

WHP Cruise Summary Information

WOCE section designation	P31
Expedition designation (EXPOCODE)	3250031_1
Chief Scientist(s) and their affiliation	Dean Roemmich, SIO
Dates	1994.01.25 – 1994.02.19
Ship	THOMAS G. THOMPSON
Ports of call	Papeete, Tahiti to Suva, Fiji
Number of stations	91
Geographic boundaries of the stations	17°28.02''S 179°31.61''W 149°53.99''W 08°00.90''S
Floats and drifters deployed	none
Moorings deployed or recovered	none
Contributing Authors (in order of appearance)	M. Rosenberg G. Anderson

WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

Cruise Summary Information	Hydrographic Measurements
Description of scientific program	CTD - general
	CTD - pressure
	CTD - temperature
Cruise track (figure)	CTD - conductivity/salinity
Description of stations	CTD - dissolved oxygen
Description of parameters sampled	
	Salinity
	Oxygen
	Nutrients
	CFCs
Principal Investigators for all measurements	
Cruise Participants	
	CO2 system parameters
Underway Data Information	
Navigation	References
Bathymetry	
	DQE Reports
	CTD
	S/O2/nutrients
	Data Status Notes

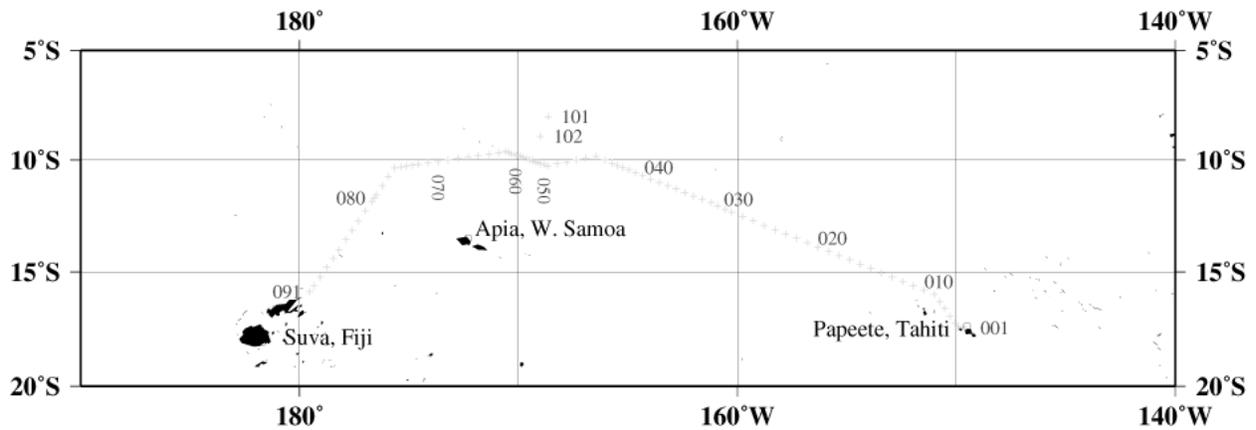
PARAMETERS, INSTITUTIONS, AND PERSONNEL

At each station location a conductivity-temperature-depth (CTD) profiler, attached to a rosette water sampler with 36 ten-liter sample bottles, will be lowered to the ocean bottom. The CTD will also carry an oxygen sensor. Water samples collected throughout the water column will be analyzed for salinity and dissolved oxygen and nutrient concentrations, as well as for concentrations of geochemical tracers including carbon dioxide and chloro-fluorocarbons (freons). An acoustic doppler current profiler (ADCP) attached to the water sampler will provide estimates of water velocity. Principal investigators with responsibility for these measurements are:

Dean Roemmich, Susan Hautala - CTD, salinity, oxygen, nutrients
(Scripps Institution of Oceanography)
John Downing (Battelle) - carbon dioxide
Mark Warner (University of Washington) - chloro-fluorocarbons
Peter Hacker, Eric Firing (University of Hawaii) - ADCP

World Ocean Circulation Experiment
Pacific Ocean P31
R/V Thomas G. Thompson
Voyage TN031
25 January 1994 - 19 February 1994
Papeete, Tahiti - Suva, Fiji
Expocode: 3250031/1

Chief Scientist: Dr. Dean Roemmich
University of California, San Diego
Scripps Institution of Oceanography



WOCE94-P31 Cruise Track

Oceanographic Data Facility (ODF)
Final Cruise Report
18 July 1997
Data Submitted by:
Oceanographic Data Facility
Scripps Institution of Oceanography
La Jolla, CA 92093-0214

1. DESCRIPTION OF MEASUREMENT TECHNIQUES AND CALIBRATIONS

Basic Hydrography Program

The basic WOCE94-P31 hydrography program consisted of salinity, dissolved oxygen and nutrient (nitrite, nitrate, phosphate and silicate) measurements made from bottles taken on CTD/rosette casts, plus pressure, temperature, salinity and dissolved oxygen from CTD profiles. 94 CTD/rosette casts were made, usually to within 10 meters of the bottom. 91 casts at Stations 1-91 were reported as WOCE94-P31 data and 2 non-WOCE casts at Stations 101 and 102 taken in the Samoan Passage were also reported. Note that stations 101 and 102 chronologically happened between stations 63 and 64. One test cast was not reported. 3045 bottles were tripped resulting in 3026 usable bottles. No insurmountable problems were encountered during any phase of the operation. The resulting data set met and in many cases exceeded WHP specifications. The distribution of samples is illustrated in Figure 1.0.0.

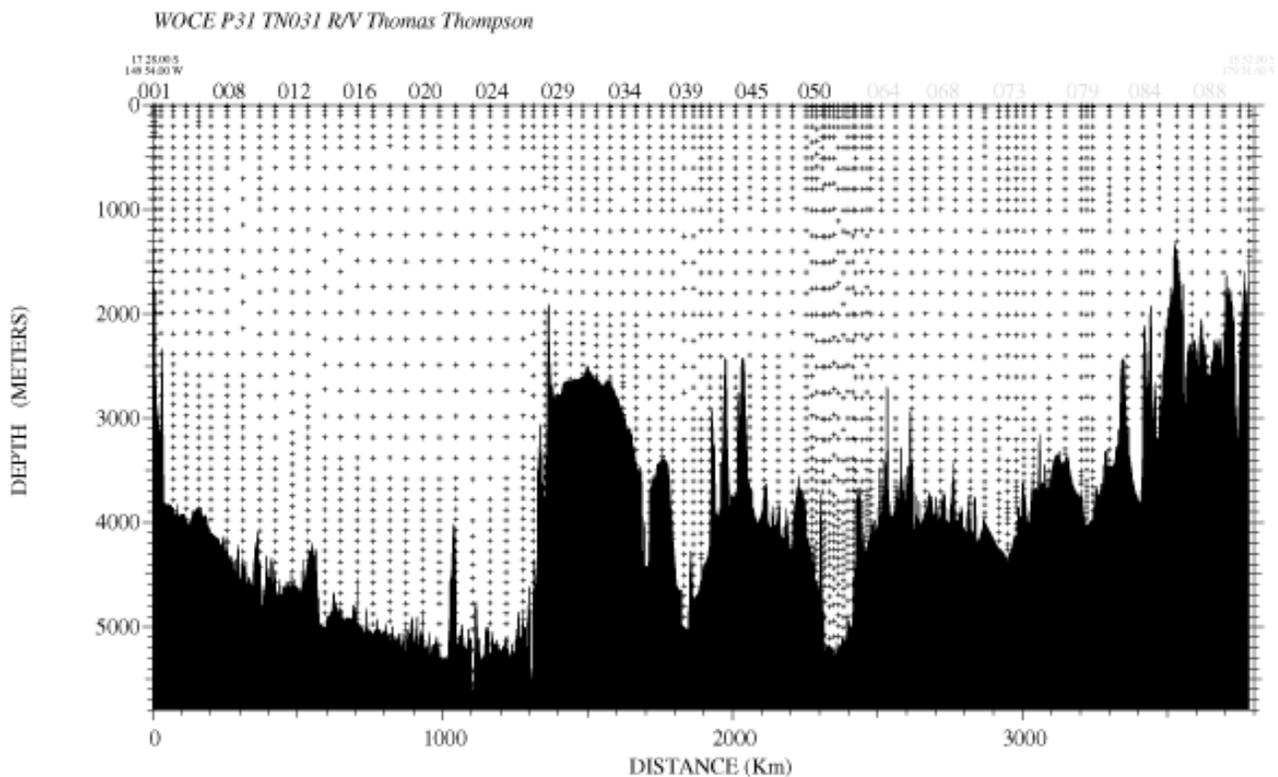


Figure 1.0.0 WOCE94-P31 sample distribution, stations 1-91

1.1. Water Sampling Package

Hydrographic (rosette) casts were performed with a rosette system consisting of a 36-bottle rosette frame (ODF), a 36-place pylon (General Oceanics 1016) and 36 10-liter PVC bottles (ODF). Underwater electronic components consisted of an ODF-modified NBIS Mark III CTD (ODF #1) and associated sensors, FSI Platinum Resistance Thermometer (PRT) 1320, Benthos altimeter and Benthos pinger. The CTD was mounted horizontally along the bottom of the rosette frame, with the Sensormedics

dissolved oxygen sensor deployed next to the CTD. The altimeter provided distance-above-bottom in the CTD data stream. The pinger was monitored during a cast with a precision depth recorder (PDR) in the ship's laboratory. The University of Hawaii Lowered Acoustic Doppler Current Profiler (LADCP) was also mounted on the rosette. The rosette system was suspended from a three-conductor electro-mechanical cable. Power to the CTD and pylon was provided through the cable from the ship. Separate conductors were used for the CTD and pylon signals.

CTD #1 was used for the entire expedition.

Each rosette cast was lowered to within 10 meters of the bottom, unless the bottom returns from both the pinger and altimeter were extremely poor. Bottles on the rosette were each identified with a unique serial number. Usually these numbers corresponded to the pylon tripping sequence, 1-36, where the first (deepest) bottle tripped was bottle #1. Bottle numbers 1-36 were used on all casts except for stations 31-38 and 61-63, where bottle #51 replaced bottle #4. Bottle 51 was a General Oceanics lever action floater bottle which was being tested on this expedition.

Averages of CTD data corresponding to the time of bottle closure were associated with the bottle data during a cast. Pressure, depth, temperature, salinity and density were immediately available to facilitate examination and quality control of the bottle data as the sampling and laboratory analyses progressed.

The deck watch prepared the rosette approximately 45 minutes prior to a cast. All valves, vents and lanyards were checked for proper orientation. The bottles were cocked and all hardware and connections rechecked. Upon arrival at station, time, position and bottom depth were logged and the deployment begun. The rosette was moved into position under a projecting boom from the rosette room using an air-powered cart on tracks. Two stabilizing tag lines were threaded through rings on the frame. CTD sensor covers were removed and the pinger was turned on. Once the CTD acquisition and control system in the ship's laboratory had been initiated by the console operator and the CTD and pylon had passed their diagnostics, the winch operator raised the package and extended the boom over the side of the ship. The package was then quickly lowered into the water, the tag lines removed and the console operator notified by radio that the rosette was at the surface.

Recovering the package at the end of deployment was essentially the reverse of the launching. Two tag lines connected to air tuggers and terminating in large snap hooks were manipulated on long poles by the deck watch to snag recovery rings on the rosette frame. The package was then lifted out of the water under tension from the tag lines, the boom retracted, and the rosette lowered onto the cart. Sensor covers were replaced, the pinger turned off and the cart with the rosette moved into the rosette room for sampling. A detailed examination of the bottles and rosette occurred before samples were taken, and any extraordinary situations or circumstances were noted on the sample log for the cast.

The rosette was stored in the rosette room between casts to insure the CTD was not exposed to direct sunlight or wind in order to maintain the internal CTD temperature near ambient air temperature.

Rosette maintenance was performed on a regular basis. O-rings were changed as necessary and bottle maintenance performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed.

Initial sea-cable problems on the primary winch were traced to a bad winch-end wire termination. There were some problems with end-cap O-rings coming unseated, resulting in leaking bottles.

1.2. Underwater Electronics Packages

CTD data were collected with a modified NBIS Mark III CTD (ODF CTD #1). The instrument provided pressure, temperature, conductivity and dissolved O₂ channels, and additionally measured a second temperature as a calibration check. Other data channels included elapsed-time, an altimeter and several power supply voltages. The instrument supplied a standard 15-byte NBIS-format data stream at a data rate of 25 Hz. Modifications to the instruments included a revised dissolved O₂ sensor mounting, ODF-designed sensor interface for the FSI PRT, implementation of 8-bit and 16-bit multiplexer channels, an elapsed-time channel, instrument ID in the polarity byte and power supply voltages channels.

Table 1.2.0 summarizes the serial numbers of the instrument and sensors used during WOCE94-P31.

ODF CTD ID#	Pressure	Temperature		Conductivity
	Paine Model 211-35-440-05 strain gage/0-8850psi	PRT1 Rosemount Model 171BJ	PRT2 FSI OTM	NBIS Model 09035-00151
1	131910	14304	OTM/1320T	5902-F117

Table 1.2.0 WOCE94-P31 Instrument/Sensor Serial Numbers

The NBIS temperature compensation circuit on the pressure interface was disabled; all thermal response characteristics were modeled and corrected in the software.

The O₂ sensor was deployed in an ODF-designed pressure-compensated holder assembly mounted separately on the rosette frame and connected to the CTD by an underwater cable. The O₂ sensor interface was designed and built by ODF using an off-the-shelf 12-bit A/D converter.

Although the secondary temperature sensor was located within 6 inches of the CTD conductivity sensor, it was not sufficiently close to calculate coherent salinities. It was used as a secondary temperature calibration reference rather than as a redundant

sensor, with the intent of eliminating the need for mercury or electronic DSRTs as calibration checks.

Standard CTD maintenance procedures included soaking the conductivity and O₂ sensors in distilled water between casts to maintain sensor stability.

The General Oceanics 1016 36-place pylon provided generally reliable operation and positive confirmation of all except 1 bottle trip attempt, which was successful on the second trip attempt. The pylon emits a confirmation message containing its current notion of bottle trip position, an invaluable aid in sorting out mis-trips.

1.3. Navigation and Bathymetry Data Acquisition

Navigation data and underway bathymetry were acquired from the ship's Bathy 2000 system until station 102 (prior to station 64). HydroSweep center-beam depth was acquired on the Sun systems after the failure of the 3.5KHz bathymetry system. Data were logged automatically at one-minute intervals by one of the Sun SPARCstations, to provide a time-series of underway position, course, speed and bathymetry data. These data were used for all station positions, PDR depths, and for bathymetry on vertical sections [Cart80].

1.4. CTD Data Acquisition, Processing and Control System

The CTD data acquisition, processing and control system consisted of a Sun SPARCstation 2 computer workstation, ODF-built CTD deck unit, General Oceanics 1016 pylon deck unit, CTD and pylon power supplies, and a VCR recorder for real-time analog backup recording of the sea-cable signal. The Sun system consisted of a color display with trackball and keyboard (the CTD console), 18 RS-232 ports, 2.5 GB disk and 8mm cartridge tape. One other Sun SPARCstation 2 system was networked to the data acquisition system, as well as to the rest of the networked computers aboard the Thompson. These systems were available for real-time CTD data display and provided for hydrographic data management and backup. Each Sun SPARCstation was equipped with a printer and an 8-color drum plotter.

The CTD FSK signal was demodulated and converted to a 9600 baud RS-232C binary data stream by the CTD deck unit. This data stream was fed to the Sun SPARCstation. The pylon deck unit was connected to the data acquisition system through a serial port, allowing the data acquisition system to initiate and confirm bottle trips. A bitmapped color display provided interactive graphical display and control of the CTD rosette sampling system, including real-time raw and processed data, navigation, winch and rosette trip displays.

The CTD data acquisition, processing and control system was prepared by the console watch a few minutes before each deployment. A console operations log was maintained for each deployment, containing a record of every attempt to trip a bottle as well as any pertinent comments. Most CTD console control functions, including starting

the data acquisition, were initiated by pointing and clicking a trackball cursor on the display at icons representing functions to perform. The system then presented the operator with short dialog prompts with automatically-generated choices that could either be accepted as defaults or overridden. The operator was instructed to turn on the CTD and pylon power supplies, then to examine a real-time CTD data display on the screen for stable voltages from the underwater unit. Once this was accomplished, the data acquisition and processing was begun and a time and position automatically logged for the beginning of the cast. A backup analog recording of the CTD signal was made on a VCR tape, which was started at the same time as the data acquisition. A rosette trip display and pylon control window then popped up, giving visual confirmation that the pylon was initializing properly. Various plots and displays were initiated. When all was ready, the console operator informed the deck watch by radio.

Once the deck watch had deployed the rosette and informed the console operator that the rosette was at the surface (also confirmed by the computer displays), the console operator or watch leader provided the winch operator with a target depth (wire-out) and maximum lowering rate, normally 60 meters/minute for this package. The package then began its descent, building up to the maximum rate during the first few hundred meters, then continuing at a steady rate without any stops during the down-cast.

The console operator examined the processed CTD data during descent via interactive plot windows on the display, which could also be run at other workstations on the network. Additionally, the operator decided where to trip bottles on the up-cast, noting this on the console log. The PDR was monitored to insure the bottom depth was known at all times.

The watch leader assisted the console operator when the package was ~400 meters above the bottom by monitoring the range to the bottom using the distance between the rosette's pinger signal and its bottom reflection displayed on the PDR. Between 100 and 60 meters above the bottom, depending on bottom conditions, the altimeter typically began signaling a bottom return on the console. The winch and altimeter displays allowed the watch leader to refine the target depth relayed to the winch operator and safely approach to within 10 meters of the bottom.

Bottles were tripped by pointing the console trackball cursor at a graphic firing control and clicking a button. The data acquisition system responded with the CTD rosette trip data and a pylon confirmation message in a window. All tripping attempts were noted on the console log. The console operator then directed the winch operator to the next bottle stop. The console operator was also responsible for generating the sample log for the cast.

After the last bottle was tripped, the console operator directed the deck watch to bring the rosette on deck. Once the rosette was on deck, the console operator terminated the data acquisition and turned off the CTD, pylon and VCR recording. The VCR tape was filed. Frequently the console operator also brought the sample log to the rosette room and served as the sample cop.

1.5. CTD Data Processing

ODF CTD processing software consists of over 30 programs running under the Unix operating system. The initial CTD processing program (ctdba) is used either in real-time or with existing raw data sets to:

- o Convert raw CTD scans into scaled engineering units, and assign the data to logical channels;
- o Filter various channels according to specified filtering criteria;
- o Apply sensor- or instrument-specific response-correction models;
- o Provide periodic averages of the channels corresponding to the output time-series interval; and
- o Store the output time-series in a CTD-independent format.

Once the CTD data are reduced to a standard-format time-series, they can be manipulated in various ways. Channels can be additionally filtered. The time-series can be split up into shorter time-series or pasted together to form longer time-series. A time-series can be transformed into a pressure-series, or into a larger-interval time-series. The pressure calibration corrections are applied during reduction of the data to time-series. Temperature, conductivity and oxygen corrections to the series are maintained in separate files and are applied whenever the data are accessed.

ODF data acquisition software acquired and processed the CTD data in real-time, providing calibrated, processed data for interactive plotting and reporting during a cast. The 25 Hz data from the CTD were filtered, response-corrected and averaged to a 2 Hz (0.5-second) time-series. Sensor correction and calibration models were applied to pressure, temperature, conductivity and O₂. Rosette trip data were extracted from this time-series in response to trip initiation and confirmation signals. The calibrated 2 Hz time-series data were stored on disk (as were the 25 Hz raw data) and were available in real-time for reporting and graphical display. At the end of the cast, various consistency and calibration checks were performed, and a 2-decibar pressure-series of the down-cast was generated and subsequently used for reports and plots.

CTD plots generated automatically at the completion of deployment were checked daily for potential problems. The two PRT temperature sensors were inter-calibrated and checked for sensor drift. The CTD conductivity sensor was monitored by comparing CTD values to check-sample conductivities and by deep T-S comparisons with adjacent stations. The CTD O₂ sensor was calibrated to check-sample data.

A few casts exhibited conductivity offsets due to biological or particulate artifacts. Some casts were subject to noise in 1 or more channels caused by sea cable or slip-ring problems. In particular, the O₂ channel was subject to noise which was traced to moisture in the interconnect cable to the sensor. Intermittent noisy data were filtered out of the 2 Hz data using a spike-removal filter. A least-squares polynomial of specified order was fit to fixed-length segments of data. Points exceeding a specified multiple of the residual standard deviation were replaced by the polynomial value.

Density inversions can appear in high-gradient regions. Detailed examination of the raw data shows significant mixing occurring in these areas because of ship roll. In order to minimize density inversions, a ship-roll filter was applied to all casts during pressure-sequencing to disallow pressure reversals.

Pressure intervals with no time-series data can optionally be filled by double-parabolic interpolation.

When the down-cast CTD data have excessive noise, gaps or offsets, the up-cast data are used instead. CTD data from down- and up-casts are not mixed together in the pressure-series data because they do not represent identical water columns (due to ship movement, wire angles, etc.). The 2 up-casts used for final WOCE94-P31 data are indicated in Appendix C.

Appendix C contains a table of CTD casts requiring special attention as well as WOCE94-P31 CTD-related comments, problems and solutions.

1.6. CTD Laboratory Calibration Procedures

Pre-cruise laboratory calibrations of CTD pressure and temperature sensors were used to generate tables of corrections applied by the CTD data acquisition and processing software at sea. These laboratory calibrations were also performed post-cruise.

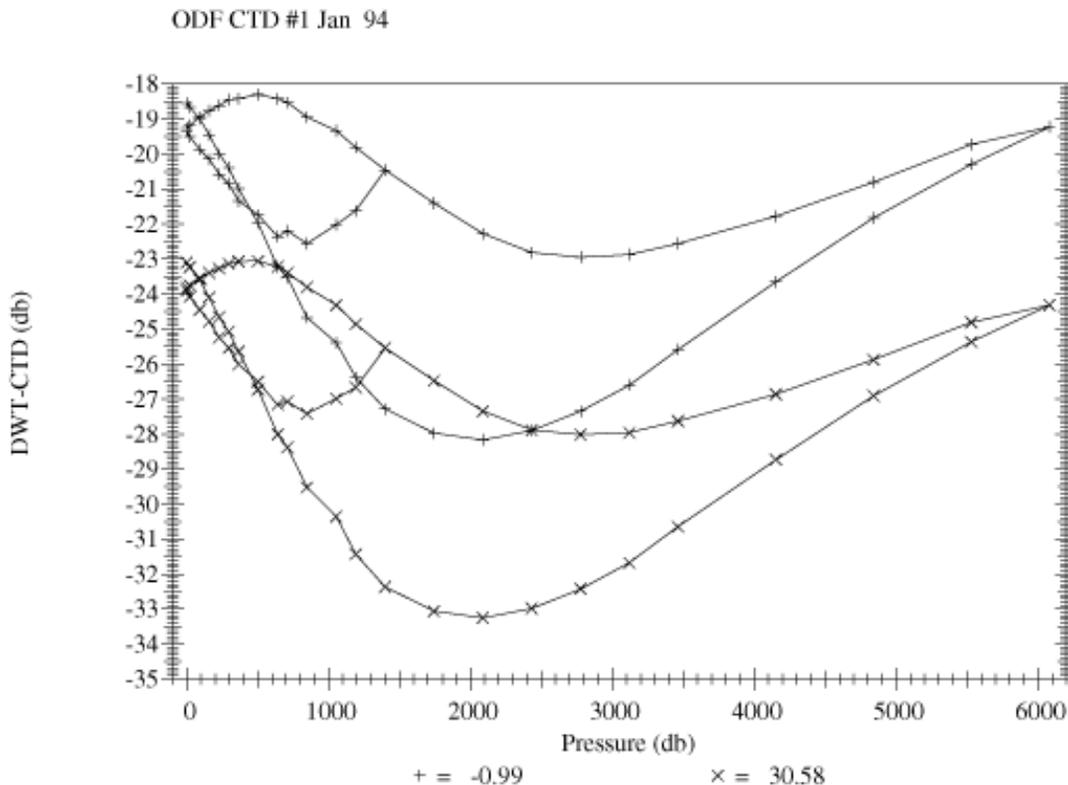


Figure 1.6.0 Pressure calibration for ODF CTD #1, January 1994.

