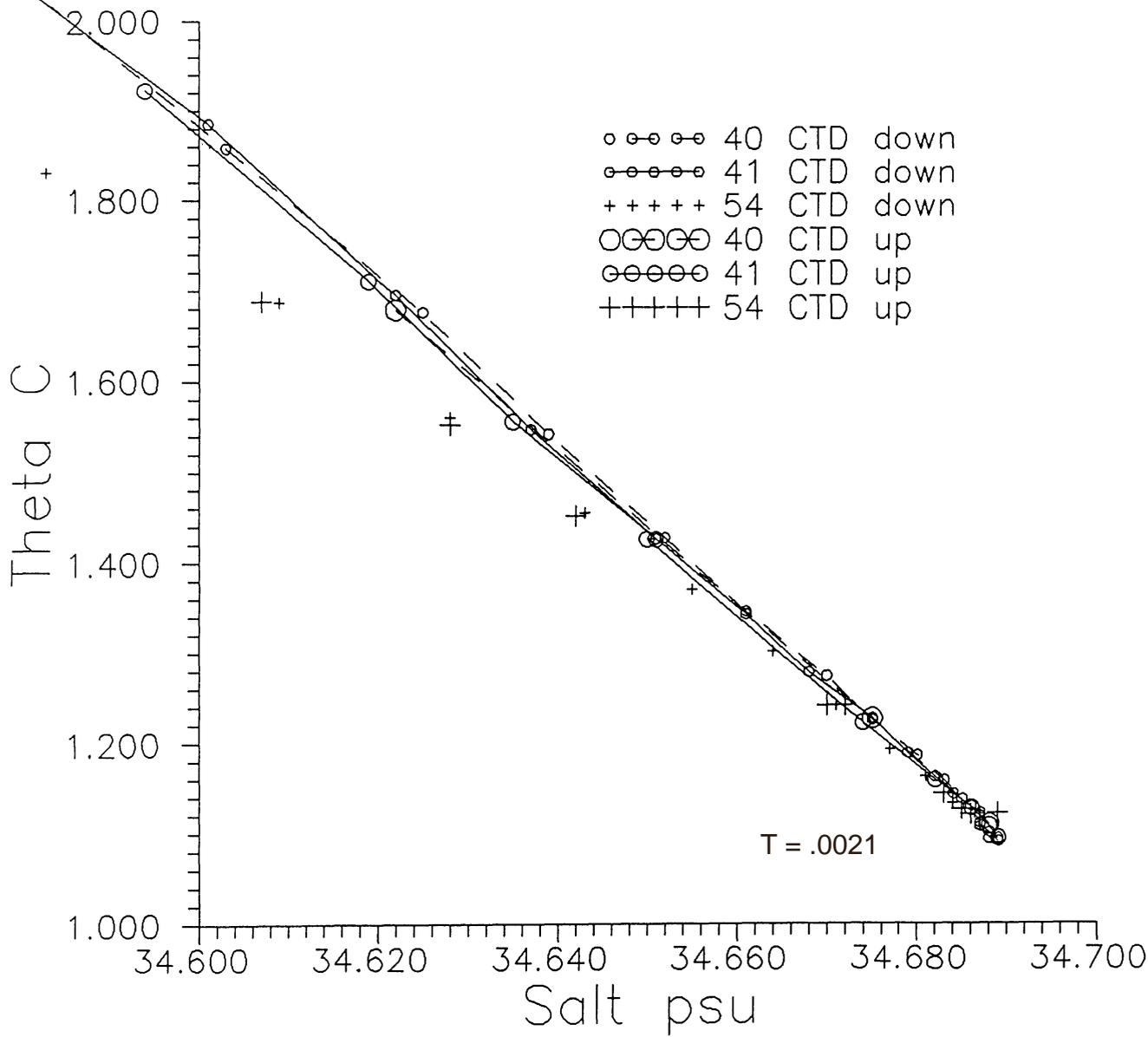


Figure 6



### C.3.a CFC DQE Report: Discoverer P16N

(Rick Van Woy)