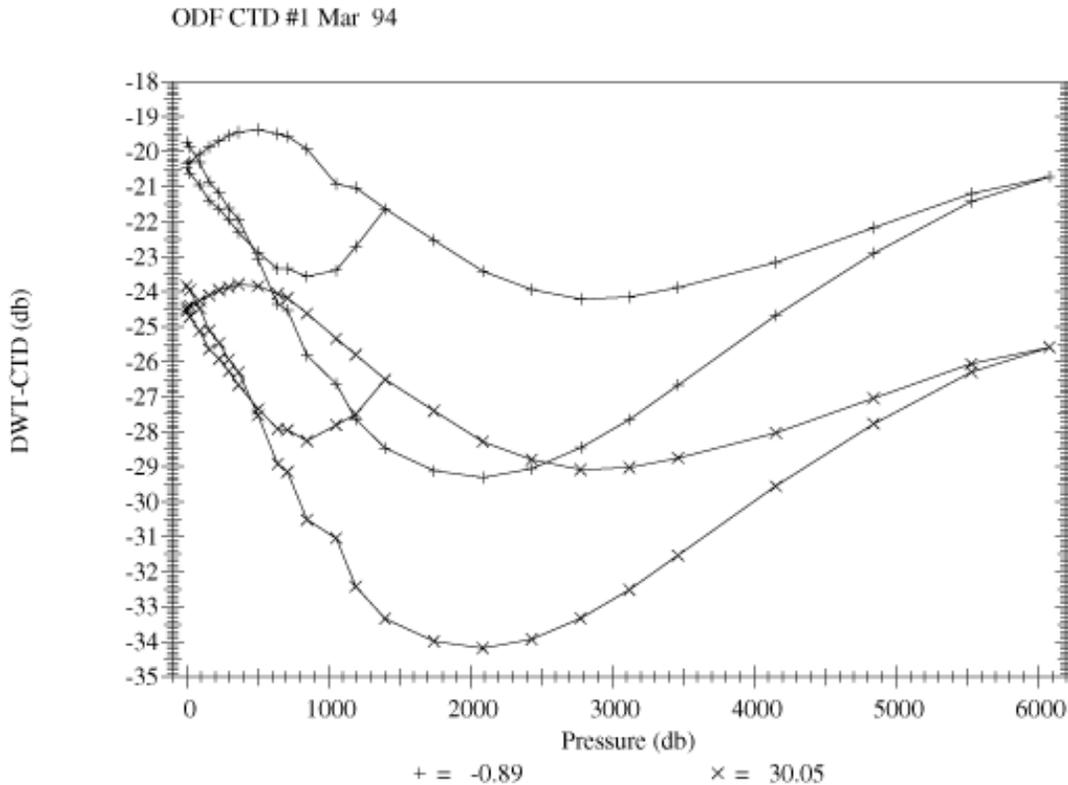


Figure 1.6.1 Pressure calibration for ODF CTD #1, March 1994.

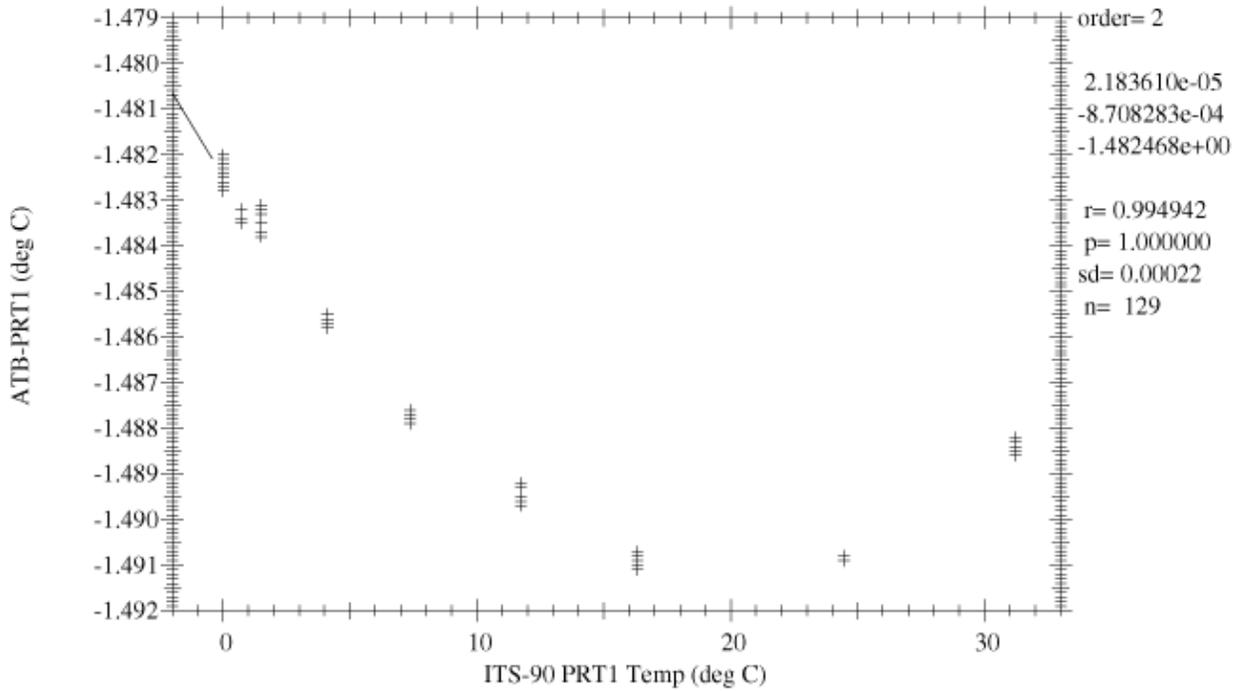
Pressure and temperature calibrations were performed on CTD #1 at the ODF Calibration Facility in La Jolla. The pre-cruise calibrations were done in January 1994 before the start of the WOCE94-P31 expedition, and the post-cruise calibrations were done in March 1994.

The CTD pressure transducer was calibrated in a temperature-controlled water bath to a Ruska Model 2400 Piston Gage pressure reference. Calibration data were measured at $-0.99/-0.89$ and $30.58/30.05^\circ$ to 2 maximum loading pressures (1400 and 6080 db) pre-/post-cruise. Figures 1.6.0 and 1.6.1 summarize the CTD #1 laboratory pressure calibrations performed in January and March 1994.

Additionally, dynamic thermal-response step tests were conducted on the pressure transducer to calibrate dynamic thermal effects.

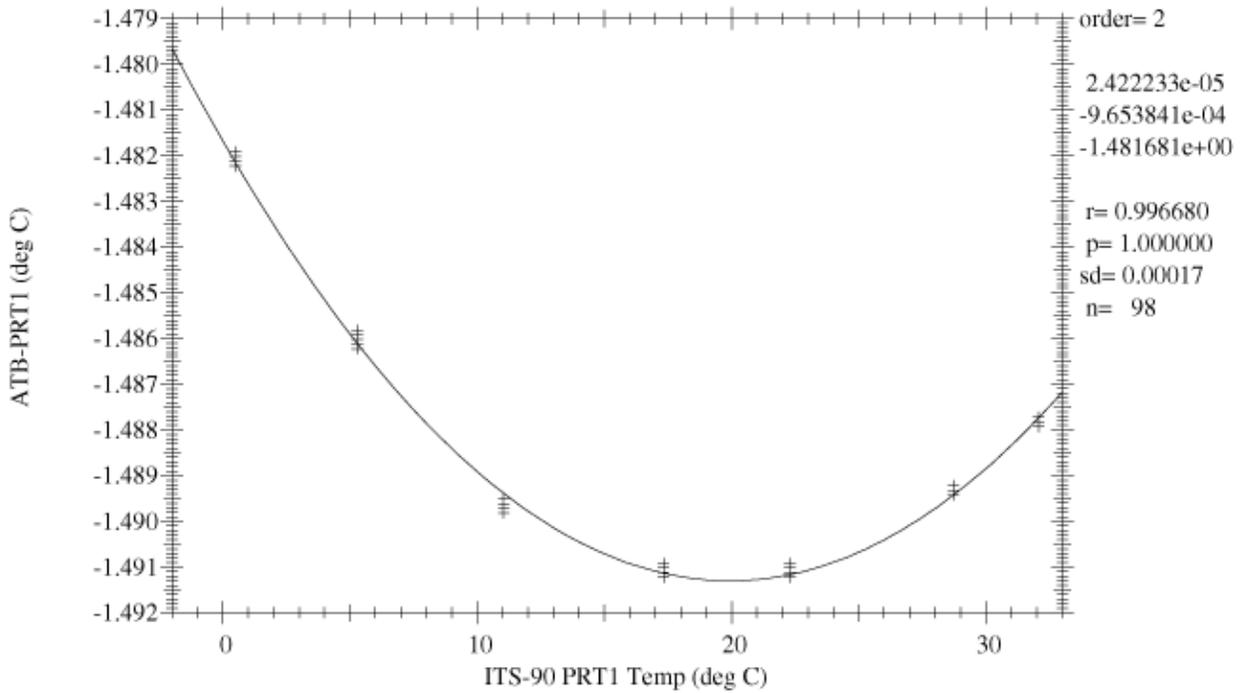
CTD PRT temperatures were calibrated to an NBIS ATB-1250 resistance bridge and Rosemount standard PRT in a temperature-controlled bath. The primary and secondary CTD temperatures were offset by $\sim 1.5^\circ\text{C}$ to avoid the 0-point discontinuity inherent in the internal digitizing circuitry. Standard and PRT temperatures were measured at 7 or more different bath temperatures between -1 and 32°C , both pre- and post-cruise. Figure 1.6.2 summarizes the laboratory calibration performed on the CTD #1 primary PRT during May 1993. It is included in this documentation because this was the actual correction applied during the cruise and retained during final processing. Figure 1.6.3 summarizes the laboratory calibration performed on the CTD #1 primary

PRT during January 1994. Figure 1.6.4 summarizes the laboratory calibration performed on the CTD #1 primary PRT during March 1994.



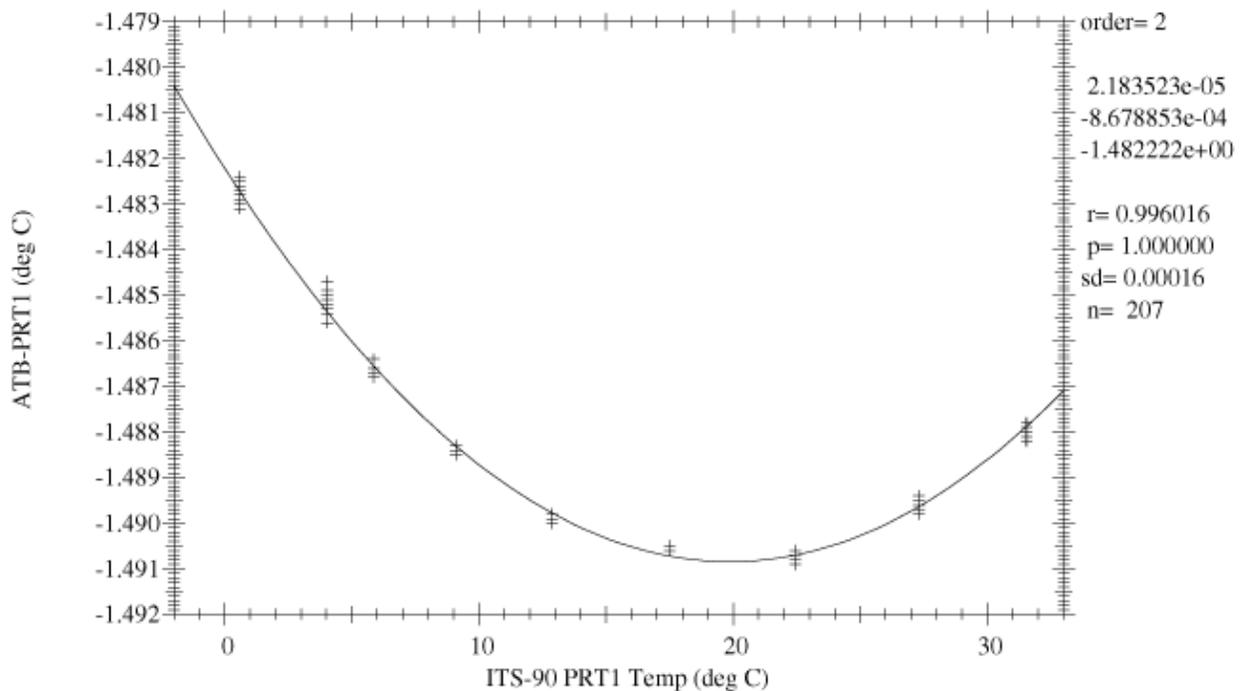
ODF CTD #1 May 93

Figure 1.6.2 Primary PRT Temperature Calibration for ODF CTD #1, May 1993.



ODF CTD #1 Jan 94

Figure 1.6.3 Primary PRT Temperature Calibration for ODF CTD #1, January 1994.



ODF CTD #1 Mar 94

Figure 1.6.4 Primary PRT Temperature Calibration for ODF CTD #1, March 1994.

Laboratory temperature calibrations were referenced to an ITS-90 standard. Temperatures were converted to the IPTS-68 standard during processing in order to calculate other parameters, including salinity and density, which are currently defined in terms of that standard only. Final calibrated CTD temperatures are reported using the ITS-90 standard.

The post-cruise calibrations showed a maximum PRT drift of 0.0003°C and a pressure drift of ~1.0 decibar.

1.7. Final CTD Calibration Procedures

A redundant sensor (FSI OTM #1320) was used on the CTD as a temperature calibration check while at sea. CTD conductivity and dissolved O₂ were calibrated to in-situ check samples collected during each rosette cast.

1.7.1. Pressure and Temperature

The final pressure and temperature calibrations were determined for CTD #1 during post-cruise processing.

A second FSI PRT sensor was deployed as the secondary temperature channel and compared with the primary PRT channel on all casts during this expedition to monitor for drift. The response times of the sensors were first matched, then preliminary corrected temperatures were compared for a series of standard depths from each CTD down-cast.

Comparison of the two CTD #1 PRTs showed a $+0.005^\circ$ drift over the course of the cruise. At sea, this drift was correctly attributed to the FSI PRT, given that the CTD salinities remained so stable. Figure 1.7.1.0 summarizes the shipboard comparison between the primary and secondary PRT channels for CTD #1.

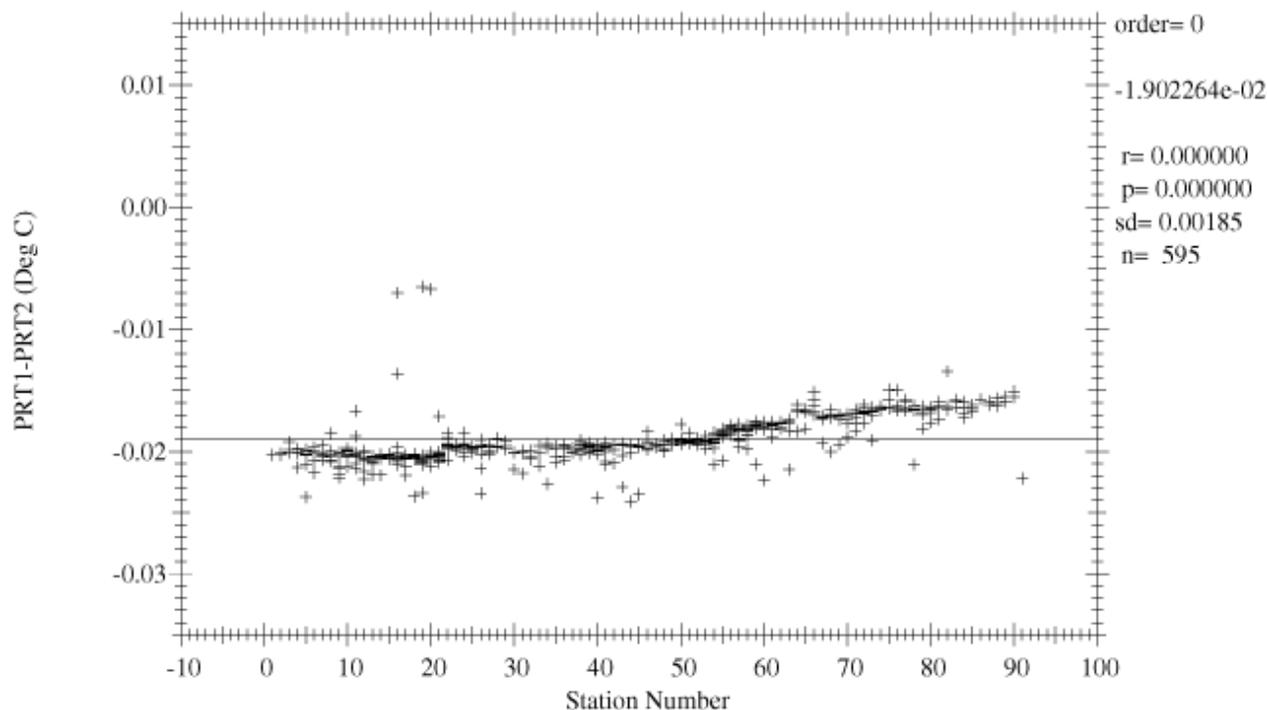


Figure 1.7.1.0 Shipboard comparison of CTD #1 primary/secondary PRT temperatures, pressure > 1000db.

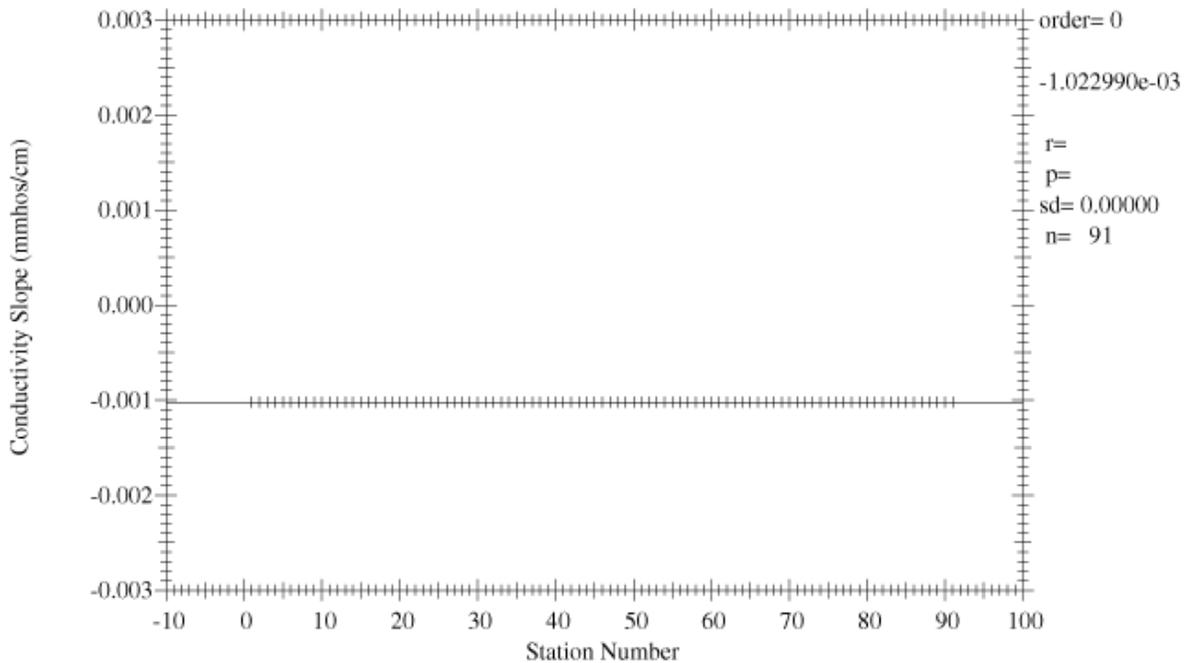
There was a small slope change from 0-6200 db between the pre- and post- cruise cold "deep" pressure laboratory calibrations. The shallow sections of each calibration shifted by ~ 1.0 db pre- to post-cruise, while the deep section of the cold calibration shifted by ~ 1.5 db. This shift is smaller than the WOCE accuracy specification of 3 decibars so it was decided to leave the pre-cruise pressure calibrations, applied during the cruise, unchanged.

The laboratory calibrations for the CTD #1 primary temperature sensor (PRT1), showed a maximum PRT drift of 0.0003° among all 3 calibrations (May 93, January 94 and March 1994) and so it was decided to also leave the May 1993 temperature calibrations, applied during the cruise, unchanged.

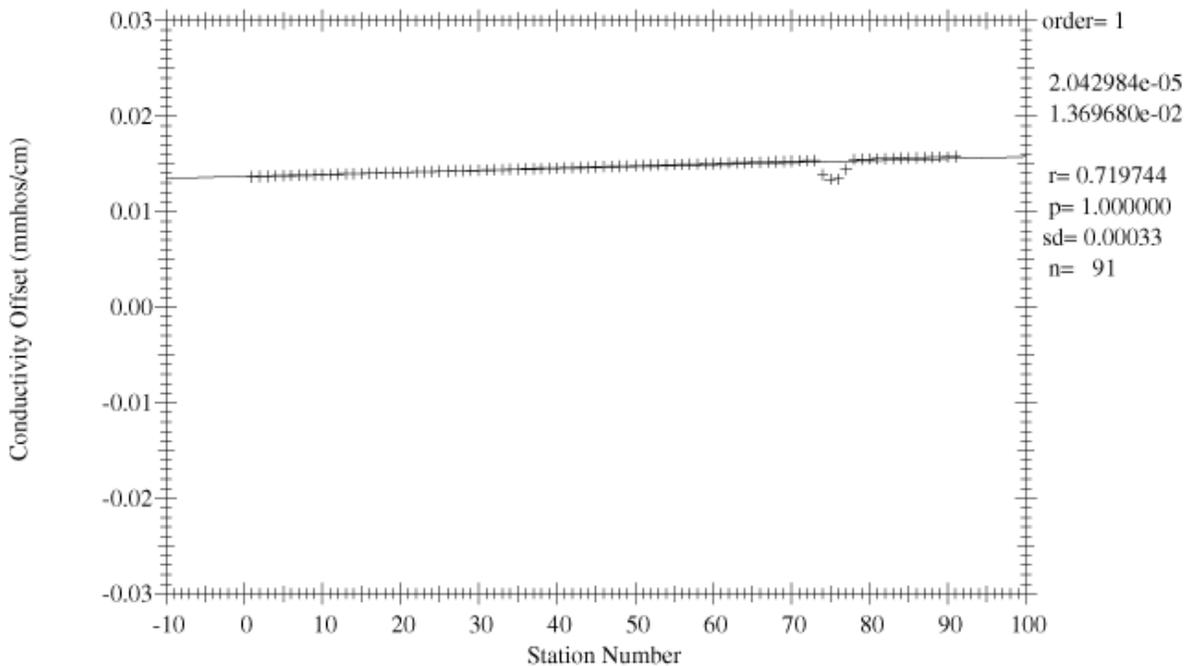
1.7.2. Conductivity

The CTD rosette trip pressure and temperature were used with the bottle salinity to calculate a bottle conductivity. Differences between the bottle and CTD conductivities were then used to derive a conductivity correction as a linear function of conductivity.

Cast-by-cast comparisons showed less than a .002 mmho/cm total drift in the conductivity sensor offset and no slope changes over the entire leg. Conductivity differences were fit to CTD conductivity for each WOCE94-P31 cast, then those slopes were used to determine the mean conductivity slope. The mean conductivity slope correction is summarized in figure 1.7.2.0.



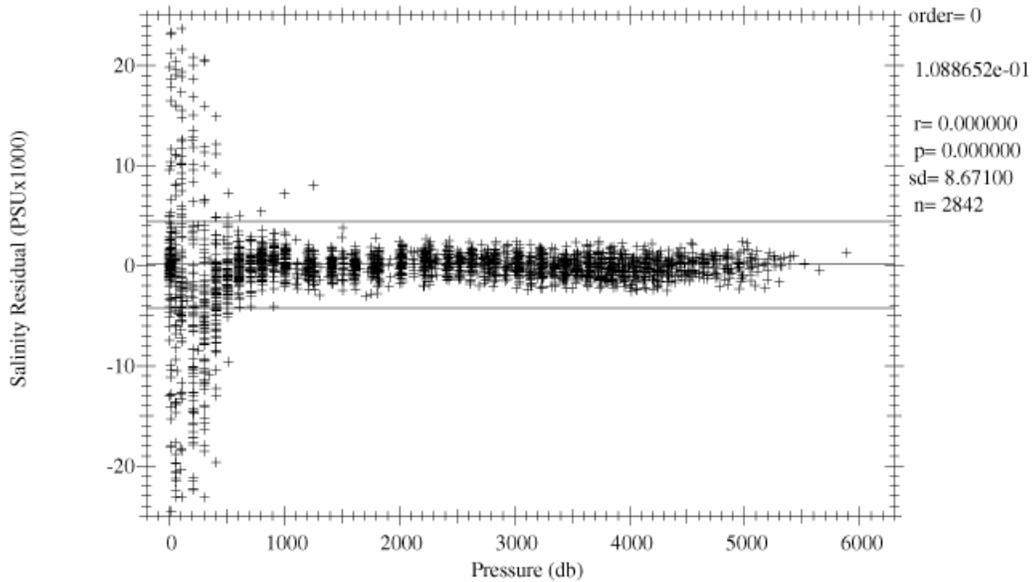
CTD #1 conductivity slopes
Figure 1.7.2.0 CTD #1 conductivity slope corrections by station number.



CTD #1 conductivity offsets
Figure 1.7.2.1 CTD #1 conductivity offsets by station number.

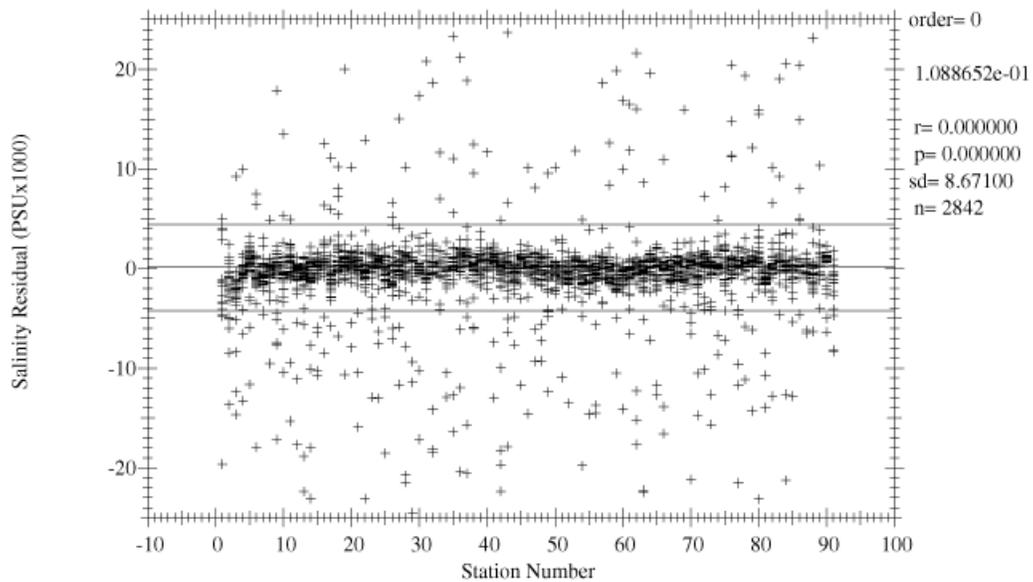
After applying the conductivity slope, residual CTD #1 conductivity offset values were calculated. Smoothed offsets were calculated over all deep casts using bottle conductivities deeper than 1500 db, then applied to each cast. Some offsets were manually re-adjusted to account for discontinuous shifts in the conductivity transducer response or bottle salinities, or to maintain deep theta-salinity consistency from cast to cast. Figure 1.7.2.1 summarizes the final conductivity offsets by station number.

WOCE94-P31 temperature and conductivity correction coefficients are tabulated in Appendix A.



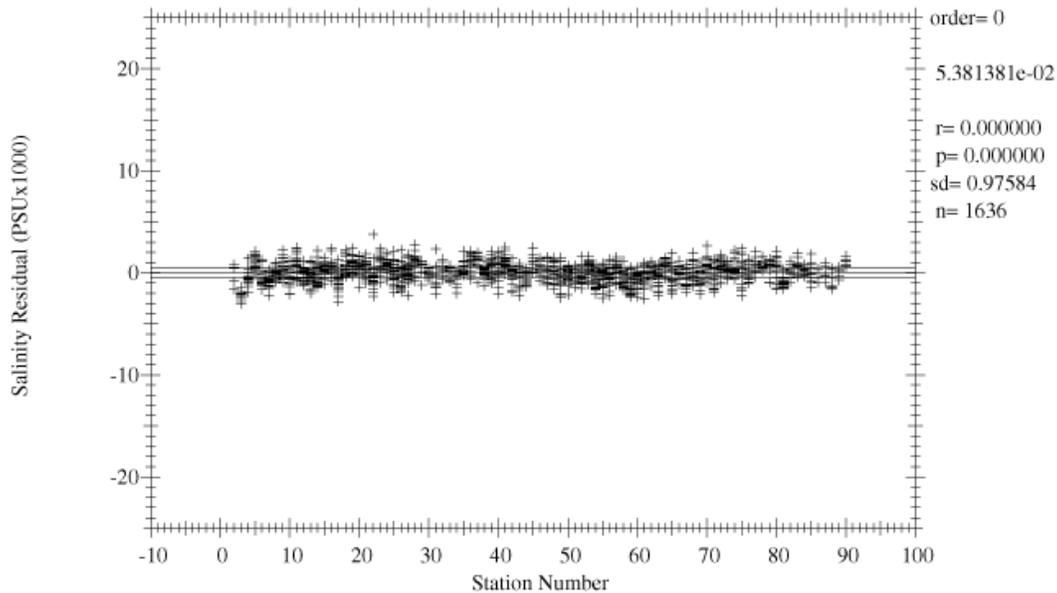
CTD #1, residual salt diffs, after correction

Figure 1.7.2.2 Salinity residual differences vs pressure (after correction).



CTD #1, residual salt diffs, after correction

Figure 1.7.2.3 Salinity residual differences vs station # (after correction).



CTDs #1, residual salt diffs > 1500db, after correction

Figure 1.7.2.4 Deep salinity residual differences vs station # (after correction).

Figures 1.7.2.2, 1.7.2.3 and 1.7.2.4 summarize the residual differences between bottle and CTD #1 salinities after applying the conductivity corrections.

The CTD conductivity calibrations represent a best estimate of the conductivity field throughout the water column. 3-sigma from the mean residual in Figures 1.7.2.3 and 1.7.2.4, or ± 0.0130 PSU for all salinities and ± 0.0015 PSU for deep salinities, represents the limit of repeatability of the bottle salinities (Autosal, rosette, operators and samplers). This limit agrees with station overlays of deep T-S. Within a cast (a single salinometer run), the precision of bottle salinities appears to exceed 0.001 PSU. The precision of the CTD salinities appears to exceed 0.0005 PSU.

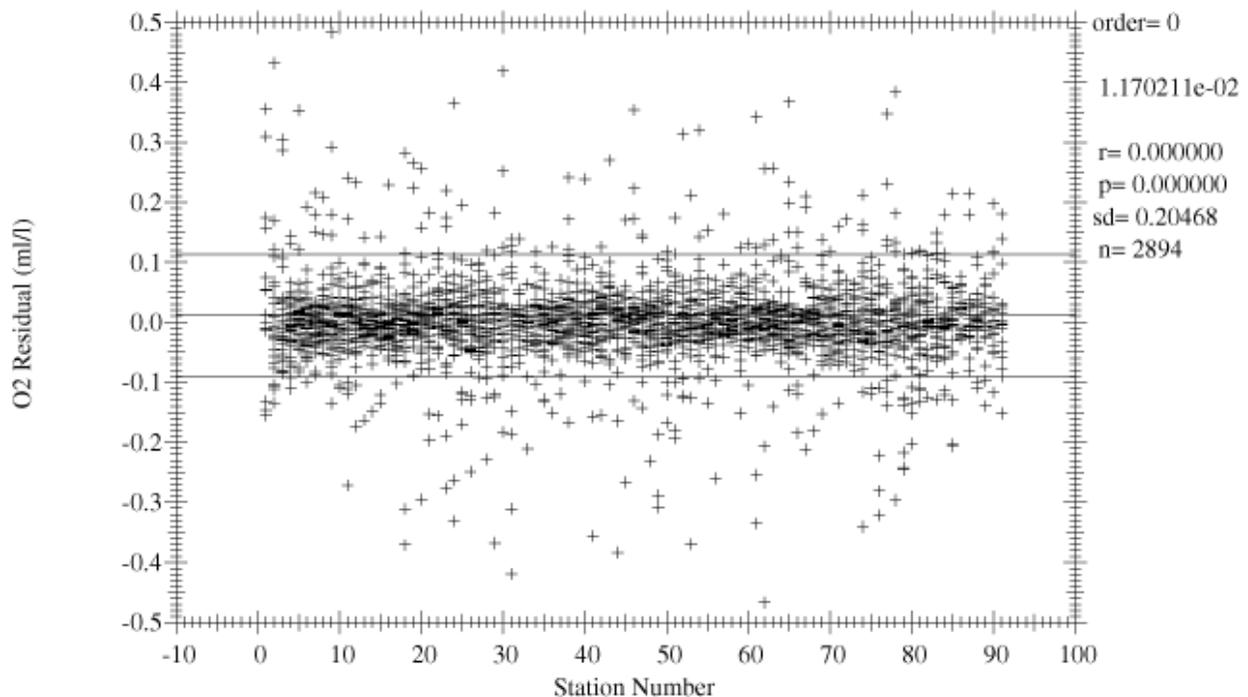
Deep WOCE94-P31 theta-salinity properties were compared with casts at the same or similar locations from the GEOSECS PACIFIC ('73/'74), PCM11 ('92), and WOCE93-P14N ('93) cruises. Although different Wormley standard seawater batches were used for salinity analyses (same standard batch for P14N and P31), the data sets for GEOSECS PACIFIC, P14N and P31 compared very well after corrections for Wormley batch-to-batch differences. However PCM11 is offset from P31 ($\sim .004$ PSU more saline in deep water). It should be noted that another cruise, TEW ('87), was done in similar locations to PCM11. The deep data for that cruise more closely match PCM11, although they are also more saline by about .002 PSU. It is unknown whether or not the TEW data set already had a Wormley batch correction applied, but if not, that data set and PCM11 would very closely agree. At this time we cannot resolve the apparent deep salinity offset between these 2 sets of cruises.

1.7.3. CTD Dissolved Oxygen

There are a number of problems with the response characteristics of the Sensormedics O₂ sensor used in the NBIS Mark III CTD, the major ones being a secondary thermal response and a sensitivity to profiling velocity. Stopping the rosette for as little as half a minute, or slowing down for a bottom approach, can cause shifts in the CTD O₂ profile. Winch stops longer than 1 minute which may have affected CTD oxygen data are documented in Appendix C.

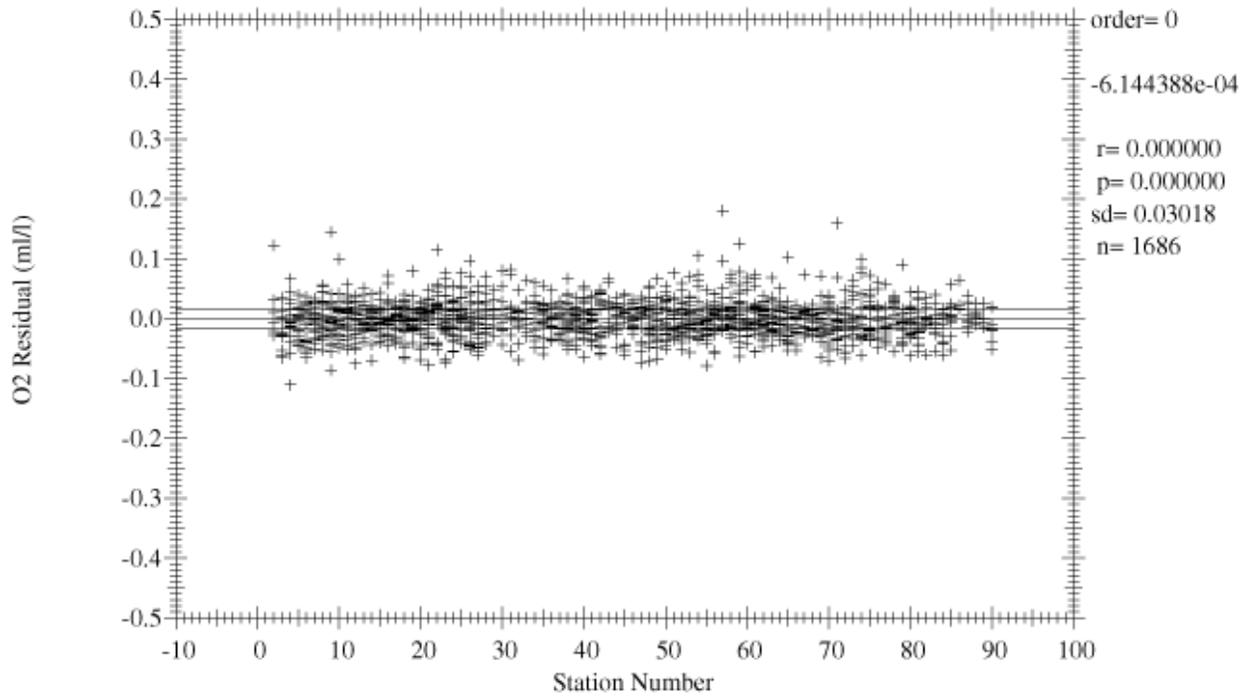
In addition, the sensor requires several seconds in the water before being wet enough to respond properly and there can be bubbles trapped upon entering the water column. This typical going-in-water bubbles/noise makes it difficult to fit CTD O₂ to the bottle data in the surface areas. This problem is compounded if there are long pauses in the near-surface area. Therefore the usefulness of data in the top 100 decibars should be carefully considered.

Because of these problems, up-cast CTD rosette trip data cannot be optimally calibrated to O₂ check samples. Instead, down-cast CTD O₂ data are derived by matching the up-cast rosette trips along isopycnal surfaces. When down-casts were deemed to be unusable (see Appendix C), up-cast CTD O₂ data were processed despite the signal drop-offs typically seen at bottle stops. The differences between CTD O₂ data modeled from these derived values and check samples are then minimized using a non-linear least-squares fitting procedure.



CTD #1, residual o2 diffs, after correction

Figure 1.7.3.0 O₂ residual differences vs station # (after correction).



CTD #1, residual o2 diffs > 1500db, after correction

Figure 1.7.3.1 Deep O₂ residual differences vs station # (after correction).

At least two oxygen sensors were used over the length of the cruise. Figures 1.7.3.0 and 1.7.3.1 show the residual differences between the corrected CTD O₂ and the bottle O₂ (ml/l) for each station.

The standard deviations of 0.205 ml/l for all oxygens and 0.030 ml/l for deep oxygens are only intended as metrics of the goodness of the fits. ODF makes no claims regarding the precision or accuracy of CTD dissolved O₂ data.

The general form of the ODF O₂ conversion equation follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. ODF does not use a digitized O₂ sensor temperature to model the secondary thermal response but instead models membrane and sensor temperatures by low-pass filtering the PRT temperature. In-situ pressure and temperature are filtered to match the sensor response. Time-constants for the pressure response τ_p , and two temperature responses τ_{Ts} and τ_{Tf} are fitting parameters. The sensor current, or O_c , gradient is approximated by low-pass filtering 1st- order O_c differences. This term attempts to correct for reduction of species other than O₂ at the cathode. The time-constant for this filter, τ_{og} , is a fitting parameter. Oxygen partial-pressure is then calculated:

$$O_{pp} = [c_1 O_c + c_2] f_{sat}(S, T, P) e^{(c_3 P + c_4 T_f + c_5 T_s + c_6 (dO_c/dt))} \quad (1.7.3.0)$$

where:

O_{pp} = Dissolved O₂ partial-pressure in atmospheres (atm);

O_c = Sensor current (uamps);

$f_{sat}(S, T, P)$ = O₂ saturation partial-pressure at S, T, P (atm);

S = Salinity at O₂ response-time (PSUs);
T = Temperature at O₂ response-time (°C);
P = Pressure at O₂ response-time (decibars);
P_l = Low-pass filtered pressure (decibars);
T_f = Fast low-pass filtered temperature (°C);
T_s = Slow low-pass filtered temperature (°C);
dO_c/dt = Sensor current gradient (uamps/secs).

WOCE94-P31 CTD O₂ correction coefficients (c1 through c6) are tabulated in Appendix B.

1.8. Bottle Sampling

At the end of each rosette deployment water samples were drawn from the bottles in the following order:

- o CFCs;
- o O₂;
- o pCO₂;
- o Total CO₂;
- o pH;
- o Nutrients;
- o Salinity.

The correspondence between individual sample containers and the rosette bottle from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles. One member of the sampling team was designated the sample cop, whose sole responsibility was to maintain this log and insure that sampling progressed in proper drawing order.

Normal sampling practice included opening the drain valve before opening the air vent on the bottle, indicating an air leak if water escaped. This observation together with other diagnostic comments (e.g., "lanyard caught in lid", "valve left open") that might later prove useful in determining sample integrity were routinely noted on the sample log.

Drawing oxygen samples also involved taking the sample draw temperature from the bottle. The temperature was noted on the sample log and was sometimes useful in determining leaking or mis-tripped bottles.

Once individual samples had been drawn and properly prepared, they were distributed to their respective laboratories for analysis. Oxygen, nutrients and salinity analyses were performed on computer-assisted (PC) analytical equipment networked to Sun SPARC stations for centralized data analysis. The analysts for each specific property were responsible for insuring that their results were updated into the cruise database.

1.9. Bottle Data Processing

The first stage of bottle data processing consisted of verifying and validating individual samples, and checking the sample log (the sample inventory) for consistency. At this stage, bottle tripping problems were usually resolved, sometimes resulting in changes to

the pressure, temperature and other CTD properties associated with the bottle. Note that the rosette bottle number was the primary identification for all samples taken from the bottle, as well as for the CTD data associated with the bottle. All CTD trips were retained (whether confirmed or not), so resolving bottle tripping problems simply consisted of assigning the right rosette bottle number to the right CTD trip level.

Diagnostic comments from the sample log were entered into the computer as part of the quality control procedure. Every potential problem indicated in these computer files was investigated. The data were coded with the results of the investigation.

The second stage of processing began once all the samples for a cast had been accounted for. All samples for bottles suspected of leaking were checked to see if the properties were consistent with the profile for the cast, with adjacent stations, and, where applicable, with the CTD data. All comments from the analysts were examined and turned into appropriate WHP water sample codes. Oxygen flask numbers were verified, as each flask is individually calibrated and significantly affects the calculated O₂ concentration.

The third stage of processing continued throughout the cruise and until the data set was considered "final". Various property-property plots and vertical sections were examined for both consistency within a cast and consistency with adjacent stations. In conjunction with this process the analysts reviewed and sometimes revised their data as additional calibration or diagnostic results became available. Assignment of a WHP water sample code to an anomalous sample value was typically achieved through consensus between analysts and one of the chief scientists.

WHP water bottle quality flags were assigned with the following additional interpretations:

- 2 No problems noted.
- 3 An air leak large enough to produce an observable effect on a sample is identified by a code of 3 on the bottle and a code of 4 on the oxygen. (Small air leaks may have no observable effect, or may only affect gas samples.)
- 4 Bottles tripped at other than the intended depth were assigned a code of 4. There may be no problems with the associated water sample data.
- 9 The samples for this bottle were not drawn.

WHP water sample quality flags were assigned using the following criteria:

- 1 The sample for this measurement was drawn from a bottle, but the results of the analysis were not (yet) received.
- 2 Acceptable measurement.
- 3 Questionable measurement. The data did not fit the station profile or adjacent station comparisons (or possibly CTD data comparisons). No notes from the analyst indicated a problem. The data could be acceptable, but are open to interpretation.
- 4 Bad measurement. Does not fit the station profile, adjacent stations or CTD data. There were analytical notes indicating a problem, but data values were reported. Sampling and analytical errors were also coded as 4.

- 5 | Not reported. There should always be a reason associated with a code of 5, usually that the sample was lost, contaminated or rendered unusable.
- 9 | The sample for this measurement was not drawn.

WHP water sample quality flags were assigned to the CTDSAL (CTD salinity) parameter as follows:

- 2 | Acceptable measurement.
- 3 | Questionable measurement. The data did not fit the bottle data, or there was a CTD conductivity calibration shift during the up-cast.
- 4 | Bad measurement. The CTD up-cast data were determined to be unusable for calculating a salinity.
- 8 | The CTD salinity was derived from the CTD down-cast, matched on an isopycnal surface.