June 1, 1993

My technique and reasoning for flagging data was abbreviated due to not having all of the information necessary to do a more thorough job. But with the information that was provided, I generated station listings for the values of CFC11, CFC12, CFC11/CFC12 ratio, percent saturation of O<sub>2</sub>, O<sub>2</sub>, pressure and density. I then plotted both CFC's concentration vs. depth for each station. The strongest indicator of questionable CFC data is the CFC11/CFC12 concentration ratio that is physically constrained by the solubility of the gases. Ratios that were thus determined to be unlikely indicate that one or possibly both CFCs could be questionable. From the station profiles and comparing to other parameters (such as O<sub>2</sub> saturation for the surface waters) I attempted to judge which of the CFCs was most likely to cause the improbable ratio. In some cases I had to flag both values questionable if the profiles, values from the stations before and/or after or other measured tracers did not provide an indication as to which value to question. If the data generator provides the information that was requested for in the report, particularly for the data points in question, I would be able to reassess those quality control words.

I suggest that the data originators for P16N recalculate their sample blank for certain stations since the CFC "free" water concentrations were consistently less than zero.

STN #	SAMP	CFC11 QUALT2	CFC12 QUALT2
13	2201	3	3
13	2203	3	3
13	2204	3	3
13	2206	3	3
13	2207	3	3
13	2208	3	2
13	2209	3	3
13	2212	3	3
13	2213	3	3
13	2214	3	3
13	2215	2	3
13	2216	3	3
13	2217	3	3
13	2218	3	3
13	2219	3	3
13	2220	3	3
13	2221	3	3
13	2222	3	3
15	2402	3	2
15	2408	3	3
15	2402	3	2
16	2508	2	3

STN #	SAMP	CFC11 QUALT2	CFC12 QUALT2
16	2506	2	3
16	2505	2	3
16	2503	2	3
17	2602	2	3
17	2601	2	3
17	2721	2	3
19	2912	3	2
19	2904	3	2
19	2903	3	2
19	2902	3	3
20	3109	3	3
20	3113	3	2
20	3115	2	3
20	3116	3	2
21	3201	3	2
21	3202	3	3
21	3203	3	2
21	3204	3	3
21	3205	3	3
21	3213	2	3
21	3214	3	3
22	3302	3	3

STN #	SAMP	CFC11 QUALT2	CFC12 QUALT2
22	3303	3	2
22	3304	3	2
22	3305	3	2
22	3307	3	2
22	3309	3	2
22	3312	3	2
22	3315	3	3
22	3319	2	3
22	3320	2	3
22	3322	2	3
22	3403	3	3
22	3410	3	3
23	3503	3	3
23	3511	3	2
24	3603	3	3
25	3803	2	3
25	3810	3	2
25	3816	3	2
25	3719	3	3
26	3918	3	2
26	3919	2	3
28	4101	2	3
28	4103	3	2
28	4105	2	3
28	4109	3	2
28	4111	2	3
28	4115	3	2
28	4207	3	2
29	4302	3	2
30	4405	2	3
30	4408	3	2
30	4413	3	2
30	4414	3	2
30	4422	3	3
31	4603	2	3
31	4614	3	2
32	4701	3	2
32	4702	3	2
32	4706	3	2
32	4708	3	2
32	4711	3	2
32	4714	3	2
32	4717	3	2
33	4805	3	2
34	4902	2	3
34	4904	3	2
35	5115	3	2

STN #	SAMP	CFC11 QUALT2	CFC12 QUALT2
36	5201	2	3
36	5202	3	2
36	5204	3	2
36	5205	3	2
36	5207	3	2
37	5301	2	3
37	5303	3	2
37	5319	3	2
37	5320	3	2
37	5321	3	2
37	5323	3	2
37	5324	3	2
39	5505	3	3
39	5518	3	2
40	5603	3	2
41	5711	3	2
41	5810	2	3
42	5901	2	3
42	5903	3	2
42	5904	3	2
42	5906	3	2
43	6024	3	2
45	6204	2	3
47	6404	2	3
47	6405	3	3
47	6406	2	3
48	6508	3	3
48	6511	3	2
49	6708	3	2
49	6713	3	3
52	7002	3	2
52	7003	3	2
52	7005	3	2
53	7107	3	2
53	7109	3	2
54	7312	3	3
54	7313	3	2
54	7323	3	2
55	7501	3	2
55	7504	3	2
55	7505	3	2
55	7509	3	3
55	7512	3	2
58	7812	3	2
59	7910	3	2
59	7911	3	2
59	7912	3	2

STN #	SAMP	CFC11 QUALT2	CFC12 QUALT2
59	7916	3	3
59	7918	3	2
60	8010	2	3

STN #	SAMP	CFC11 QUALT2	CFC12 QUALT2
61	8209	2	3
63	8401	2	3
63	8402	3	2
65	8602	3	3

### C.3.b Final CFC Data Quality Evaluation (DQE) Comments on P16N.

(David Wisegarver)

Dec 2000

During the initial DQE review of the CFC data, a small number of samples were given QUALT2 flags which differed from the initial QUALT1 flags assigned by the PI. After discussion, the PI concurred with the DQE assigned flags and updated the QUAL1 flags for these samples.

The CFC concentrations have been adjusted to the SIO98 calibration Scale (Prinn et al. 2000) so that all of the Pacific WOCE CFC data will be on a common calibration scale.

For further information, comments or questions, please, contact the CFC PI for this section

J. Bullister (johnb@pmel.noaa.gov)

or

David Wisegarver (wise@pmel.noaa.gov).

Additional information on WOCE CFC synthesis may be available at: <http://www.pmel.noaa.gov/cfc>.

Prinn, R. G., R. F. Weiss, P. J. Fraser, P. G. Simmonds, D. M. Cunnold, F. N. Alyea, S. O'Doherty, P. Salameh, B. R. Miller, J. Huang, R. H. J. Wang, D. E. Hartley, C. Harth, L. P. Steele, G. Sturrock, P. M. Midgley, and A. McCulloch, "A history of chemically and radiatively important gases in air deduced from ALE/GAGE/AGAGE." *Journal of Geophysical Research*, 105, 17,751-17,792, 2000.

## D. WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary	
8/19/92	Mantyla	NUTs/S/O	DQE Begun	
8/19/92	Van Woy	CFCs	Data sent to DQE	
3/30/93	Mantyla	NUTs/S/O	DQE Report rcvd @ WHPO	
4/16/93	Millard	CTD	DQE Report rcvd @ WHPO	
5/3/93	Bullister	CTD/NUTs	DQE Report sent to PI	
5/7/93	Van Woy	CFCs	DQE Report rcvd @ WHPO	
6/10/93	Bullister	CFCs	DQE Report sent to PI	
2/21/98	Key	DELC14lvs	Submitted	
9/28/98	Johnson	BTL/CTD	Make data PUBLIC OKd by J. Bullister John Bullister and I have discussed it and the other PMEL Pacific data, and have the following table for access (bottle and CTD):	
		DQE?	Public	Gouretski
	P13	Yes	No	No
	P14S	No	No	Yes
	P15S	No	No	Yes
	P16N	Yes	Yes	Yes
	P18	No	Yes	Yes
10/2/98	Talley	CTD	Update Needed The first ctd file in the p16n dat set was corrupted - someone had tarred the whole set and all of the data had ended up tarred into a file with the name of the first station. Do you have the original ctd data submission and can you fix the website data set?	
12/14/98	Key	DELC14	Data are Public	
1/11/99	Bullister	CTD/BTL	Data are Public Tr/He data requested from Lupton/Jenkins	
4/15/99	Diggs	CTD	Data Update file fixed I have managed to fix the CTD file for P16N over a SLOW line from England. I dug up an old version from the WHOI Pacific Atlas since they made the old file#1 a USTAR file. Station "0012a001.wct" has been replaced and all tables and associated files have been replaced.	
4/16/99	Jenkins	He/Tr	Projected Submission Date 1999.05.15	
4/29/99	Quay	DELC13	Data and/or Status info requested by dmb	
10/8/99	Evans	HELIUM/DELHE3	Submitted	