WHP water sample quality flags were assigned to the CTDOXY (CTD O₂) parameter as follows:

- 2 | Acceptable measurement.
- 4 | Bad measurement. The CTD data were determined to be unusable for calculating a dissolved oxygen concentration.
- 5 | Not reported. The CTD data could not be reported, typically when CTD salinity is coded 3 or 4
- 9 | Not sampled. No operational CTD O₂ sensor was present on this cast.

Note that all CTDOXY values were derived from the pressure-series CTD data, typically down-casts. CTD data were matched to the up-cast bottle data along isopycnal surfaces. If the CTD salinity was footnoted as bad or questionable, the CTD O₂ was not reported.

Table 1.9.0 shows the number of samples drawn and the number of times each WHP sample quality flag was assigned for each basic hydrographic property:

Rosette Samples Stations 1-91								
	Reported levels	WHP Quality Codes						
		1	2	3	4	5	8	9
Bottle	3045	0	3006	20	0	0	0	19
CTDSalt	3045	0	3018	1	26	0	0	0
CTDOxy	3018	0	3018	0	0	27	0	0
Salinity	3019	0	2933	58	28	7	0	19
Oxygen	3020	0	2992	2	26	2	0	23
Silicate	3024	0	3003	3	18	0	0	21
Nitrate	3024	0	3006	0	18	0	0	21
Nitrite	3024	0	3006	0	18	0	0	21
Phosphate	3003	0	2734	251	18	21	0	21

Table1.9.0 Frequency of WHP quality flag assignments.

Additionally, all WHP water bottle/sample quality code comments are presented in Appendix D.

1.10. Pressure and Temperatures

All pressures and temperatures for the bottle data tabulations on the rosette casts were obtained by averaging CTD data for a brief interval at the time the bottle was closed on the rosette, then correcting the data based on CTD laboratory calibrations.

The temperatures are reported using the International Temperature Scale of 1990.

1.11. Salinity Analysis

Salinity samples were drawn into 200 ml Kimax high alumina borosilicate bottles after 3 rinses, and were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. As loose inserts were found, they were replaced to insure an airtight seal. Salinity was determined after a box of samples had equilibrated to laboratory temperature, usually within 8-15 hours of collection. During the first week of the expedition, the salinity samples may not have been analyzed for up to 24 hours after collection. The draw time, equilibration time, and per-sample analysis time were logged.

One Guildline Autosal Model 8400A salinometer (55-654) was used to measure salinities. The spare salinometer (57-396) was not used. These were located in a temperature-controlled laboratory. The salinometers were modified by ODF and contained interfaces for computer-aided measurement. A computer (PC) prompted the analyst for control functions (changing sample, flushing) while it made continuous measurements and logged results. The salinometer cell was flushed until successive readings met software criteria for consistency, then two successive measurements were made and averaged for a final result.

The salinometer was standardized for each cast with IAPSO Standard Seawater (SSW) Batch P-122, using at least one fresh vial per cast. The estimated accuracy of bottle salinities run at sea is usually better than 0.002 PSU relative to the particular Standard Seawater batch used. PSS-78 salinity [UNES81] was then calculated for each sample from the measured conductivity ratios, and the results were merged with the cruise database.

The salinometer was set up at a bath temperature of 21°C for the first 18 stations after which time it was changed to 24°C.

3019 salinity measurements were made and 196 vials of standard water were used. Minor temperature instability of the laboratory where the salinometers were located was encountered.

1.12. Oxygen Analysis

Samples were collected for dissolved oxygen analyses soon after the rosette sampler was brought on board and after CFC was drawn. Nominal 125 ml volume-calibrated iodine flasks were rinsed twice with minimal agitation, then filled via a drawing tube, and allowed to overflow for at least 3 flask volumes. The sample temperature was measured with a small platinum resistance thermometer embedded in the drawing tube. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice to assure thorough dispersion of the $\text{MnO}(\text{OH})_2$ precipitate, once immediately after drawing, and then again after 20 minutes. The samples were analyzed within 4-6 hours of collection.

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365 nm wavelength ultra-violet light. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF uses a whole-bottle modified-Winkler titration following the technique of Carpenter [Carp65] with modifications by Culberson et al. [Culb91], but with higher concentrations of potassium iodate standard (approximately 0.012N) and thiosulfate solution (50 gm/l). Standard solutions prepared from pre-weighed potassium iodate crystals were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Several standards were made up during the cruise and compared to assure that the results were reproducible, and to preclude the possibility of a weighing error. Reagent/distilled water blanks were determined to account for oxidizing or reducing materials in the reagents. The auto-titrator generally performed very well.

The samples were titrated and the data logged by the PC control software. The data were then used to update the cruise database on the Sun SPARCstations.

Thiosulfate normalities were calculated from each standardization and corrected to 20°. The 20° normalities and the blanks were plotted versus time and were reviewed for possible problems. New thiosulfate normalities were recalculated after the blanks had been smoothed. These normalities were then smoothed, and the oxygen data were recalculated.

Oxygens were converted from milliliters per liter to micromoles per kilogram using the in-situ temperature. Ideally, for whole-bottle titrations, the conversion temperature should be the temperature of the water issuing from the bottle spigot. The sample temperatures were measured at the time the samples were drawn from the bottle, but were not

used in the conversion from milliliters per liter to micromoles per kilogram because the software was not available. Aberrant drawing temperatures provided an additional flag indicating that a bottle may not have tripped properly.

Oxygen flasks were calibrated gravimetrically with degassed deionized water (DIW) to determine flask volumes at ODF's chemistry laboratory. This is done once before using flasks for the first time and periodically thereafter when a suspect bottle volume is

detected. All volumetric glassware used in preparing standards is calibrated, as is the 10 ml Dosimat buret used to dispense standard iodate solution.

Iodate standards are pre-weighed in ODF's chemistry laboratory to a nominal weight of 0.44xx grams. The exact normality is calculated at sea when the volumetric flask volume and dilution temperature are known. Potassium iodate (KIO_3) is obtained from Johnson Matthey Chemical Co. and is reported by the supplier to be > 99.4% pure. All other reagents are "reagent grade."

3020 oxygen measurements were made. No major problems were encountered with the analyses. There were some early problems with leaks traced to tubing fittings. The analyst had to borrow a flaring tool to refabricate fittings.

1.13. Nutrient Analysis

Nutrient samples were drawn into 45 ml high density polypropylene, narrow mouth, screw-capped centrifuge tubes which were rinsed three times before filling. The tubes were also rinsed with 1.2N HCl before each filling. Standardizations were performed at the beginning and end of each group of analyses (one cast, usually 36 samples) with a set of an intermediate concentration standard prepared for each run from secondary standards. These secondary standards were in turn prepared aboard ship by dilution from dry, pre-weighed primary standards. Sets of 5-6 different concentrations of shipboard standards were analyzed periodically to determine the deviation from linearity as a function of concentration for each nutrient.

Nutrient analyses (phosphate, silicate, nitrate and nitrite) were performed on an ODF-modified 4-channel Technicon AutoAnalyzer II, generally within one hour of the cast. Occasionally some samples were refrigerated at 2 to 6° for a maximum of 4 hours. The methods used are described by Gordon et al. [Gord92], Hager et al. [Hage72], Atlas et al. [Atla71]. The colorimeter output from each of the four channels were digitized and logged automatically by computer (PC), then split into absorbance peaks. All the runs were manually verified.

Silicate is analyzed using the technique of Armstrong et al. [Arms67]. Ammonium molybdate is added to a seawater sample to produce silicomolybdic acid which is then reduced to silicomolybdous acid (a blue compound) following the addition of stannous chloride. Tartaric acid is also added to impede PO_4 color development. The sample is passed through a 15 mm flowcell and the absorbance measured at 820nm. ODF's methodology is known to be non-linear at high silicate concentrations (>120 μM); a correction for this non-linearity is applied in ODF's software.

Modifications of the Armstrong et al. [Arms67] techniques for nitrate and nitrite analysis are also used. The seawater sample for nitrate analysis is passed through a cadmium column where the nitrate is reduced to nitrite. Sulfanilamide is introduced, reacting with the nitrite, then N-(1-naphthyl)ethylenediamine dihydrochloride which couples to form a red azo dye. The reaction product is then passed through a 15 mm flowcell and the

absorbance measured at 540 nm. The same technique is employed for nitrite analysis, except the cadmium column is not present, and a 50 mm flowcell is used.

Phosphate is analyzed using a modification of the Bernhardt and Wilhelms [Bern67] technique. Ammonium molybdate is added to the sample to produce phosphomolybdic acid, then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine sulfate. The reaction product is heated to ~55° to enhance color development, then passed through a 50 mm flowcell and the absorbance measured at 820 nm.

Nutrients, reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure, in-situ salinity, and an assumed laboratory temperature of 25°.

Na₂SiF₆, the silicate primary standard, is obtained from Fluka Chemical Company and Fisher Scientific and is reported by the suppliers to be >98% pure. Primary standards for nitrate (KNO₃), nitrite (NaNO₂), and phosphate (KH₂PO₄) are obtained from Johnson Matthey Chemical Co. and the supplier reports purities of 99.999%, 97%, and 99.999%, respectively.

3024 nutrient analyses were performed. The AutoAnalyzer performed well. However, early on, stations 5-11 had a phosphate problem due to a bad reagent.

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Appendix A

WOCE94-P31: CTD Temperature and Conductivity Corrections Summary

Sta/ Cast	PRT Response Time (secs)	ITS-90 Temperature Coefficients			Conductivity Coefficients		
		corT = t2*T ² + t1*T + t0			corC = c2*C ² + c1*C + c0		
		t2	t1	t0	c2	c1	c0
001/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01365
002/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01368
003/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01370
004/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01372
005/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01375
006/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01377
007/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01379
008/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01382
009/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01384
010/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01386
011/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01389
012/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01391
013/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01393
014/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01396
015/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01398
016/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01400
017/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01403
018/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01405
019/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01407

064/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01513
065/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01515
066/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01518
067/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01520
068/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01522
069/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01525
070/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01527
071/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01529
072/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01532
073/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01534
074/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01387
075/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01339
076/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01341
077/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01444
078/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01546
079/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01548
080/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01551
081/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01553
082/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01555
083/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01558
084/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01560
085/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01562
086/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01565
087/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01567
088/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01569
089/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01572
090/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01574
091/01	.30	2.1836e-05	-8.7083e-04	-1.4825	5.81063e-06	-1.02299e-03	0.01576

Appendix B

Summary of WOCE94-P31 CTD Oxygen Time Constants

Stations	Temperature		Pressure (τ_p)	O ₂ Gradient (τ_{og})
	Fast(τ_{Tf})	Slow(τ_{Ts})		
1-3, 7-13, 15, 16, 18, 20, 21, 23, 25-30, 32-35, 37-43, 47-54, 57-60, 64-67, 69, 74, 75, 78, 81-83, 86, 89-91	30.0	400.0	20.0	16.0
4, 17, 24, 45, 46, 62, 63, 71, 73, 76	32.0	363.0	19.4	60.0
5, 6, 14, 19, 22, 31, 36, 44, 55, 56, 61, 68, 70, 72, 77, 79, 80, 84, 85, 87, 88	10.0	400.0	16.0	16.0

WOCE94-P31: Conversion Equation Coefficients for CTD Oxygen
(refer to Equation 1.7.3.0)

Sta/ Cast	O _c Slope (c1)	Offset (c2)	P _i coeff (c3)	T _f coeff (c4)	T _s coeff (c5)	(dO _c /dt)coeff (c6)
001/01	6.10794e-04	1.53419e-01	9.57292e-05	4.23545e-03	-1.87935e-02	6.21885e-06
002/01	6.10794e-04	1.53419e-01	9.57292e-05	4.23545e-03	-1.87935e-02	6.21885e-06
003/01	8.91765e-04	5.34336e-02	1.03889e-04	3.45053e-03	-2.92591e-02	-3.14431e-04
004/01	8.75558e-04	3.35896e-02	1.30740e-04	2.83053e-03	-2.85068e-02	3.34791e-04
005/01	7.87388e-04	7.49877e-02	1.21083e-04	1.43864e-03	-2.43675e-02	3.69296e-05
006/01	7.91966e-04	7.39058e-02	1.18824e-04	6.50720e-03	-2.64112e-02	1.27646e-05
007/01	8.12441e-04	6.81542e-02	1.17566e-04	6.33718e-03	-2.66179e-02	-6.84325e-05
008/01	1.08212e-03	-5.17083e-02	1.44446e-04	1.04624e-03	-3.28048e-02	7.68964e-04
009/01	6.48761e-04	1.21659e-01	1.17704e-04	1.36231e-03	-1.88743e-02	1.05318e-03
010/01	1.03617e-03	-2.28091e-02	1.33047e-04	1.69951e-03	-3.09805e-02	-3.87410e-05
011/01	9.89556e-04	-4.81668e-03	1.32353e-04	4.89604e-03	-3.04782e-02	-1.18690e-05
012/01	1.20836e-03	-1.00356e-01	1.52948e-04	4.33520e-03	-3.73519e-02	-2.18134e-04
013/01	8.28893e-04	6.14208e-02	1.22072e-04	4.47389e-03	-2.64473e-02	-1.39109e-06
014/01	7.12002e-04	9.82494e-02	1.22337e-04	4.62229e-03	-2.31299e-02	-1.49965e-05
015/01	8.66230e-04	4.02245e-02	1.28943e-04	3.36951e-03	-2.67112e-02	-2.18174e-05
016/01	7.51666e-04	7.59790e-02	1.30830e-04	4.43366e-03	-2.38260e-02	2.22642e-05
017/01	8.35133e-04	5.45487e-02	1.25781e-04	-4.14808e-04	-2.39449e-02	-7.60570e-06
018/01	9.95943e-04	-1.64935e-03	1.31879e-04	6.30676e-03	-3.53809e-02	2.79633e-05
019/01	9.23951e-04	1.41047e-02	1.33051e-04	-1.45033e-03	-2.43496e-02	2.63620e-05
020/01	9.78878e-04	-1.49006e-02	1.44262e-04	4.02130e-03	-3.01228e-02	1.47716e-04
021/01	9.72238e-04	2.65003e-03	1.32986e-04	4.08644e-03	-3.23094e-02	1.85353e-05
022/01	7.83339e-04	6.70166e-02	1.27559e-04	2.00672e-03	-2.26502e-02	-6.71942e-06
023/01	1.03732e-03	-3.19868e-02	1.43210e-04	1.72666e-03	-3.05402e-02	9.26865e-06
024/01	9.04874e-04	1.96096e-02	1.34412e-04	1.23438e-02	-3.40277e-02	-1.12339e-04
025/01	8.95241e-04	2.83570e-02	1.31934e-04	1.82714e-03	-2.70774e-02	-1.05211e-05
026/01	1.18265e-03	-7.02414e-02	1.39635e-04	8.78837e-03	-4.05279e-02	-1.61044e-05
027/01	9.53597e-04	1.52372e-02	1.28375e-04	1.72020e-02	-4.13093e-02	2.61836e-06
028/01	7.42626e-04	9.11398e-02	1.17778e-04	7.26979e-03	-2.60373e-02	-3.57024e-06
029/01	8.13507e-04	7.63240e-02	1.12686e-04	1.18231e-02	-3.54048e-02	-3.14853e-05
030/01	9.01234e-04	4.21229e-02	1.12906e-04	2.35453e-03	-2.78129e-02	-3.15008e-06
031/01	1.10587e-03	-4.30597e-02	1.29619e-04	-1.29893e-03	-2.87514e-02	1.08037e-05
032/01	6.40185e-04	1.20206e-01	1.18908e-04	1.13248e-02	-2.58221e-02	3.69099e-04
033/01	6.44106e-04	1.30237e-01	1.05635e-04	1.33116e-02	-2.81024e-02	9.26303e-06
034/01	7.86121e-04	7.31146e-02	1.17905e-04	4.05807e-03	-2.50740e-02	1.99444e-03
035/01	6.73991e-04	1.14141e-01	1.12403e-04	1.07034e-02	-2.72089e-02	-1.34256e-05
036/01	7.57370e-04	7.78460e-02	1.25140e-04	5.52912e-03	-2.59748e-02	6.05625e-06
037/01	7.81469e-04	6.88680e-02	1.26026e-04	6.42016e-03	-2.67557e-02	1.37245e-06
038/01	7.63078e-04	8.19975e-02	1.20648e-04	7.45751e-03	-2.69428e-02	2.49885e-05
039/01	9.67699e-04	6.06414e-03	1.31660e-04	2.23504e-03	-2.88260e-02	-1.50161e-03
040/01	1.21456e-03	-7.25460e-02	1.32210e-04	7.59853e-04	-3.42779e-02	9.04242e-06
041/01	9.10498e-04	1.13509e-02	1.39786e-04	5.19827e-03	-2.75547e-02	7.93857e-06

042/01	9.82410e-04	-4.77592e-03	1.35629e-04	1.63698e-03	-2.81105e-02	4.85789e-05
043/01	1.03158e-03	-2.02732e-02	1.37044e-04	3.60128e-03	-3.14207e-02	3.05438e-05
044/01	8.31410e-04	5.29444e-02	1.28041e-04	3.58923e-04	-2.44292e-02	1.35726e-05
045/01	9.27689e-04	2.65429e-02	1.24339e-04	4.76677e-03	-3.15064e-02	1.59162e-05
046/01	8.15747e-04	4.68693e-02	1.34642e-04	-2.70882e-03	-2.09033e-02	5.24326e-05
047/01	9.33846e-04	8.92297e-03	1.38510e-04	1.94305e-04	-2.54686e-02	2.60674e-05
048/01	1.11185e-03	-5.27496e-02	1.43328e-04	-2.09923e-03	-2.94079e-02	6.17007e-04
049/01	8.93427e-04	2.44536e-02	1.34266e-04	6.24553e-03	-2.82641e-02	-2.54065e-05
050/01	8.47820e-04	3.81733e-02	1.35847e-04	-6.53302e-03	-1.93142e-02	4.07083e-06
051/01	9.14163e-04	1.59994e-02	1.36837e-04	-4.04792e-04	-2.68395e-02	4.10790e-05
052/01	8.96641e-04	2.04602e-02	1.36968e-04	5.04682e-03	-2.81215e-02	-8.89585e-06
053/01	1.00713e-03	-1.22087e-02	1.35444e-04	6.62358e-03	-3.27867e-02	3.46041e-06
054/01	1.03019e-03	-2.37083e-02	1.38948e-04	2.37698e-04	-2.95586e-02	7.30090e-05
055/01	1.00018e-03	-1.62487e-02	1.37058e-04	7.92176e-04	-2.93374e-02	5.21999e-06
056/01	9.48703e-04	-4.45366e-03	1.40596e-04	9.07545e-03	-3.49919e-02	-5.42536e-06
057/01	9.94938e-04	-1.20535e-02	1.36084e-04	2.12826e-04	-2.72413e-02	-4.37442e-06
058/01	9.51305e-04	-4.48873e-03	1.41945e-04	-7.83406e-04	-2.66667e-02	1.27073e-06
059/01	9.52725e-04	3.52495e-03	1.34780e-04	3.98609e-03	-2.96949e-02	-3.21413e-05
060/01	1.02314e-03	-2.43931e-02	1.38951e-04	1.72724e-03	-2.91050e-02	7.09613e-06
061/01	1.02801e-03	-2.59730e-02	1.38533e-04	4.81448e-04	-2.82726e-02	-5.61772e-06
062/01	9.12178e-04	8.98292e-03	1.40148e-04	7.31833e-03	-3.01042e-02	5.07886e-05
063/01	9.19482e-04	1.10780e-02	1.36866e-04	3.52037e-03	-2.98212e-02	4.32223e-05
101/01	9.23680e-04	1.31505e-02	1.36020e-04	-1.42210e-03	-2.65788e-02	-2.18032e-05
102/01	8.73843e-04	2.64529e-02	1.38791e-04	-4.87359e-04	-2.48400e-02	-6.37009e-06
064/01	1.00724e-03	-1.23725e-02	1.37137e-04	1.30423e-03	-3.10986e-02	-2.82715e-05
065/01	9.21076e-04	1.17373e-02	1.38758e-04	-4.14355e-04	-2.62442e-02	4.16222e-05
066/01	8.47832e-04	5.09422e-02	1.21727e-04	3.09951e-03	-2.70342e-02	-5.47857e-04
067/01	9.98803e-04	-1.54176e-02	1.37630e-04	-3.19498e-03	-2.67395e-02	-2.76187e-06
068/01	7.97906e-04	5.77473e-02	1.30486e-04	-1.06666e-03	-2.25602e-02	1.45093e-05
069/01	9.87755e-04	-1.43274e-02	1.43180e-04	-1.05622e-03	-2.75633e-02	-1.79734e-06
070/01	9.03967e-04	2.04488e-02	1.34109e-04	1.85712e-03	-2.64075e-02	2.58931e-03
071/01	9.77817e-04	9.46549e-05	1.32688e-04	5.71185e-03	-3.35156e-02	-1.64437e-05
072/01	9.67558e-04	-3.23327e-03	1.40736e-04	-4.97599e-03	-2.55564e-02	2.31904e-03
073/01	8.40351e-04	3.02846e-02	1.47385e-04	-4.24923e-04	-2.60118e-02	-1.53036e-04
074/01	1.70043e-03	-4.36042e-02	1.11078e-04	9.02179e-03	-4.27803e-02	-9.32946e-06
075/01	1.57824e-03	-4.41172e-02	1.34268e-04	1.26492e-03	-3.54222e-02	2.42794e-05
076/01	1.33434e-03	-3.23606e-02	1.55111e-04	7.98396e-03	-3.37607e-02	-5.88887e-05
077/01	1.35051e-03	-8.09733e-03	1.29706e-04	4.25884e-03	-3.38899e-02	5.41412e-05
078/01	1.28072e-03	-1.01799e-02	1.37245e-04	-2.34975e-02	1.89965e-03	-5.64111e-05
079/01	1.34924e-03	-1.58629e-02	1.34151e-04	4.95123e-03	-3.29211e-02	-3.08392e-05
080/01	1.37201e-03	-2.16346e-02	1.39685e-04	5.83392e-03	-3.42664e-02	-9.86610e-06
081/01	1.44341e-03	-3.53834e-02	1.37287e-04	5.20269e-03	-3.51165e-02	4.13808e-06
082/01	1.24457e-03	2.51073e-02	1.21063e-04	3.11932e-03	-3.11532e-02	2.84150e-07
083/01	1.48006e-03	-5.08391e-02	1.41664e-04	1.07640e-03	-3.37531e-02	-3.28229e-04
084/01	1.54089e-03	-6.82107e-02	1.43193e-04	2.68106e-03	-3.56601e-02	-1.30906e-05
085/01	1.25995e-03	5.44413e-02	7.81035e-05	4.17071e-03	-3.10060e-02	-1.73968e-05

086/01	1.39145e-03	3.28507e-02	5.97387e-05	5.34880e-03	-3.63284e-02	6.34441e-06
087/01	1.18930e-03	3.28800e-02	1.06903e-04	-2.21495e-02	2.23348e-03	-3.71357e-05
088/01	8.30799e-04	1.65081e-01	6.88561e-05	-2.81239e-03	-1.56678e-02	-1.50691e-05
089/01	1.38667e-03	1.48226e-02	8.53667e-05	2.78418e-03	-3.40384e-02	7.18365e-06
090/01	8.59579e-04	2.07863e-01	1.90086e-05	1.47026e-03	-1.98218e-02	5.49714e-06
091/01	1.00065e-03	2.46397e-01	-9.52290e-05	6.12425e-06	-2.34098e-02	2.14526e-05

Appendix C

WOCE94-P31: CTD Processing Comments

Key to Problem/Comment Abbreviations	
OQ	bottom area ctdoxy questionable - probably due to slowdowns for bottom approach
OS	surface ctdoxy fit questionable
SS	probable sea slime on conductivity sensor

Key to Solution/Action Abbreviations	
DO	despiked oxygen
NA	no action taken
O3	quality code 3 oxygen in .ctd file for pressures specified
O4	quality code 4 oxygen in .ctd file for pressures specified
UP	used up-cast data for final pressure-series data

Cast	Problem/Comment	Solution/Action
998/01	test cast	cast not processed nor reported
001/01	could not get ctdoxy to fit	used ctdoxy coefficients from 002/01
	1.2 min. stop at 2 db	NA
002/01	1.7 min. stop at 2 db	NA
	ctdoxy offset	O3 2540-2640db
	OQ	O3 2666-2680db
003/01	1.4 min. stop at 2 db	NA
004/01	2.6 min. stop at 2 db	NA
	1.2 min stop 1472 db	O3 1470-1750db
005/01	OQ	O3 3980-4032db
007/01	1.4 min. stop at 2 db	NA
008/01	OQ	O3 4180-4240db
009/01	poor ctdoxy fit 2600-3100db but upcast showed a lot of structure in that area	NA
	OQ	O3 4390-4510db, 4540-4566db
010/01	OQ	O3 4440-4492db
011/01	2.1 min. stop at 2 db	NA
	OQ	O3 4760-4820db
012/01	ctdoxy bad section	DO 170-225 db, O3 166-244db
	OQ	O3 4560-4650db
013/01	ctdoxy bad section	DO 210-242 db, O3 210-242db
	OQ	O3 4240-4280db, 4350-4430db

015/01	OQ	O3 4850-4934db
016/01	OQ	O3 4670-4730db, 4940-4986db
017/01	OQ	O3 5150-5190db
018/01	7.0 min stop 212 db	O3 200-350db
020/01	1.4 min stop 632 db	O3 630-660db
	OQ	O3 5140-5200db
021/01	1.2 min. stop at 2 db	NA
	6.0 min. stop at 160 db	NA
	OQ	O3 5330-5380db
023/01	ctdoxy cutouts 194-194 db	DO 150-206 db
	1.2 min stop 716 db	O3 710-820db
	OQ	O3 5580-5710db, 5760-5860db
024/01	oxy cutouts 114-232 db - couldn't despiked	O3 0-104db,O4 106-260db,O3 262-270db
025/01	ctdoxy bad section	DO 65-105 db,O3 0-50db
026/01	7.8 min stop 180 db	DO 110-210 db, O3 0-280db
	ctdoxy area looks suspicious on ctdoxy overlays	O3 340-360db
027/01	ctdoxy bad sections	DO 70-95 & 110-120 db
	4.1 min stop 300 db	O3 300-326db
	OQ	O3 4760-4880db
028/01	7.0 min stop 102 db	DO 120-190 db, O3 90-150db
029/01	8.5 min stop 202 db	DO 170-200 db, O3 0-270db
031/01	1.6 min. stop at 10 db	NA
033/01	ctdoxy area looks suspicious on ctdoxy overlays	O3 620-670db
034/01	OS	O3 0-100db
035/01	ctdoxy bad section	DO 70-200 db, O3 0-110db
036/01	oxy cutouts 118-136 db	DO 60-140 db
	OQ	O3 4110-4134db
039/01	OQ	O3 5040-5090db
040/01	OQ	O3 4736-4820db
041/01	ctdoxy area looks suspicious on ctdoxy overlays	O3 90-200db
043/01	1.9 min. stop at 948 db	NA
046/01	OS	O3 0-100db
050/01	conductivity offset	offset salinity +.006 1842-1890 db
051/01	conductivity dropouts	despiked conductivity 4646-4700 db
	3.1 min. stop at 4700 db	NA
054/01	OS	O3 0-90db
	1.6 min. stop at 1108 db	NA
	OQ	O3 5196-5250db
056/01	ctdoxy bad section	DO 20-50 db
	3.8 min stop 372 db	O3 340-380db
	"low" ctdoxy bulge approx. 2000 db is feature on both dn+up casts	NA

057/01	OQ	O3 5150-5258db
058/01	ctdoxy cutout at 38 db conductivity offset	DO 10-60 db, O3 0-80db offset salinity +.003 4110-4122 db
059/01	"high" ctdoxy bulge approx. 600 db is feature on both dn+up casts	NA
060/01	similar deep ctdoxy structure on both dn+up casts	NA
061/01	ctdoxy drop-off OQ	O3 4170-4220db O3 4336-4362db
063/01	1.3 min. stop at 2 db	NA
101/01	Samoa Passage station (non- WOCE cast) OQ	NA O3 5080-5320db
102/01	Samoa Passage station (non- WOCE cast) OQ	NA O3 4950-5022db
065/01	OS OQ	O3 0-70db O3 3830-3850db
066/01	1.0 min. stop at 3 db O2 sensor possibly fouled? OQ	NA O3 3406-3452db O3 3480-3510db
068/01	4.2 min. stop at 3 db	NA
071/01	features approx. 800 & 2000 db on both dn+up casts	NA
072/01	ctdoxy bad section 0-130 db; oxy cutouts top 108 db features approx. 600 & 1800 db on both dn+up casts OQ	O4 0-130db NA O3 4160-4240db
073/01	ctdoxy bad section 0-190 db; oxy cutouts top 168 db 1.6 min stop 578 db - ctdoxy fit all right, though not great	O4 0-180db, O3 182-200db NA
074/01	new CTD O2 sensor oxy cutouts 1714-2006 db OQ	NA DO 1660-2100 db O3 4100-4120db
075/01	new CTD O2 sensor	NA
078/01	conductivity offset approx. 900 db down OQ	UP O3 3330-3384db
079/01	feature approx. 800 db on both dn+up casts	NA
080/01	a lot of structure 400-1400 db on both dn+up casts OQ	NA O3 4012-4018db
081/01	OQ	O3 3870-3944db
086/01	OQ	O3 1600-1636db
087/01	300 db yo-yo near surface on down cast (ADCP experiment)	UP
088/01	OQ	O3 2600-2618db

089/01	SS	despiked temperature & conductivity 8-10 db O3 2206-2216db O3 1416-1456db
	OQ	
091/01	OQ	

Appendix D

WOCE94-P31: Bottle Quality Comments

Remarks for deleted samples, missing samples, PI data comments, and WOCE codes other than 2 from WOCE P31 TN031. Investigation of data may include comparison of bottle salinity and oxygen data with CTD data, review of data plots of the station profile and adjoining stations, and rereading of charts (i.e., nutrients). Comments from the Sample Logs and the results of ODF's investigations are included in this report. Units stated in these comments are degrees Celsius for temperature, Practical Salinity Units for salinity, and unless otherwise noted, milliliters per liter for oxygen and micromoles per liter for Silicate, Nitrate, and Phosphate. The first number before the comment is the cast number (CASTNO) times 100 plus the bottle number (BTLNBR).

STATION 001

- 114 Delta-S at 46db is -0.0248. Autosal diagnostics indicate 3 tries to get a good reading, sometimes indicating a problem with the samples. Variation in CTD salinity uptrace at this sampling point, because the package has stopped to trip a bottle. Footnote CTD salinity questionable, value is probably good on its own merit just not to compare with the bottle data. No CTDO is calculated because the CTD Salinity is coded bad.
- 101 Sample log: "Probably contaminated with air because of delays with thermometers." Bottle O2 looks good compared to CTDO and subsequent stations.

STATION 002

- 123 Sample log: "Top o-ring not seated." Delta-S at 13db is 0.003 high. Other water samples also look ok.
- 121 Sample log: "Top o-ring not seated." Delta-S at 105db is 0.007. Other water samples also look ok.
- 101 CTD data processor: "CTD oxygen values questionable 2666 to 2680 db."
- 101-104 Nutrients: "Reran 1-5 for PO4 but all unreadable." Footnote PO4 lost.

STATION 003

- 108 Delta-S at 2008db is -0.0027. Salinity is also a little low compared with adjoining stations. Footnote salinity questionable.

STATION 004

- Cast 1 Nutrients: "PO4, dipper probe not quite adjusted-have to help it at each tube advance." Some PO4 data lost and not reported.
- 129-133 See Cast 1 PO4 comment. Footnote PO4 lost.
- 120 CTD data processor: "CTD oxygen values questionable 1470 to 1750 db."

- 110-121 See Cast 1 PO4 comment. Footnote PO4 lost.
105 Sample log: "Bottom o-ring." Assume bottom o-ring out of groove. Delta-S at 3530db is 0.0128. Nutrients also indicate leak. Footnote bottle leaking, samples bad.

STATION 005

- Cast 1 PO4s questionable due to bad reagent (PO4 Moly).
135 On 9406, chemist (RVS) flagged oxygen flask 958 because it had a bad stopper fit. The old flask volume of 134.59 was used for this cruise and oxygen is acceptable.
121 Sample log: "Air leak, vent not tight enough" Delta-S at 1406db is 0.000. Other water samples also ok.
121-136 See Cast 1 PO4 comment. Footnote PO4 questionable.
120 Sample log: "o-ring out, top". Delta-S at 1606db is 0.209. Other water samples also indicate leak. Footnote bottle leaking, all samples bad.
115 Hydro O2 appears 0.16 high at 2614db. Other water samples ok. This O2 run aborted after sample 118 due dosimat bubble problem. May have affected this sample. Footnote O2 bad.
102 Hydro O2 appears 0.05 high at 3929db. Other water samples ok. This O2 run aborted after sample 118 due dosimat bubble problem. May have affected this sample. Footnote O2 bad.
101 CTD data processor: "CTD oxygen values questionable 3980 to 4032 db."
101-119 See Cast 1 PO4 comment. Footnote PO4 questionable.

STATION 006

- 101-136 PO4s questionable due to bad reagent (PO4 Moly). Footnote PO4 questionable.

STATION 007

- 109 Delta-S at 3329db is -0.003. Autosal diagnostics do not indicate a problem. Salinity also appears low compared with adjoining stations. Footnote salinity questionable.
101-136 PO4s questionable due to bad reagent (PO4 Moly). Footnote PO4 questionable.

STATION 008

- Cast 1 There appears to be a salinity operator error. Operator accepted that there was a drift. When in fact, it appears that the ending Standard Seawater was bad. Corrected file to have no drift and data is acceptable.
102 CTD data processor: "CTD oxygen values questionable 4180 to 4240 db."
101-136 PO4s questionable due to bad reagent (PO4 Moly). Footnote PO4 questionable.

STATION 009

- 133 Sample log: "Air leak, vent not tight" Delta-S .004 low. Other water samples also look ok.
125 Oxygen lost, problem with computer files and sample could not be saved.

- 102 CTD data processor: "CTD oxygen values questionable 4390 to 4510 db."
101 Delta-S at 4565db is 0.0033. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Also higher than adjoining stations. Other samples appear to be okay. Footnote salinity questionable.
CTD data processor: "CTD oxygen values questionable 4540 to 4566 db."
101-136 PO4s questionable due to bad reagent (PO4 Moly). Footnote PO4 questionable.

STATION 010

- 105 Salinity: "Sample lost due to salinometer problems."
104 Salinity: "Sample lost due to salinometer problems."
103 Salinity a little low compared with CTD and adjoining stations. Delta-S at 4344db is -0.0018. Not within precision of other salinities. Analyst had a problem with the autosal on the next couple of samples, perhaps this was affected too. Footnote salinity questionable.
101 CTD data processor: "CTD oxygen values questionable 4440 to 4492 db."
101-136 PO4s questionable due to bad reagent (PO4 Moly). See Cast 1 PO4 comment. Footnote PO4 questionable.

STATION 011

- 131 Delta-S 1.97 low at 3-4db. No notes. Other water samples ok. Appears wrong suppression setting used on Autosal run. Assume 2.01454 2cr vs 1.91454 2cr gives Delta-S at 305db is -0.0095 in high gradient.
101-136 PO4s questionable due to bad reagent (PO4 Moly). Footnote PO4 questionable.

STATION 012

- 132 CTD data processor: "CTD oxygen values questionable 166 to 244 db."
103 Delta-S at 4429db is -0.0021. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.
101 CTD data processor: "CTD oxygen values questionable 4560 to 4650 db."

STATION 013

- Cast 1 Sample log: "Appeared to be no bottles open at surface, but pylon between number 36 & number 1. Problem likely between 21 & 22. lots of dead critter on bottles & inside caught on lanyard." Had computer problems during surface trip. Surface bottle at 2.5db. Data look ok. It appears that bottle was eventually tripped at the surface. The data does not indicate that any of the other bottles tripped prematurely or late.
103 CTD data processor: "CTD oxygen values questionable 4240 to 4280 db." Delta-S at 4243db is -0.002.
101 CTD data processor: "CTD oxygen values questionable 4350 to 4430 db."

STATION 014

- Cast 1 There appears to be a salinity operator error. Probably a bad beginning standardization. Applied a +0.00019 conductivity corrected to all salinity values, accepted no drift and data is acceptable.

106 Sample log: "Leaking from spigot before vent opened." Delta-S .001 high. Other water samples also look ok.

STATION 015

101-102 CTD data processor: "CTD oxygen values questionable 4850 to 4934 db."

STATION 016

106 Sample log: "Top o-ring not seated." Delta-S at 4545db is 0.002. Oxygen appears .02 high tho CTDO has inversions this level. PO4 & SIL appear slightly low. CTD Processor also indicated that this salinity was high. Footnote salinity questionable.

102 CTD data processor: "CTD oxygen values questionable 4940 to 4986 db."

101 Delta-S at 5017db is 0.0025. Autosal diagnostics do not indicate a problem. Salinity is high compared with adjoining stations vs. potemp. Footnote salinity questionable.

STATION 017

131 Salinity: "Analyst couldn't get 2 results near enough to one another before running out of sample, no salinity value to report."

123 Delta-S at 2009db is -0.0034. No Autosal diagnostics indicating a problem. Footnote salinity questionable.

111 Delta-S at 4142db is -0.0023. No Autosal diagnostics indicating a problem. Accept salinity as is.

101 Delta-S at 5198db is 0.0029. No Autosal diagnostics indicating a problem. Footnote salinity questionable.

STATION 018

Cast 1 There appears to be a salinity operator error. Operator accepted that there was a drift. When in fact, it appears that the ending Standard Seawater was bad. Corrected file to have no drift and data is better. Analyst (non-ODF personnel) still had other problems. Salinity analyst: "Temperature in lab fluctuating between 19.5 and 23 deg C during measurement the entire measurement period. I ran out of samples on 13, 25 and 31 before getting an agreeable measurement.

131 Salinity:"Analyst ran out of sample before getting an agreeable measurement." Salinity not reported.

131-132 CTD data processor: "CTD oxygen values questionable 200 to 350 db."

125 Salinity:"Analyst ran out of sample before getting an agreeable measurement." Salinity not reported.

113 Salinity:"Analyst ran out of sample before getting an agreeable measurement." Salinity not reported.

109 Delta-S at 4339db is -0.0032. Salinity lower than adjoining stations. Footnote salinity questionable.

101 Delta-S at 5178db is 0.0028. Autosal diagnostics do not indicate a problem. High compared with adjoining stations at the same potemp. Footnote salinity questionable.

STATION 019

116 Delta-S at 3633db is 0.0027. Autosal diagnostics do not indicate a problem. Does not agree with adjoining stations. Footnote salinity questionable.

STATION 020

122 Delta-S at 2263db is 0.0025. Autosal diagnostics do not indicate a problem. Also higher than adjoining stations. Footnote salinity questionable.

116 Delta-S at 3633db is 0.0028. Autosal diagnostics do not indicate a problem. Also higher than adjoining stations. Footnote salinity questionable.

113 Delta-S at 3935db is 0.0028. Autosal diagnostics do not indicate a problem. Also higher than adjoining stations. Footnote salinity questionable.

112 Delta-S at 4035db is 0.0029. Autosal diagnostics reports 3 tries before getting a good reading, indicating a possible problem with the sample. Footnote salinity questionable.

STATION 022

136 Sample log: "Lanyard broke on 36, but was seen to close at the surface."
Delta-S at 2db is -0.0002 at 2db. Other water samples also ok. None 940209/dm

131 Delta-S at 306db is -0.0365. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

128 CTD processor: "CTD oxygen values questionable 710 to 820 db."

105 Delta-S at 4748db is -0.0024. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.

STATION 023

136 Sample log: "bottom o-ring leaking" Delta-S .003 high at 3db. Other water samples also ok.

128 CTD data processor: "CTD oxygen values questionable 710 to 820 db."

116 Sample log: "top o-ring in the bottle." Delta-S at 3634db is 0.0027. Other water samples look ok. Footnote salinity questionable.

114 Delta-S at 4041db is 0.0026. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

103 CTD data processor: "CTD oxygen values questionable 5580 to 5710 db."

102 Sample log: "Bottom oring leaking" No water samples drawn. CTD data processor: "CTD oxygen values questionable 5760 to 5860 db."

STATION 024

136-134 CTD data processor: "CTD oxygen values questionable 0 to 104 db."

134 Delta-S at 57db is -0.1313. Appears that salinity was drawn from bottle 35. Footnote salinity bad.

132 Delta-S at 205db is -0.048. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

- 132-133 CTD data processor: "CTD oxygen values bad 106 to 260 db." Couldn't despiked CTDoxy."
- 115 Delta-S at 3830db is 0.0033. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.
- 114 Top lanyard broken. Data indicates bottle closed about 300m deeper than intended. Delta-S at 3932db is 0.0064. Footnote bottle leaking, all samples bad.

STATION 025

- 135-136 CTD data processor: "CTD oxygen values questionable 0 to 50 db."
- 101 Bottom end cap hung up on pinger. No water. Footnote no samples drawn.

STATION 026

- 134 Delta-S at 56db is -0.0535. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 132-136 CTD data processor: "CTD oxygen values questionable 0 to 280 db."

STATION 027

- 135 Bottom o-ring leaking. No water samples drawn.
- 131 CTD data processor: "CTD oxygen values questionable 300 to 326 db."
- 102 CTD data processor: "CTD oxygen values questionable 4760 to 4880 db."

STATION 028

- 133 CTD data processor: "CTD oxygen values questionable 90 to 150 db."
- 117 Sample log: "lanyard caught top end cap" Delta-S at 2307db is 0.0471. O2 & nits also indicate leak. Footnote bottle leaking, all samples bad.
- 113 Delta-S at 2709db is 0.0027. Autosal diagnostics do not indicate a problem. High compared with adjoining stations. Could be a drawing error. Footnote salinity questionable.

STATION 029

- 120 Sample log: "Spigot leaking." Delta-S at 204db is -0.0289. Other water samples ok. High CTD S & T gradient.
- 120-124 CTD data processor: "CTD oxygen values questionable 0 to 270 db."
- 118 Sample log: "Spigot leaking" Delta-S at 404db is -0.0003. Other water samples also ok.
- 110 Sample log: "o-ring(top)." Delta-S at 1606db is 0.053. Other water samples also indicate bottle leaked. Footnote bottle leaking, all samples bad.

STATION 031

- 151 G.O. Floater bottle on in place of NB number 4. Safety not released. No water samples.

STATION 032

- 123 Delta-S at 56db is -0.1015. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

151 Delta-S at 2328db is 0.0026. This bottle may have had a slight leak. This was a "floater" bottle test, and had some problems. Other samples agree within specs of the measurements, so will accept data, except salinity. Footnote salinity questionable.

STATION 033

119 Sample log: "Lanyard stuck in top end cap." Delta-S at 508db is 0.1641. Oxygen, nitrate & phosphate also indicate leak. Footnote bottle leaking, all samples bad.

151 Sample log: "Lanyard never released from pylon (closed early?)." Assume cable slipped at wing nut bolt and bottle closed on way down. Delta-S at 2432db is -0.0064. Oxygen & silicate also indicate water from higher in column. Footnote bottle leaking, all samples bad.

STATION 034

125 Sample log: "Top o-ring not seated. Lid clearly cocked open" No water samples taken per sample log. However salinity was run and gives Delta-S - 0.0095. No oxygen or nutrients were run. Footnote bottle leaking, salinity bad.

125-127 CTD data processor: "CTD oxygen values questionable 0 to 100 db."

110 Delta-S at 2226db is -0.0022. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.

109 Delta-S at 2327db is -0.0025. Autosal diagnostics indicate 4 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.

151 Sample log: "4 lid opened before sampling" Not sure what this means, cannot open top lid of lever action bottle without opening bottom. Maybe air vent? Delta-S .001 low. Other water samples also appear slightly low. Delta-S at 2732db is -0.0019. Footnote bottle leaking, samples bad.

102 Delta-S at 2937db is -0.0028. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 035

130-133 CTD data processor: "CTD oxygen values questionable 0 to 110 db."

127 Sample log: "Bottom o-ring out" No samples drawn.

151 Sample log: "Sample bottle valve open" Delta-S at 3143db is -0.0096. Oxygen and silicate also indicate leak. Footnote bottle leaking, all samples bad.

STATION 036

128 Oxygen appears 0.2 high at 507db compared to CTDO trace. Same value as 127 but both higher than CTDO. Footnote oxygen bad.

127 Oxygen appears 0.1 high at 608db compared to CTDO trace. Same value as 128 but both higher than CTDO. Footnote oxygen bad.

126 Delta-S at 709db is 0.0551. Autosal run ok. Other water samples ok. No notes. Same value as 128, 2 levels above. Normal CTD S gradient. Possible dupe draw. Footnote salinity bad.

125 Oxygen appears 0.1 high at 810db compared to CTDO trace. Same value as 124 below. Calc ok. Possible dupe draw. Footnote oxygen bad.

- 119 Oxygen appears 0.05 high at 1822db compared to CTDO trace. Same value as 118 below. Calc ok. Possible dupe draw. Footnote oxygen bad.
- 114 Delta-S at 2838db is 0.0037. Footnote salinity questionable.
- 108 Delta-S at 3553db is -0.0010. Autosal run ok. Other water samples ok. No notes. Same value as 109, one level above. Normal CTD S gradient. Possible dupe draw. Salinity is acceptable.
- 151 Delta-S at 3860db is 0.0016. Salinity is acceptable. Duplicate trip with bottle 05, agreement is acceptable.

STATION 037

- 130 Sample log: "Leaking, top o-ring." Delta-S at 11db is 0.0037 high. Other water samples also look ok in mixed layer.
- 151 Delta-S at 3143db is 0.0035. This was a "floater" bottle test, and had some problems. Data does not agree with duplicate trip bottle 05. Footnote bottle leaking and samples bad.