<b>Date</b>	<b>Contact</b>	<b>Data Type</b>	<b>Data Status Summary</b>
5/31/00	Bullister	BTL/SUM/DOC	Submitted I just re-sent P16N.sea, .sum and .doc files to the WHPO ftp site. The file names are: P16N.doc.senttoWOCE31may2000* P16N.sea.senttoWOCE.31May2000 P16N.sum.senttoWOCE31May2000*  These files have a number of updates compared to the ones now posted at the WHPO web site. The .sea file includes tcarb and pH data; the CFCs are reported on the SI093 calibration scale. The QUALT2 flags which were set by the DQEs for salnty, oxygen, phspt, silcat, nitrat and nitrit are unchanged. The QUALT1 flags for these parameters have been changed in response to the DQE recommendations. We did the DQE checking for the CFC data and have set the QUALT1 and QUALT2 flags for CFC-11 and CFC-12. There are columns for delhe3 data in the .sea file, but I don't have a copy of the delhe3 data files, so the values are reported as -9.
6/9/00	Bartolacci	BTL/SUM/DOC	Website Updated I have replaced the sum, bottle and doc files for P16n 31DICGC91_1/2 sent from Bullister on 05/31. I have updated the tables to reflect the change.  Please note: the bottle file is not pressure sorted yet, and there are he/delhe3 data that still needs merging (there is a problem with the he file having NO documentation associated with it, and PI needs contacting).
6/21/00	Bartolacci	helium/delhe3	not yet merged into btl file
8/7/00	Huynh	DOC	Website Updated; txt file online
8/31/00	Anfuso	HELIUM/DELHE3	Data merged into online BTL file Merged %deltaHe3 and molal[He] data into BTL file.  p16nhe_edt.dat: this is an edited version of p16nwoce.csv.txt. Substituted spaces for ',' column delimiter; replaced missing [He] data with -9.0000 value (formerly white space) for sta/cst/btl: 13/2/6;22/1/1004;22/1/1028;25/2/1003;34/1/1019.  Runtime format: %delHe3: a7, i6, 2x, a7, f10.2, i6 molal[He]: a7, i6, 2x, a7, 16x, f11.4, i6  original/p16nhy_rplcd_2000.08.31.txt: former p16nhy.txt file prior to helium data merge. Ran wocecvf: Data is reported in reverse pressure order.
11/27/00	Uribe	DOC	Submitted File (Received 1997 August 15th) contained here is a CRUISE SUMMARY and NOT sumfile. Documentation is online.
6/22/01	Uribe	CTD/BTL	CSV File Added to Website
8/9/01	Bartolacci	THETA	Website Updated; THETA header realigned
11/16/01	Bartolacci	CFCs	Updated Data ready to be merged I have placed the updated CFC data file sent by Wisegarver into the P16n original directory in a subdirectory called 2001.07.09_P16N_CFC_UPDT_WISEGARVER This directory contains data, documentation and readme files. data are ready for merging
1/8/02	Uribe	CTD	CSV File Added to Website

<b>Date</b>	<b>Contact</b>	<b>Data Type</b>	<b>Data Status Summary</b>
1/22/02	Hajrasuliha	CTD	Internal DQE completed Created *check.txt file only.
3/8/02	Kozyr	TCARBN/C14	Flag numbers need updating I have been working with the final data from WOCE P16N (NOAA CGC91) cruise and found some problems with the quality flags for TCARBN and deltaC14 measurements in the WHPO data file. In many cases there are flags "3" for missing TCARBN data and flags "2" for missing deltaC14 data. Also, I found that WHPO CFC numbers are different from those at John's ftp site for this cruise. You can copy the correct data file from: <a href="http://cdiac.ornl.gov/oceans/woce_p16n.html">http://cdiac.ornl.gov/oceans/woce_p16n.html</a> (I did not update the CFC data in my file though).
3/8/02	Bullister	CFCs	Clarification Request In 1996, The original DIC QC people (see below) inserted '-9' as the DIC value for some samples assigned QC flag '3'. There are about 52 of these samples in my file. Does the final DQE'ed data set for this cruise report the actual values? If so, I think that the actual values should used, instead on -9.
3/11/02	Roberts	TCARBN	Data Update All - I will merge the DIC data back into the file, maintaining the revised QC flags. This will reinsert the values into the cells where Slansky replaced them with -9's, therefore reporting all data.