STATION 038

- 131 Delta-S 1.97 low at 306db. No notes. Other water samples ok. Appears wrong suppression setting used on Autosal run. Assume 2.00479 2cr vs 1.90479 2cr gives Delta-S at 306db is -0.0059 high gradient.

STATION 039

- 136 Sample log: "Bottom o-ring out" Salt & nutrients only since surface bottle. No freon, O2 or CO2. Delta-S at 4db is 0.0029. Nutrients also ok.
- 134 Delta-S at 56db is -0.0795. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 133 Delta-S at 106db is -0.0289. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 132 Delta-S at 206db is -0.0619. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 130 Sample log: "Top o-ring out" No samples drawn.
- 104 Sample log: "Air vent open" Delta-S at 4782db is 0.0006. NO3 .03 low, peak good. Oxygen and other nutrients ok.

STATION 040

- 136 Delta-S at 3db is 0.0621. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 134 Delta-S at 56db is -0.1249. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

- 110 Bottle oxygen appears 0.05 low at 3860db. Same value as 111 above. Other water samples have normal gradient. Titration & calc ok. Possible dupe draw. Footnote oxygen bad.
- 101 CTD data processor: "CTD oxygen values questionable 4736 to 4820 db."

STATION 041

- 136 Delta-S at 3db is -0.0337. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 134 Delta-S at 57db is 0.1891. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 133 Delta-S at 107db is 0.0327. Thermocline, salinity agrees with adjoining stations. CTD data processor: "CTD oxygen values questionable 90 to 200 db. Looks suspicious as per overlays."

STATION 043

- 115 Sample log: "Leak on bottom end cap, reseated" Delta-S at 1416db is 0.0015. Other water samples also look ok.

STATION 044

- 115 Sample log: "Bottom o-ring out" No water samples.
- 110 Delta-S at 2836db is -0.0027. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 045

- 127 Sample log: "Top o-ring not seated." No water samples drawn.
- 113 Delta-S at 2422db is 0.0036. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.
- 112 Delta-S at 2629db is 0.0026. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.
- 107 Delta-S at 3124db is 0.0026. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 046

- 131-133 CTD data processor: "CTD oxygen values questionable 0 to 100 db."
- 128 Delta-S at 308db is -0.0333. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

STATION 048

- 128 Delta-S .039 high at 604db. Autosal run ok. Normal CTD S gradient. Other water samples ok. No notes. Value .002 lower than 129 salinity in bottle above. Probably draw or run order error. See 127 & 126 below. Salt bottle 28 gives Delta-S .0005 for NB 29. Salt bottle 27 gives Delta-S .0001 for NB 28.

- Assume salt btl 28 is 2nd draw or run for 129 and salt btl run 27 is for NB 28.
Delta-S at 604db is -0.0006.
- 127 Delta-S .015 high at 702db. Autosal run ok. Normal CTD S gradient. Other water samples ok. No notes. Probably draw or run order error. See 128 & 126 quality notes. Salt bottle 26 gives Delta-S .0001 for NB 27. Used Salt 26 for bottle 27. Delta-S at 702db is -0.0001.
- 126 Delta-S .003 high at 798db-preliminary data. Autosal diagnostics indicate 3 tries for average but problems with 127 & 128 indicate out of order draw or run problem may affect 126 salt also. Assume salt run number 26 is for NB number 27 and no bottle salt for sample 126.
- 116 Delta-S at 2627db is 0.0028. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 051

- Cast 1 It appears that the salinity lab temperature was changing. That could account for the fluctuation in the salinity samples. But not confident with this scenario. The difference was 3.3° in an hour and a half. If salinity is questionable, the lab temperature could be the reason.
- 124 Sample log: "Lanyard unhooked at bottom, however bottle appears to have closed." Delta-S at 1264db is 0.000. Other water samples also ok.
- 123 Delta-S at 1518db is -0.0030. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 117 Delta-S at 3032db is -0.0022. Salinity also lower compared with adjoining stations. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.
- 115 Delta-S at 3451db is -0.0023. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 111 Delta-S at 3856db is -0.0031. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 110 Delta-S at 3957db is -0.0029. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 109 Delta-S at 4058db is -0.0036. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 104 Delta-S at 4465db is -0.0023. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 103 Delta-S at 4533db is -0.0021. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 102 Delta-S at 4644db is -0.0024. Salinity also lower compared with adjoining stations. Footnote salinity questionable.
- 101 Delta-S at 4701db is -0.0021. Salinity also lower compared with adjoining stations. Footnote salinity questionable.

STATION 052

- 131 Sample log: "Leaks from bottom end cap when air vent open." No water samples taken.

- 123 Hydro O2 appears .02 low at 1772db compared to adjacent. stations. Calc ok. No notes. Same value as 124 at level above. CTDO shows normal gradient. Possible dupe draw. Footnote oxygen bad.
- 120 No confirm on 1st trip attempt. Tripped from diagnostic file. Two extra trips on original B file.
- 101 Hydro O2 appears .06 low at 4732db. One freon only drawn before oxygen. Other water samples ok. Possibly thio tip not rinsed after flush on first sample. Footnote oxygen questionable.

STATION 053

- 114 Delta-S at 4042db is 0.0071. Other water samples also indicate 14 closed early, near 12 level at 4195db. No notes. Footnote bottle leaking, all samples bad.
- 110 Sil inversion not seen in other properties. Footnote SiO3 questionable.
- 109 Sil inversion not seen in other properties. Footnote SiO3 questionable.
- 108 Sil inversion not seen in other properties. Footnote SiO3 questionable.

STATION 054

- 134-136 CTD data processor: "CTD oxygen values questionable 0 to 90 db."
- 102 CTD data processor: "CTD oxygen values questionable 5196 to 5250 db."

STATION 055

- 135 Sample log: "Leaky bottom o-ring." No samples drawn.
- 134 Delta-S at 57db is -0.0635. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 131 Delta-S at 308db is -0.0286. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

STATION 056

- 123 CTD data processor: "Low CTDOxy bulge approx. 2000 db is feature dn+up casts."
- 103 Delta-S at 5074db is -0.0028. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 057

- 116 Sample log: "leaking out bottom?" After air vent opened water dripped from bottom end cap. Delta-S at 3964db is 0.0026. Oxygen ~0.04 low & PO4 look ok, but NO3 ~0.5 high and Sil ~2.0 high. Both NO3 & Sil are same as 117 at level above. Footnote bottle leaking, all samples bad.
- 106 Delta-S at 4785db is 0.0074. Autosal diagnostics indicate 5 tries to get a good reading, indicating a problem with the sample. Other water samples ok. Possible salt crystal contamination from cap. Footnote salinity bad.
- 101-102 CTD processor: "CTD oxygen values questionable 5150 to 5258 db."

STATION 058

- 134-136 CTD data processor: "CTD oxygen values questionable 0 to 80 db."
- 129 CTD data processor: "High CTDOxy bulge approx. 600 db is feature on dn+up casts."

115 Delta-S at 3642db is -0.0034. Salinity: "This one dropped with each rinse, no reason." Footnote salinity questionable.

STATION 059

Cast 1 Suspect bad vial of wormley at beginning of run. Applied +0.00011 to all conductivity ratios, which is ~0.002. Data is much better on deep samples, but mid-water samples still have a lower precision. Accept salinity values.

135 Delta-S at 16db is -0.0351. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

134 Delta-S at 56db is -0.0615. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

133 Sample log: "Top o-ring" out of groove. No samples drawn.

132 Delta-S at 207db is -0.0297. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

128 Delta-S at 810db is 0.0146. Autosal run ok. Same value as 127 below. Normal CTD S gradient. Other water samples ok. No notes. Probable dupe draw or run. Footnote salinity bad.

125 Sample log: "Stopcock o-ring" Drain valve closes by water pressure, won't stay open by itself. Delta-S -0.0013 at 1512db. Other water samples also look ok.

102 Delta-S at 4967db is -0.002. Bottle oxygen appears .02 low. Calc & titration ok. Smooth CTDO trace. One freon and TWO CCl₄s drawn before oxygen. Other water samples ok. Within WOCE standards, footnote oxygen acceptable.

STATION 060

134 Delta-S at 56db is 0.032. Salinity agrees with adjoining stations. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

101 Hydro oxygen .05 lower than level above. Other water samples have normal gradient. One freon & one CCl₄ drawn before oxygen. Possibly thio tip not rinsed after flush before first sample. 102 oxygen may be high and also possible samples switched ???. Both samples very near western boundary of Samoan Passage. Agrees with CTDO, difference within WOCE standards, oxygen is acceptable.

STATION 061

134 Delta-S at 56db is 0.1292. Salinity is acceptable. Spike in CTD trace. Footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

151 Sample log: "Top vent not closed properly" No samples drawn. CTD data processor: "CTD oxygen values questionable 4170 to 4220 db."

101 CTD data processor: "CTD oxygen values questionable 4336 to 4362 db."

STATION 062

151 Floater stuck to top end cap after air vent unscrewed. Need to push air vent against floater to free it. All samples drawn with floater still attached to top end cap. Samples agree with duplicate trip (bottle 05). Operator error on oxygen titration. No oxygen data obtained. Code oxygen lost.

STATION 063

113 Delta-S at 3143db is 0.0064. Autosol run ok. Other water samples ok. No notes. Footnote salinity bad.

106 Delta-S at 3885db is 0.0021. 6 Autosol runs to get agreement. This is comparison bottle for floater bottle draw down test. Forgot to trip 2 bottles at NB 51 level so lowered rosette after NB 5 tripped to get NB 6 at same depth as NB 51. Other water samples ok. NB 51 Delta-S .001 high at 3882db. Footnote salinity questionable.

STATION 101

123 Delta-S at 2027db is -0.0032. Autosol diagnostics do not indicate a problem. Footnote salinity questionable.

116 Delta-S at 3645db 0.0012. Autosol run ok. Other water samples & CTD S have normal gradient. Same value as 115 below. Same bottles as Sta 102 salt irregularity. Salinity is acceptable.

115 Delta-S at 3852db is -0.0023. Autosol run ok. Other water samples & CTD S have normal gradient. Same value as 116 above. Same bottles as Sta 102 salt irregularity. Footnote salinity questionable.

113 Delta-S at 4058db is -0.0632. Autosol run ok. Other water samples also indicate leak or closed near 400db. No notes. Nothing obviously wrong with bottle. Footnote bottle leaking, all samples bad.

110 Delta-S at 4362db is -0.0027. Autosol diagnostics do not indicate a problem. Footnote salinity questionable.

101-103 CTD data processor: "CTD oxygen values questionable 5080 to 5320 db."

STATION 102

133 Delta-S at 108db is 0.8826. Value close (.007 higher) than mixed layer values but CTD S and all other parameters well into thermocline at this level. Autosol run ok. Assume draw or run error. Footnote salinity bad.

132 Delta-S at 208db is -0.1061. 3 Autosol runs for agreement. High gradient. Probably ok. Footnote salinity questionable.

115 Delta-S at 3658db is 0.0038. Autosol run ok. Same value as 114 & 113 below. CTD S & other parameters have normal gradient this level. Possible dupe draw or run of 113. Footnote salinity bad.

114 Delta-S at 3760db is 0.0016. Autosol run ok. Same value as 114 & 113 below. CTD S & other parameters have normal gradient this level. Possible dupe draw or run of 113. Footnote salinity bad.

101 CTD data processor: "CTD oxygen values questionable 4950 to 5022 db."

STATION 064

- 131 Delta-S at 108db is -0.0343. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 130 Delta-S at 208db is 0.0235. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 129 Delta-S at 308db is 0.0276. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

STATION 065

- 133 Sample log: "Leaker, no obvious reason. top o-ring?" Air leak, top end cap wobbly, possibly o-ring partly out of groove. Surface bottle. Delta-S at 4db is 0.0012. Other water samples also okay.
- 131-133 CTD data processor: "CTD oxygen values questionable 0 to 70 db."
- 102 Delta-S at 3808db is -0.0027. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 066

- 102 CTD data processor: "CTD oxygen values questionable 3406 to 3510 db. O2 sensor possibly fouled."

STATION 067

- 131 Sample log: "bottom o-ring, leaker" No samples drawn.

STATION 068

- 131 Sample log: "Leaking, top o-ring" No samples drawn.

STATION 070

- 131 Sample log: "Top not seated, o-ring out." No water samples.
- 106 Delta-S at 3443db is 0.0031. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.

STATION 071

- 131 Sample log: "Bottom o-ring" No samples drawn.
- 103 Delta-S at 3885db is -0.004. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 072

- 133-136 CTD data processor: "CTD oxygen values bad 0 to 130 db; oxy cutouts top 108 db."
- 125 Delta-S at 914db is 0.0055. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.
- 110 Delta-S at 3437db is -0.0028. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

101 CTD data processor: "CTD oxygen values questionable 4160 to 4240 db."

STATION 073

133-136 CTD data processor: "CTD oxygen values bad 0 to 180 db; oxy cutouts top 168 db."

STATION 074

134 Delta-S at 57db is -0.0569. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

129 Sample log: "Leaking after O2 draw" Oxygen and other water samples look ok.

113 Delta-S at 3247db is -0.0028. All water samples same as 114 at level above. B & B.rt files look fine, tripped at intended level. No notes. Possible lanyard hangup? Footnote bottle leaking, all samples bad.

STATION 075

124 Sample log: "Bottom hook off (may have closed early)." Delta-S at 1014db is 0.000. Other water samples also look ok.

113 Sample log: "T increasing during O2 sample (quite a bit ~1 degree" Both Hg & electronic therms. Hydro oxygen looks good at 3044db compared to CTDO and adjacent stations.

104 Delta-S at 3806db is -0.0035. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 076

126 Sample log: "Bottom o-ring" out. No samples drawn.

125 Delta-S 1.95 low at 308db. Wrong suppression setting on Autosal run. 2CR 2.00494 vs 1.90494. Delta-S at 308db is 0.0113. Okay in high gradient area. Other water samples ok.

STATION 077

113 Delta-S at 2024db is 0.0028. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

103 Delta-S at 3448db is -0.003. Autosal diagnostics do not indicate a problem. Footnote salinity questionable.

STATION 078

101-102 CTD data processor: "CTD oxygen values questionable 3330 to 3384 db."

STATION 079

131 Sample log: "leaking from top cap" Not sure what this means. Surface bottle so all samples drawn. Delta-S at 3db is 0.0006. Other water samples also look ok.

STATION 080

135 Sample log: "air leak". Other water samples also look ok.

- 119 Delta-S at 2024db is -0.0453. Autosal run ok. Other water samples also indicate taken from about 500db higher. Footnote bottle leaking, all samples bad.
- 116 Delta-S at 2630db is 0.0038. Autosal diagnostics indicate 4 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.
- 107 Entry error on oxygen, changed sample number from 6 to 7. No oxygen value to report.
- 101 CTD data processor: "CTD oxygen values questionable 4012 to 4018 db."

STATION 081

- 133 Sample log: "air leak, top o-ring". Surface bottle so all samples drawn. Delta-S at 3db is -0.0009. Other water samples also look ok.
- 119 Delta-S at 1415db is -0.045. Autosal run ok. Oxygen and nutrients also low but CTDO shows oxygen inversion this level and bottle oxygen looks good. NO₃ & PO₄ could easily be ok, but silicate is very low (20uM/L). Salinity is same value as level above so could be dupe draw or run. Oxygen and all nutrients could fit well at 1050db but salinity would be .01 too high. Footnote bottle leaking, all samples bad.
- 101 CTD data processor: "CTD oxygen values questionable 3870 to 3944 db."

STATION 082

- 127 Sample log: "leak, top end cap" o-ring out. No samples drawn. Delta-S at 57db is -0.0615. Evidently, a salinity sample was drawn. Footnote bottle leaking, salinity bad, other samples not drawn.

STATION 083

- 125 Delta-S at 107db is -0.0541. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 124 Delta-S at 207db is 0.0278. Salinity agrees with adjoining stations. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 101 Delta-S at 3129db is 0.0021. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.

STATION 085

- 119 Bottles 19 & 20 tripped at same depth (601db). Oxygens differ by .024, while all other parameters agree. Thio debubbled just prior 119 so possible this somehow made 119 high. Within WOCE specs, oxygen is acceptable.

STATION 086

- 117 Delta-S at 105db is -0.057. Spike in CTD trace, footnote CTD salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.
- 101 CTD data processor: "CTD oxygen values questionable 1600 to 1636 db."

STATION 087

- 123 Sample log: "top o-ring out." Freon sampled 10m bottle so took other samples also. Autosal run ok. High S Gradient on CTD. Other water samples look ok. Delta-S at 16db is 0.038. Area of high salinity gradient, salinity value OK.
- 121 Sample log: "top 0-ring out" No samples drawn.
- 116 Sample log: "bottom o-ring not set"? (Leaked from bottom end cap after air vent opened. Reseated end cap, then okay.) Delta-S at 608db is 0.0015. Other water samples also ok.

STATION 088

- 108 Delta-S at 2431db is 0.0341. Autosal run ok. Oxygen & nutrients also indicate leak. No notes. Footnote bottle leaking, all samples bad.
- 101-106 CTD data processor: "CTD oxygen values questionable 2600 to 2618 db."

STATION 089

- 108 Delta-S at 1012db is 0.3369. Autosal run ok. Oxygen & nutrients also indicate leak. Footnote bottle leaking, all samples bad.
- 101 CTD data processor: "CTD oxygen values questionable 2206 to 2216 db."

STATION 090

- 104 Console Ops: "No cap/spring" Not tripped as scheduled, no samples.
- 123 Sample log: "Top o-ring leaking." Samples appear to be okay.
- 122 Sample log: "Top o-ring leaking." Samples appear to be okay.
- 116 Sample log: "Bottom o-ring leaking" No samples drawn.
- 101 Bottle oxygen appears 0.1 low at 2394db. Titration ok. No notes. Delta-S at 2393db is 0.0011. Nutrients also look ok. Good titration but CTDO doesn't show decrease at bottom. Footnote oxygen questionable.

STATION 091

- 101 CTD data processor: "CTD oxygen values questionable 1416 to 1456 db."

WOCE P-31 CFC-11 and CFC-12 Measurements

Analysts: Mr. Steven Covey, University of Washington;
Mr. Jordan Clark, Lamont-Doherty Geological Observatory

Sample Collection and Analysis

Samples for CFC analysis were drawn from the 10-liter Niskins into 100-cc ground glass syringes fitted with plastic stopcocks. These samples were the first aliquots drawn from the particular Niskins. The CFC analysis on this cruise was affected by two separate problems which are reflected in the large number of samples flagged as questionable or bad.

The samples were analyzed using the University of Washington CFC extraction and analysis system. The analytical procedure and data analysis are similar to those described by Bullister and Weiss (1988). The system was set up in the main laboratory of the R.V. Thompson. The CFC concentrations in air were measured approximately once per day during this expedition. Air was pumped to the main laboratory from the bow through Dekabon tubing.

The major analytical difficulty was the misalignment of a Valco valve through which there is continuous carrier gas flow. This misalignment results in a reduced flow of carrier gas through the system and greatly affects the amount of CFCs transferred to the column and precolumn. The result is a drop in the measured peak areas for standards (and other samples) of greater than 10 percent. The misalignment mainly occurs when the valve switches between its two positions, and only at the one position at first. Early in the cruise this resulted in random "bad" samples. These can be easily distinguished from the "good" samples. However, the frequency with which this misalignment occurred increased during the cruise, until it was occurring at more than 25 percent of the time (at Station 72), and deteriorated quickly from that point until the analysts could no longer run samples. Unfortunately, they never did diagnose the problem correctly.

The second problem was CFC-11 contamination of some of the plastic syringe stopcocks. This problem manifests itself in the CFC-11 concentrations in deep samples. One or two samples in the deep waters at each station have reported CFC-11 concentrations which are significantly greater than the over- and under-lying waters and also result in impossible CFC-11/CFC-12 ratios. A little detective work revealed this to be due to particular syringes (and not the Niskins). These samples have been flagged as questionable in the upper water column or "bad" in the deep waters.

Calibration

A working standard, calibrated on the SIO1993 scale, was used to calibrate the response of the electron capture detector of the Shimadzu Mini-2 GC to the CFCs. This standard, Airco cylinder CC88098, contained gas with CFC-11 and CFC-12 concentrations of 267.20 parts per trillion (ppt) and 502.32 ppt, respectively.

Sampling Blanks

After the samples which were contaminated with CFC-11 from the syringe tips have been removed from the data set, the sampling blanks were assessed using the CFC concentrations in samples from depths where the waters should be CFC-free. The mode of the distributions of the 390 deep samples were chosen to represent the sampling blanks. For CFC-11, the sampling blank applied to all samples is 0.004 pmol/kg. For CFC-12, this sampling blank is 0.000 pmol/kg (Essentially, the stripper blanks were as great as the sampling blank.) It may be possible to apply separate sampling blanks for the contaminated syringe tips. It is currently being investigated.

Data

In addition to the CFC concentrations which have merged with the .hyd file, the following three tables have been included to complete the data set. The first two are tables of the duplicate samples. The third is a table of the atmospheric CFC concentrations interpolated to each station.

Table 1: CFC-11 Concentrations in Replicate Samples

Sta	Samp	CFC-12	Sta	Samp	CFC-12
2	119	1.957	22	132	1.830
2	119	1.929	24	132	1.838
4	104	0.008	24	132	1.812
4	104	0.006	26	134	1.640
4	132	1.858	26	134	1.663
4	132	1.730	28	134	1.625
6	104	0.015	28	134	1.625
6	104	0.005	30	120	1.851
6	131	1.833	30	120	1.833
6	131	1.843	32	122	1.718
8	132	1.741	32	122	1.734
8	132	1.747	34	124	1.712
10	130	0.753	34	124	1.720
10	130	0.768	35	128	0.928
12	132	1.834	35	128	0.933
12	132	1.821	37	128	1.670
14	134	1.671	37	128	1.679
14	134	1.685	37	131	1.523
18	131	1.420	37	131	1.512
18	131	1.450	45	130	1.504
20	132	1.767	45	130	1.523
20	132	1.757	49	101	0.000
22	130	0.247	49	101	0.015
22	130	0.250	53	101	0.003
22	132	1.852	53	101	0.009

Sta	Samp	CFC-12
57	131	0.184
57	131	0.196
61	132	1.680
61	132	1.689
63	134	1.525
63	134	1.530

Sta	Samp	CFC-12
64	132	1.516
64	132	1.499
66	126	1.761
66	126	1.805
102	102	0.002
102	102	0.003

Table 2: CFC-12 Concentrations in Replicate Samples

Sta	Samp	CFC-12
2	119	1.019
2	119	1.012
4	104	0.000
4	104	0.009
4	132	0.956
4	132	0.894
6	104	0.018
6	104	0.001
6	131	0.959
6	131	0.962
8	132	0.899
8	132	0.878
10	130	0.375
10	130	0.391
12	132	0.954
12	132	0.958
14	134	0.914
14	134	0.929
18	131	0.734
18	131	0.733
20	132	0.929
20	132	0.929
22	130	0.133
22	130	0.138
22	132	0.978
22	132	0.939
24	132	0.937
24	132	0.949
26	134	0.875
26	134	0.884
28	134	0.868
28	134	0.928
30	120	0.969
30	120	0.979
32	122	0.935

Sta	Samp	CFC-12
32	122	0.929
34	124	0.910
34	124	0.944
35	128	0.461
35	128	0.462
37	128	0.882
37	128	0.891
37	131	0.823
37	131	0.823
42	132	0.899
42	132	0.871
45	126	0.124
45	126	0.108
45	130	0.807
45	130	0.804
49	101	-0.006
49	101	0.004
53	101	-0.001
53	101	-0.001
57	131	0.103
57	131	0.114
59	101	-0.001
59	101	0.001
61	132	0.858
61	132	0.918
63	134	0.855
63	134	0.857
64	132	0.841
64	132	0.829
66	126	0.941
66	126	0.952
102	102	-0.003
102	102	-0.002
102	132	0.873
102	132	0.849

Table 3 - Atmospheric CFC Concentrations

Date	Time (hhmm)	Latitude	Longitude	FREON RUN NO.	FREON FLAG	F12 PPT	a
27 Jan 94	1622	15 48.3 S	151 28.7 W	267	0	516.1	263.2
27 Jan 94	1632	15 48.3 S	151 28.7 W	268	0	505.7	262.9
27 Jan 94	1643	15 48.3 S	151 28.7 W	269	0	512.7	262.9
28 Jan 94	0426	15 25.8 S	152 27.0 W	315	0	524.5	270.5
28 Jan 94	0437	15 25.8 S	152 27.0 W	316	0	517.9	266.1
28 Jan 94	0448	15 25.8 S	152 27.0 W	317	0	522.5	266.3
29 Jan 94	0944	14 28.0 S	154 52.1 W	443	0	522.1	267.0
29 Jan 94	0954	14 28.0 S	154 52.1 W	444	0	522.1	266.8
29 Jan 94	1005	14 28.0 S	154 52.1 W	445	10000	520.5	263.9F
30 Jan 94	0150	13 53.8 S	156 19.2 W	515	0	515.9	264.1
30 Jan 94	0202	13 53.8 S	156 19.2 W	516	0	519.1	264.3
30 Jan 94	0213	13 53.8 S	156 19.2 W	517	0	517.1	263.4
31 Jan 94	0348	13 07.0 S	158 17.3 W	621	0	524.0	267.0
31 Jan 94	0359	13 07.0 S	158 17.3 W	622	0	524.6	265.4
31 Jan 94	0410	13 07.0 S	158 17.3 W	623	0	522.2	266.0
2 Feb 94	0854	11 27.1 S	162 24.3 W	862	0	521.6	264.0
2 Feb 94	0905	11 27.1 S	162 24.3 W	863	0	522.8	264.1
2 Feb 94	0915	11 27.1 S	162 24.3 W	864	0	517.0	264.1
4 Feb 94	0000	10 19.4 S	165 14.7 W	1019	0	518.2	265.1
4 Feb 94	0011	10 19.4 S	165 14.7 W	1020	0	514.7	262.2
4 Feb 94	0022	10 19.4 S	165 14.7 W	1021	0	521.8	265.0
4 Feb 94	0827	10 07.8 S	165 43.8 W	1058	0	515.0	264.3
4 Feb 94	0838	10 07.8 S	165 43.8 W	1059	0	524.8	265.5
4 Feb 94	0850	10 07.8 S	165 43.8 W	1060	0	518.4	262.7
5 Feb 94	1736	10 15.1 S	168 40.0 W	1201	0	516.7	263.7
5 Feb 94	1748	10 15.1 S	168 40.0 W	1202	0	521.7	265.9
5 Feb 94	1759	10 15.1 S	168 40.0 W	1203	0	520.2	262.7
6 Feb 94	0351	10 09.1 S	168 59.1 W	1242	0	511.5	261.1
6 Feb 94	0402	10 09.1 S	168 59.1 W	1243	0	521.3	265.9
6 Feb 94	0413	10 09.1 S	168 59.1 W	1244	0	516.1	262.3
6 Feb 94	2339	09 57.9 S	169 30.0 W	1323	0	533.8	272.8
6 Feb 94	2351	09 57.9 S	169 30.0 W	1324	0	524.3	267.7
7 Feb 94	0002	09 57.9 S	169 30.0 W	1325	0	516.7	264.7
8 Feb 94	0341	09 45.3 S	170 08.7 W	1435	0	525.7	267.4
8 Feb 94	0352	09 45.3 S	170 08.7 W	1436	0	531.6	268.8
8 Feb 94	0404	09 45.3 S	170 08.7 W	1437	0	545.9	271.3
8 Feb 94	1831	09 35.0 S	170 38.8 W	1503	0	532.7	270.4
8 Feb 94	1842	09 35.0 S	170 38.8 W	1504	0	529.1	268.0
8 Feb 94	1853	09 35.0 S	170 38.8 W	1505	0	532.5	268.3
11 Feb 94	1702	08 54.6 S	167 00.3 W	1578	0	519.6	263.5
11 Feb 94	1713	08 54.6 S	167 00.3 W	1579	0	520.9	264.0
11 Feb 94	1725	08 54.6 S	167 00.3 W	1580	0	512.9	260.4

Date	Time (hhmm)	Latitude	Longitude	FREON RUN NO.	FREON FLAG	F12 PPT	a
12 Feb 94	2314	09 51.5 S	172 18.1 W	1702	0	519.7	266.8
12 Feb 94	2325	09 51.5 S	172 18.1 W	1703	0	518.0	263.9
12 Feb 94	2336	09 51.5 S	172 18.1 W	1704	0	514.6	262.5

DQE Evaluation of CTD data for RV Thomas G. Thompson Cruise along WOCE Section P31 Expocode 3250031_1

Mark Rosenberg, November 1998

This report contains a data quality evaluation of the CTD data files for the Pacific sector cruise along WOCE section P31 (Figure 1) on the RV Thomas G. Thompson in January to February, 1994. Bottle data are evaluated by George Anderson in a separate report. 2 dbar CTD data and upcast CTD burst data in the .sea file were examined for all stations. In general, CTD salinity data quality is very good, while CTD oxygen data quality is good below 100 dbar. CTD data processing methodology and processing notes are well described in the cruise report from ODF.

STATION SUMMARY FILE (.sum)

- Ocean depth values for station 102 look wrong, in particular for the bottom and end of the cast.
- Sound speed and transducer depth information for the ship's sounder were not provided in the documentation. "Corrected depth" (.sum file) was therefore calculated from the CTD at the bottom of the cast i.e. altimeter reading + maximum CTD pressure recalculated in meters (using the method of Saunders and Fofonoff, 1976). For stations with no altimeter reading, no corrected depth was calculated. These corrected depth values are in an ascii file corrdepth.dat, and have not been merged into the .sum file.

SALINITY

In the following discussion, only CTD and bottle values with a quality flag of 2 are considered (i.e. QUALT1=2 for CTDSAL and SALNTY in the .sea file). See Table 2 for a station by station summary of salinity data problems.

The salinity residual data ΔS (where ΔS = bottle – CTD salinity difference) for all depths is shown in Figure 2a (an additional ~40 data points lie outside the axis limits). Below 500 dbar, scatter of ΔS is greatly reduced (Figure 2b). The averaging period used by the ODF group for CTD burst data at bottle stops is typically ~3.5 seconds (not mentioned in the cruise report). I recommend increasing this averaging period to 10 seconds. Obviously there will still be a residual in the steepest gradients (e.g. in the tropics) due to vertical separation of the bottles and CTD sensors, however the increased averaging period may help decrease residuals in less dramatic gradients when the ship is rolling during bottle stops.

Standard deviations for ΔS for the whole cruise were calculated from data in the .sea file (Table 1). The salinity standard deviation of 0.0017, calculated using all sampling depths and $|\Delta S| \leq 0.008$, is a reasonable estimate of the salinity accuracy for the cruise.

Overall the calibration is very good, and the salinity accuracy is well within the WOCE requirement. A small bias in ΔS does however remain for some stations (Figure 2, and Table 2). From deepwater comparisons of θ -S curves, this bias is often due to the bottle data. It appears that the bottle salinity data, though very good, are not 100%. Some examples are shown in Figure 3, showing the larger scatter of bottle compared to CTD salinities. Several instances of salinometer problems are noted in the cruise report, however bottle sampling inaccuracies could also have contributed to the scatter. Overall these small bottle inaccuracies do not affect calibration of the CTD salinity data, as indicated by the very tight fit of CTD θ -S curves in the example plots (Figure 3).

For stations 53, 58-60, 67 and 77-79, the bias is most likely due to variations in conductivity cell response not accounted for by the conductivity calibration, as follows. When fitting CTD to bottle conductivity for this cruise, all stations were fitted in a single group; a constant slope and a station dependent offset were applied (except for stations 74 to 77, where the offset was adjusted manually), as described in the documentation. For the stations listed above, calibration results ought to improve by selecting smaller station groupings for the conductivity calibration e.g. fit stations 58 to 60 in one group, fit stations 77 to 79 in another group. It's interesting to note the difference in calibration methodology between different institutions: within each station group, ODF at Scripps uses a constant slope and a station dependent offset, while WHOI and CSIRO use a constant offset and a station dependent slope. The selection of station groups is probably more significant in changing the end results.

Table 1: Standard deviations for salinity residuals ΔS (using only bottle and CTD data for which the quality flag=2).

data	standard deviation of ΔS
all depths	0.0086
deeper than 500 dbar	0.0012
all depths, $ \Delta S \leq 0.008$	0.0017

Numerous bottle salinity values have been flagged “3” in the .sea file even though $|\Delta S|$ is < 0.003 . In most cases I think this residual is too small to justify the “3” flag, and I recommend these values be resurrected to a flag value of “2”. See George Anderson’s bottle data report for more details.

Many upcast CTD salinity bursts have been flagged as “4” in the .sea file in regions of high vertical gradients (Table 3). In the cruise report, the data processors have noted a large ΔS value, and commented: “Salinity agrees with adjoining stations. Spike in CTD trace”. If there is indeed an erroneous spike in the 2 Hz CTD data, then the flag value is justified. However the vertical separation between bottles and CTD sensors in high vertical gradients could also cause residuals of these magnitudes, in which case the CTD data are not bad. Please confirm whether the spikes are there or not (if not, flag should be changed to “2” for CTDSAL in .sea file).

The deepwater structure for station 5 is very interesting – from the deepwater θ -S curve, there appears to be a shift in θ at $S \sim 34.655$, confirmed as real by the upcast data. No equivalent structure occurs in the adjacent stations.

OXYGEN

Oxygen residual data (i.e. bottle – CTD oxygen difference) are plotted in Figure 4, noting that large outliers lie beyond the axis limits on the graph. CTD oxygen calibrations are in general very good, except for the few cases listed in Table 4. The data processors have obviously examined all the CTD oxygen data closely, as indicated by the numerous flagged segments of suspicious values (typically near the bottom or near the surface) – I agree with all these flag values. I also agree with the disclaimer made in the cruise report: “usefulness of oxygen data in the top 100 dbar should be carefully considered”. In general, approximately half the oxygen profiles look suspicious down to ~ 100 dbar, and the other half down to ~ 50 dbar. I’m willing to accept the general disclaimer about the top 100 dbar of oxygen data, rather than a painstaking station by station assessment.

CTD oxygen data is quite noisy for much of this cruise, presumably due to noise in the oxygen current signal (installation of the new sensor at station 75 did not fix the problem). Noise levels are typically up to $\pm 5 \mu\text{mol/kg}$ for more than half the stations. This is a common problem with oxygen data, and it does not detract from the usefulness of the profiles. The sensor response is sufficient to reveal structure on a finer scale than the bottle data e.g. the features at 800 and 2000 dbar for station 71, both confirmed by bottle samples. Data users can smooth the oxygen profiles if they wish.

In the .sea file, no CTDOXY value was calculated for samples where the CTDSAL value was flagged as “4” (Table 3), noting that these flag values are in doubt as discussed earlier in this report. Recalculation of CTDOXY values for these samples is not necessary: most occur in steep vertical gradients where a high bottle-CTD oxygen residual might be expected, so oxygen calibrations for these profiles would not be significantly altered.

Final CTD oxygen calibration coefficient values (from Appendix B in the cruise report) look reasonable, except for the following:

- stations 78 and 87 – the T_S coefficient c_5 is positive (upcast data were used for both these stations);
- station 91 – the P_1 coefficient c_3 is negative.

DESPIKING, INTERPOLATION AND FLAGS

A flag value of 6 has been used for most data at the 0.0 dbar level – these data are presumably extrapolations rather than interpolations. This extrapolation often continues to the surface a suspicious gradient between the 4 and 2 dbar levels. More notable

examples are the 0.0 dbar temperature value for stations 6 and 7, and the 0.0 dbar salinity value for station 28. I don't believe these data extrapolations are necessary – if there's insufficient data to create a 0.0 dbar bin, it would be preferable to leave a gap at that bin and flag as 9.

The flag value of 7 (“despiked”) in the .ctd files has been applied to more than just the usual data despiking cases. For station 50 (1842-1890 dbar) and station 58 (4110-4122 dbar), CTD salinity data have been artificially offset and a flag value of 7 applied. Presumably the original shifted data were due to fouling of the conductivity cell. In general, I would advise against artificially shifting segments of a profile to match the surrounding profile. The alternatives are to leave the bad data there and flag as 4, or else remove the data (my preference in more severe cases) and flag as 5.

For station 51, 4646-4700 dbar, the data processors note “conductivity dropouts” and consequent “despiked conductivity”, with a flag value of 7 applied to the salinity data. Bearing in mind the ambiguity of the flag 7 value discussed above, I am not sure what has been done to the conductivity data here – this needs clarification from the data processors.

Many blocks of CTD oxygen data have been flagged as 3 (and in some cases 4), indicating the oxygen data have been carefully examined by the data processors – well done.

DENSITY INVERSIONS

Locations of unstable vertical density gradients are shown in Figure 5; only gradients more unstable than $-0.003 \text{ kg/m}^3/\text{dbar}$ are shown. Density gradient values for these instabilities are summarised in Table 5. Most occur in the top 6 dbar, and are probably mostly due to sensor transient errors/instabilities at the start of casts. 3 cases occur below 10 dbar (stations 40 and 41 in Table 5), all coinciding with “despiked” salinity data (i.e. quality flag 7).

COMPARISONS WITH OTHER CRUISES

Deepwater θ -S and θ -oxygen curves were compared for P31 stations coincident with or close to stations from WOCE cruises P16C, P16S and P15S. Positions of stations used in the P31/P16C and P31/P16S comparisons are plotted in Figure 6a. For the P31/P15S comparison, station latitudes are shown in Figure 8, while station longitudes are approximately equal between comparison pairs. In general, θ -S agreement lies well within the expected inter-cruise accuracy of 0.002 for salinity, except for P16S. Oxygen agreement is within 1% of deepwater oxygen values.

P31 and P16C (P.I. L. Talley) (Figure 6b)

Salinities agree within 0.001.

No CTD oxygen data for the P16C comparison stations.

P31 and P16S (P.I. J. Swift) (Figure 7)

P16S salinity lower than P31 by ~0.002. This is consistent with the salinity difference between P16S and other data sets (i.e. P16S is 0.002 lower), as reported by the Scripps ODF group in the P16S cruise report (Swift et al.)

Oxygen data compare well (agreement within 1% of deepwater oxygen values).

P31 and P15S (P.I.'s J. Bullister and G. Johnson) (Figure 8)

P15S salinity higher than P31 by on average ~0.001. This difference is possibly due to differences in standard seawater batches (batch P122 used on cruise P31; batch P114 used on cruise P15S).

Oxygen data compare well (agreement within 1% of deepwater oxygen values).

SUMMARY OF QUESTIONS/RECOMMENDED FLAG CHANGES

- Ocean depth values for station 102 in .sum file look wrong, in particular for the bottom and end of the cast.
- Please confirm whether the spikes are there or not for data listed in Table 3 (if no spikes, flag should be changed to 2 for CTDSAL in .sea file).
- For station 50 (1842-1890 dbar) and station 58 (4110-4122 dbar), change flag to 3 in .ctd files, or else remove the data and flag as 5.
- For station 51, 4646-4700 dbar, the data processors note “conductivity dropouts” and consequent “despiked conductivity”, with a flag value of 7 applied to the salinity data. Bearing in mind the ambiguity of the flag 7 value discussed above, I am not sure what has been done to the conductivity data here – this needs clarification from the data processors.

REFERENCES

Saunders, P.M. and Fofonoff, N.P., 1976. Conversion of pressure to depth in the ocean. Deep Sea Research, 23:109-111.

J. Swift et al., 1994. P16S Cruise Report.

Table 2: Comments on CTD salinity data for individual stations. “Reason” is as determined from comparison of deepwater θ -S curves with surrounding stations, for both S_{ctd} and S_{btl} (CTD and bottle salinity).

station	comment	reason
3	S_{ctd} high by ~0.002 for whole profile	S_{btl} low by ~0.002
5	S_{ctd} low by ~0.001 below 500 dbar	S_{btl} high by ~0.001
7	S_{ctd} mostly high by ~0.001 below 1000 dbar	possibly due to bottles
16	S_{ctd} low by ~0.001 for 500-3000 dbar	unknown
17	S_{ctd} high by ~0.001 for 500-3000 dbar	possibly due to bottles
19	S_{ctd} low by ~0.001 below 1000 dbar	unknown (S_{ctd} is okay)
22	S_{ctd} mostly high by ~0.001 below 3000 dbar	S_{btl} a bit low below 3000 dbar
23	S_{ctd} mostly low by ~0.001 below 1000 dbar	possibly due to bottles

24	S _{ctd} mostly low by ~0.001 below 1500 dbar	possibly due to bottles
28	S _{ctd} mostly low by ~0.001 below 2000 dbar	probably due to bottles
29	S _{ctd} mostly low by ~0.001 below 2000 dbar	unsure (S _{ctd} is okay)
36	S _{ctd} mostly low by ~0.001 below 500 dbar	probably due to bottles
37	S _{ctd} low by ~0.001 below 500 dbar	possibly due to bottles
41	S _{ctd} low by ~0.001 below 500 dbar	unsure (S _{ctd} is okay)
45	S _{ctd} low by ~0.001 below 750 dbar	possibly due to bottles
53	S _{ctd} mostly low by ~0.0008 below 1000 dbar	possibly due to calibration
54	S _{ctd} high by ~0.001 below 4000 dbar	unsure
57	S _{ctd} mostly low by ~0.001 below 3000 dbar	possibly due to bottles
58	S _{ctd} mostly high by ~0.001 below 2000 dbar	possibly due to calibration
59	S _{ctd} mostly high by ~0.001 below 1000 dbar	possibly due to calibration
60	S _{ctd} mostly high by ~0.001 for whole profile	possibly due to calibration
64	S _{ctd} mostly low by ~0.001 below 1000 dbar	unknown
65	S _{ctd} low by ~0.001 above 3000 dbar, high by ~0.001 below 3000 dbar	possibly due to bottles
67	S _{ctd} mostly high by ~0.001 below 3000 dbar	possibly due to calibration
69	S _{ctd} high by ~0.001 below 3000 dbar	unsure
71	S _{ctd} high by ~0.001 below 3000 dbar	probably due to bottles
71	ΔS increases with pressure below 3000 dbar	unknown
72	S _{ctd} mostly low by ~0.001 below 500 dbar	possibly due to bottles
74	S _{ctd} mostly low by ~0.001 for whole profile	unsure
77	S _{ctd} low by ~0.001 for 1000-3000 dbar	possibly due to calibration
78	S _{ctd} low by ~0.001 below 1500 dbar	possibly due to calibration
79	S _{ctd} mostly low by ~0.001 below 1500 dbar	possibly due to calibration
80	S _{ctd} low by ~0.001 for 600-3200 dbar	possibly due to bottles
81	S _{ctd} high by ~0.001 for whole profile	unsure
83	S _{ctd} mostly low by ~0.001 below 500 dbar	unsure
90	S _{ctd} low by ~0.001 below 500 dbar	unsure

Table 3: Upcast CTD salinity bursts (CTDSAL), flagged as “4” in .sea file, which need confirmation for presence or absence of a spike in 2Hz CTD data (if no spike, flag value should be changed to “2”).

station	bottle number	station	bottle number
22	31	55	34, 31
23	32	59	35, 34, 32
26	34	60	34
32	23	61	34
39	34, 33, 32	64	31, 30, 29
40	36, 34	74	34
41	36, 34	83	25, 24
46	28	86	17

Table 4: Comments on CTD oxygen data for individual stations.

station	comment
22	CTD oxygen mostly low by ~1.5 $\mu\text{mol/kg}$ below 3000 dbar
42	fit to bottles between 2600 and 3200 dbar is not optimum, but within 1%
78	CTD oxygen low by ~1 $\mu\text{mol/kg}$ below 1300 dbar

Table 5: Density inversions $< -0.003 \text{ kg/m}^3/\text{dbar}$, and quality flag for salinity in .ctd file for the pressure bin.

stn	pressure (dbar)	density gradient	sal. flag	stn	pressure (dbar)	density gradient	sal. flag	stn	pressure (dbar)	density gradient	sal. flag
2	2	-0.0045	2	26	6	-0.0130	2	52	4	-0.0046	2
2	4	-0.0045	2	27	2	-0.0047	2	53	2	-0.0036	2
3	2	-0.0089	2	27	4	-0.0047	2	53	4	-0.0036	2
3	4	-0.0089	2	33	2	-0.0042	2	57	2	-0.0041	2
4	2	-0.0136	2	33	4	-0.0042	2	57	4	-0.0041	2
4	4	-0.0136	2	37	2	-0.0086	2	60	2	-0.0035	2
5	2	-0.0075	2	37	4	-0.0048	2	60	4	-0.0035	2
5	4	-0.0075	2	38	2	-0.0031	2	69	2	-0.0069	2
13	2	-0.0046	2	38	4	-0.0031	2	73	2	-0.0104	2
13	4	-0.0046	2	40	16	-0.0032	7	73	4	-0.0105	2
19	2	-0.0035	2	41	76	-0.0032	7	79	2	-0.0030	6
19	4	-0.0035	2	41	80	-0.0059	7	79	4	-0.0030	2
22	2	-0.0048	2	43	2	-0.0032	2	79	6	-0.0030	2
22	4	-0.0048	2	43	4	-0.0032	2	86	6	-0.0033	2
22	6	-0.0070	2	44	2	-0.0039	2	102	2	-0.0040	2
22	10	-0.0063	2	52	2	-0.0046	2	102	4	-0.0040	2

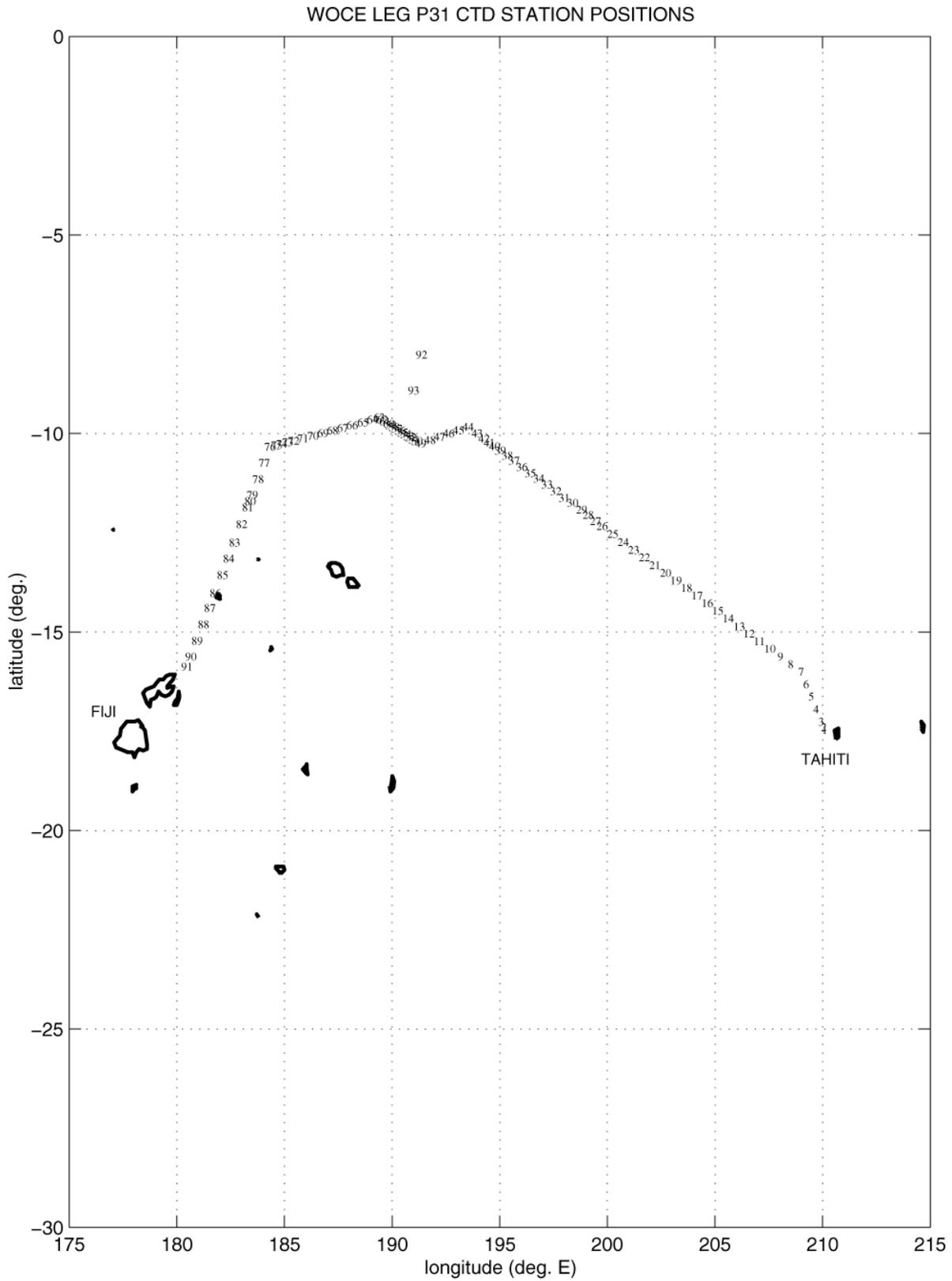


Figure 1

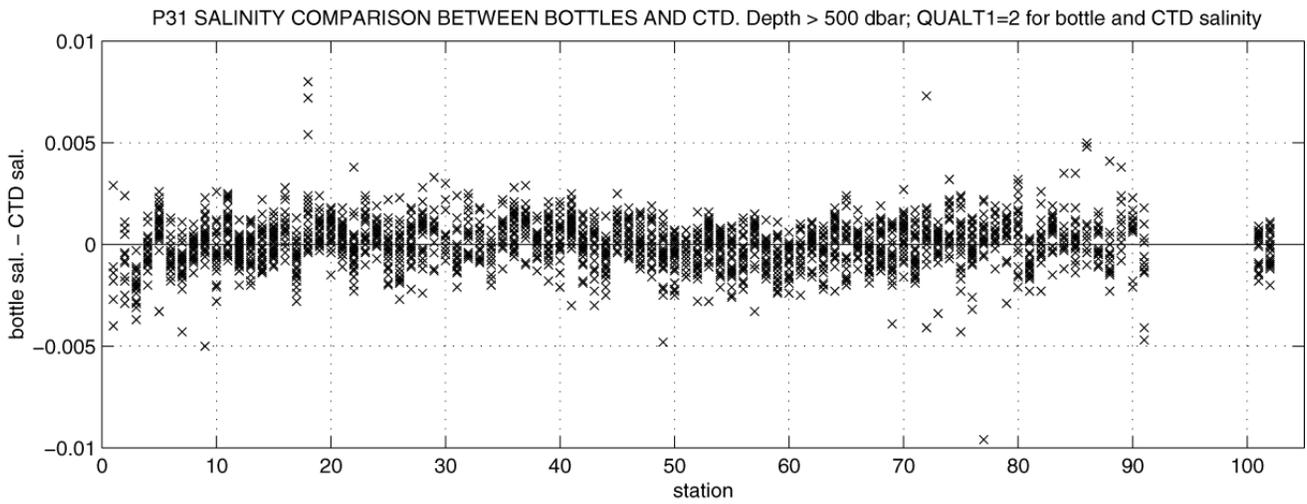
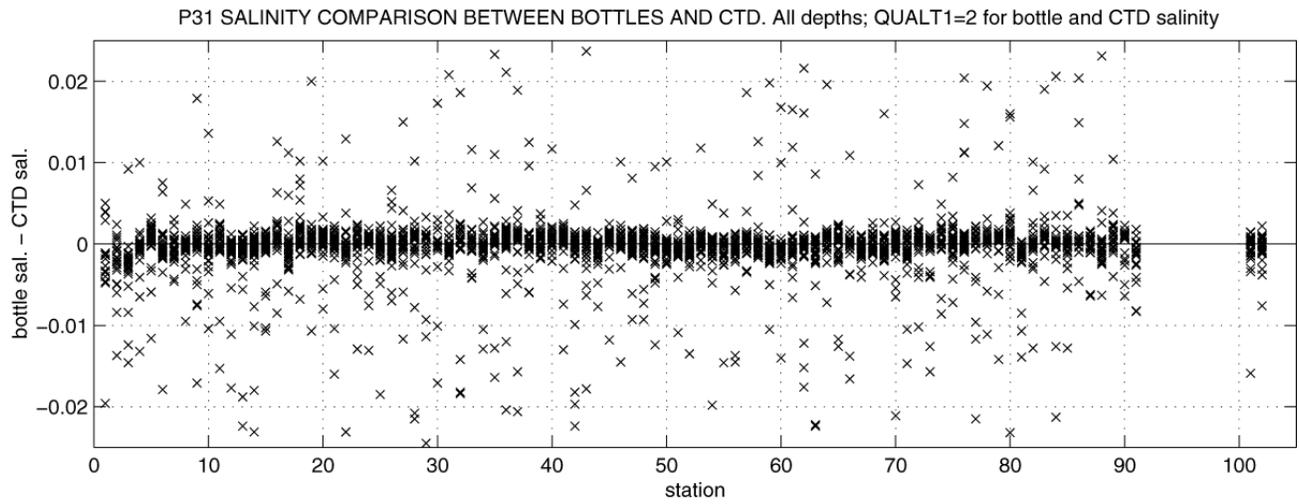


Figure 2a and b: Salinity residuals

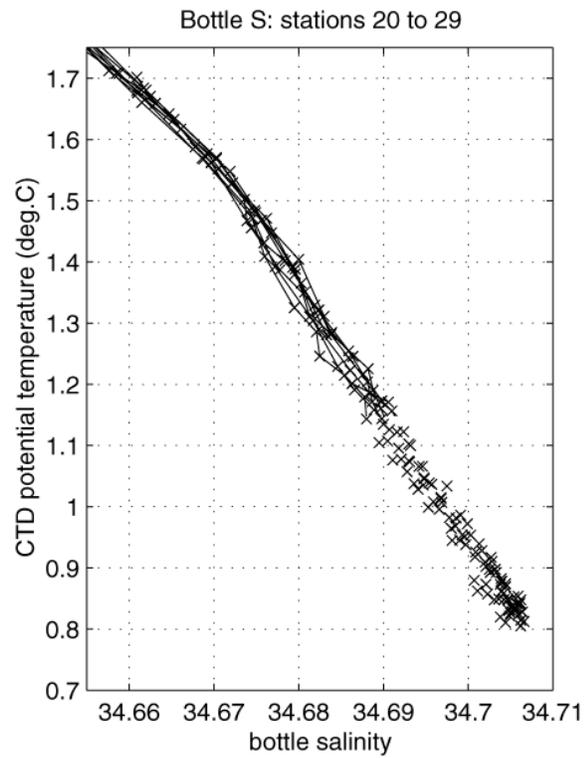
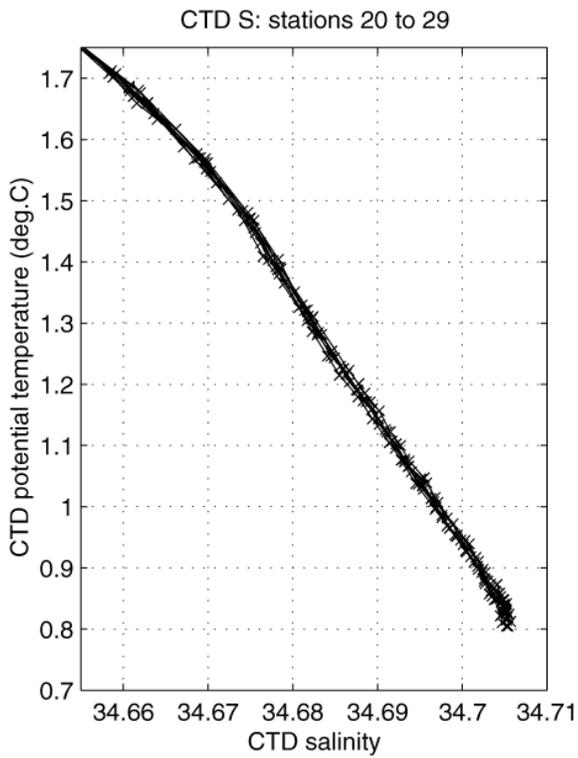
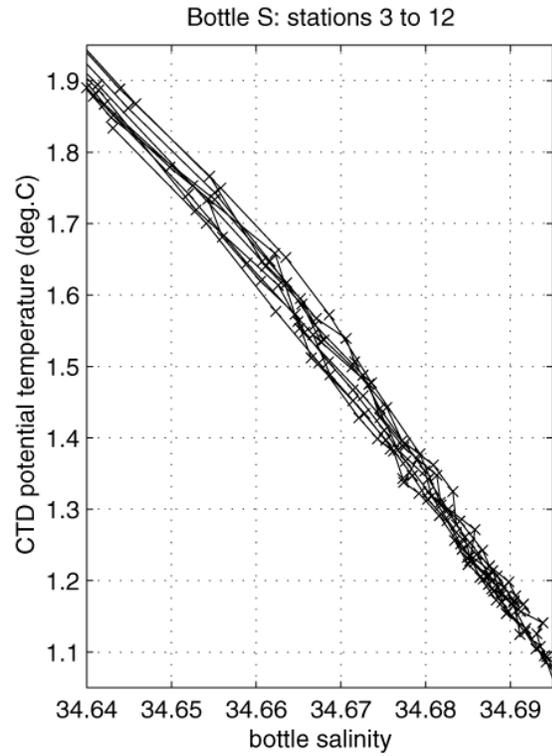
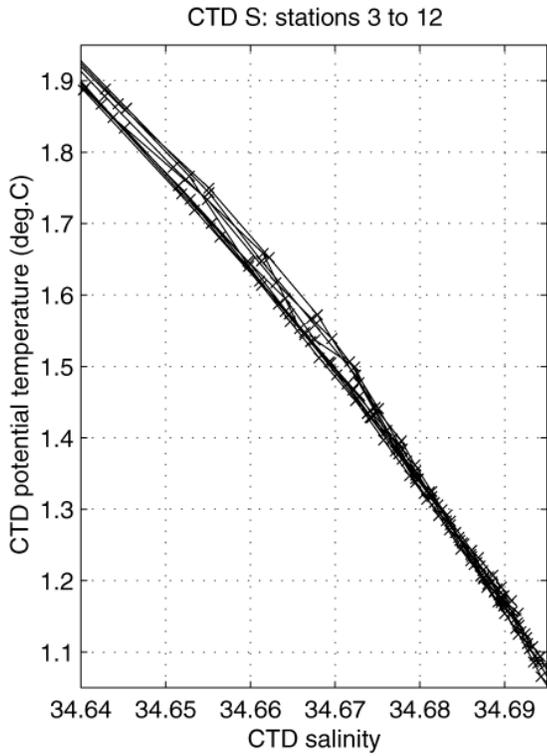


Figure 3: Comparison of deepwater θ -S curves for CTD salinities and bottle salinities

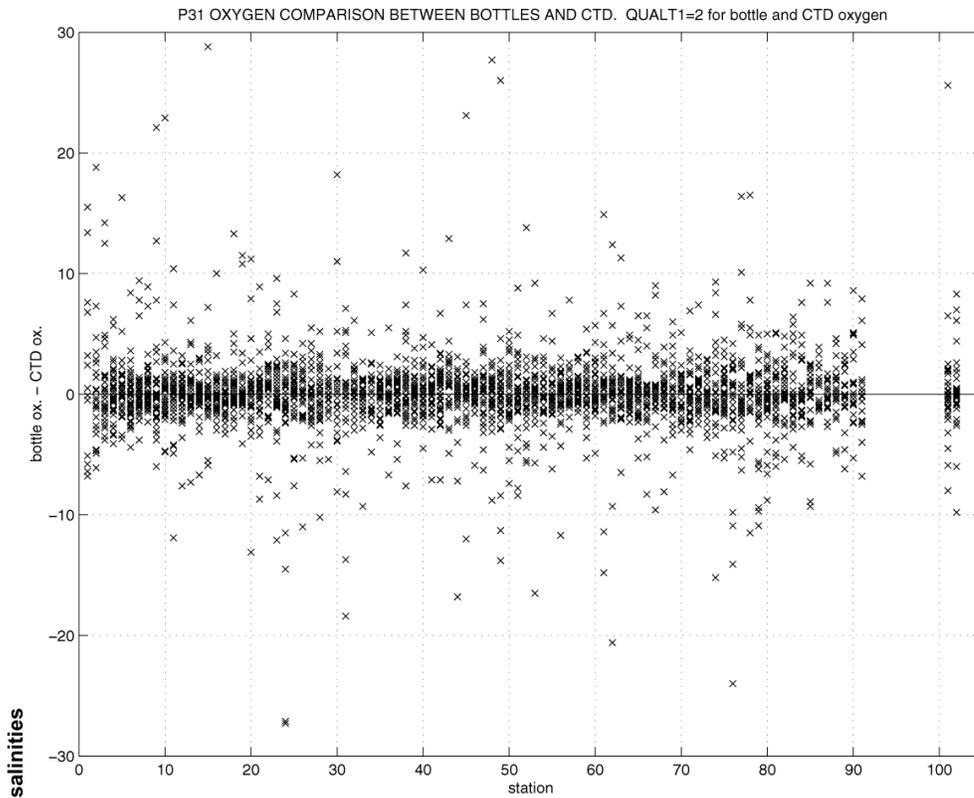


Figure 4: Dissolved oxygen residuals

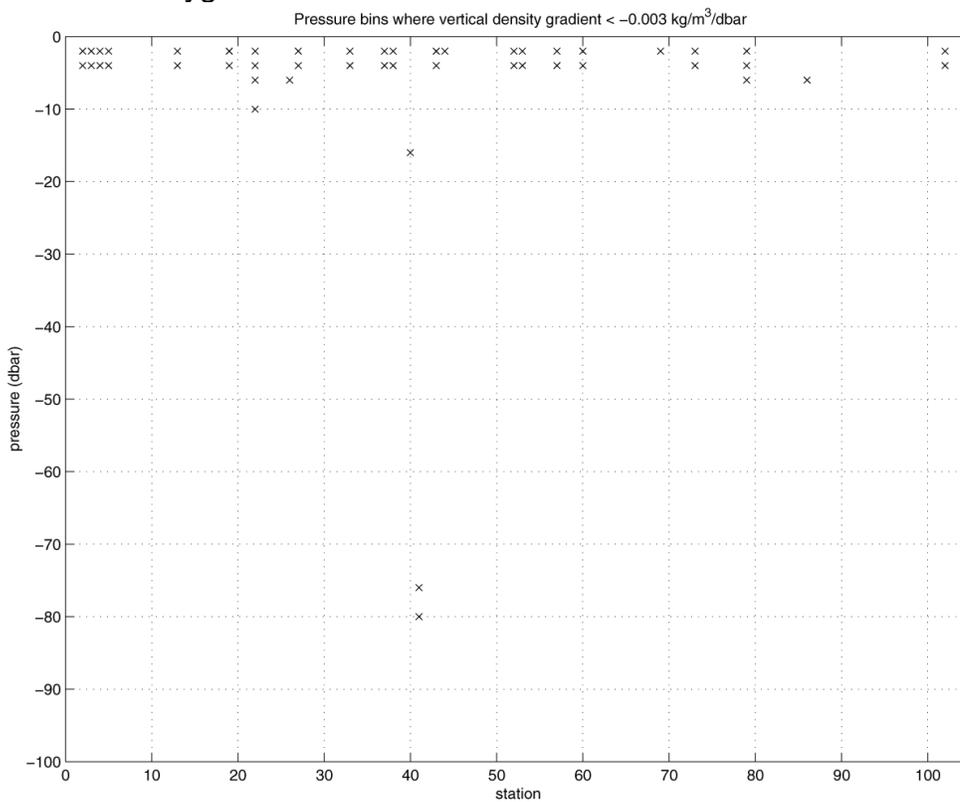


Figure 5: Local density instabilities

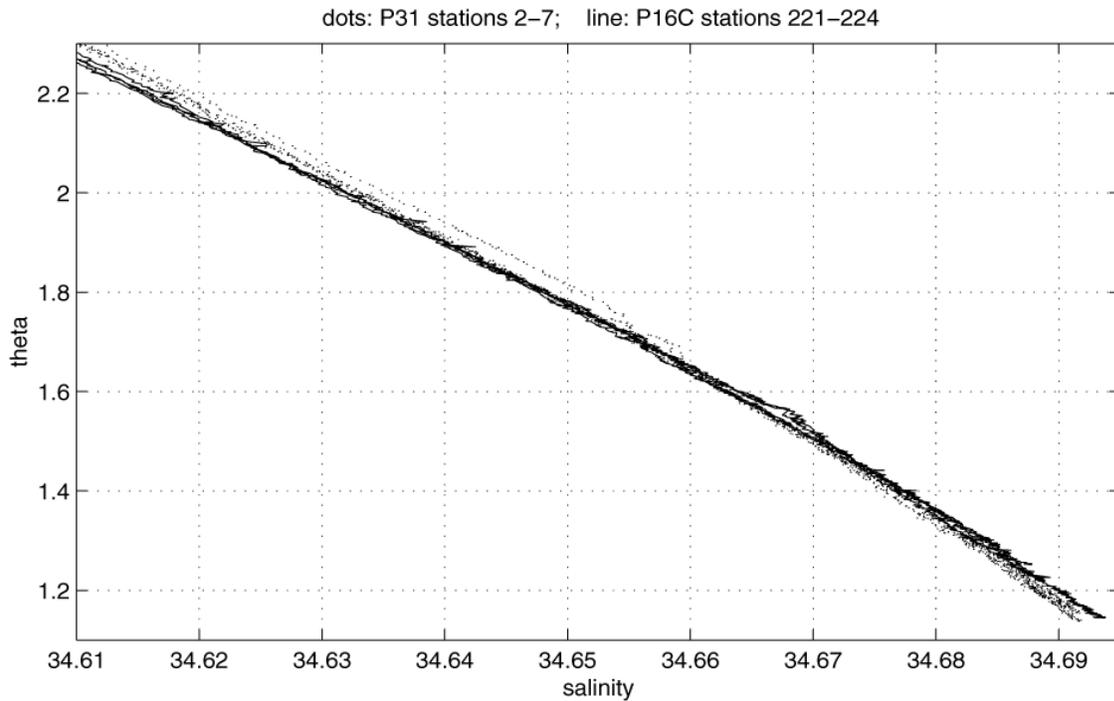
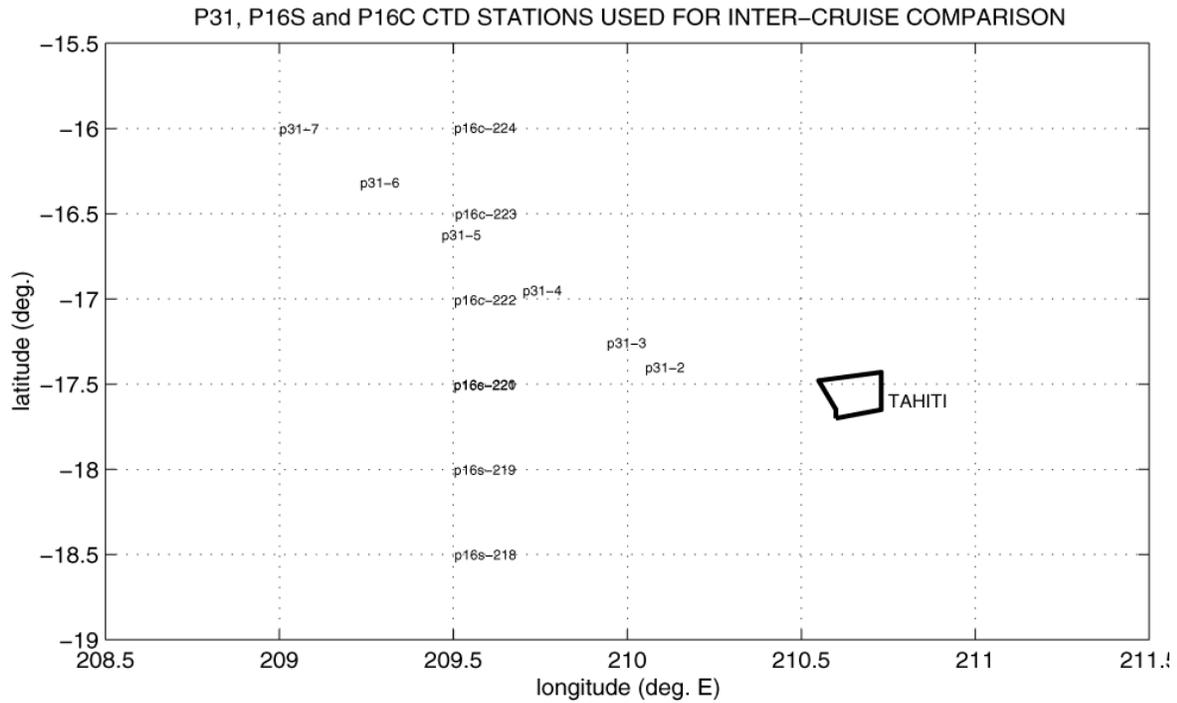


Figure 6a and b: (a) Station locations for P31/P16S and P31/P16C comparisons; (b) comparison of P31 with P16C.

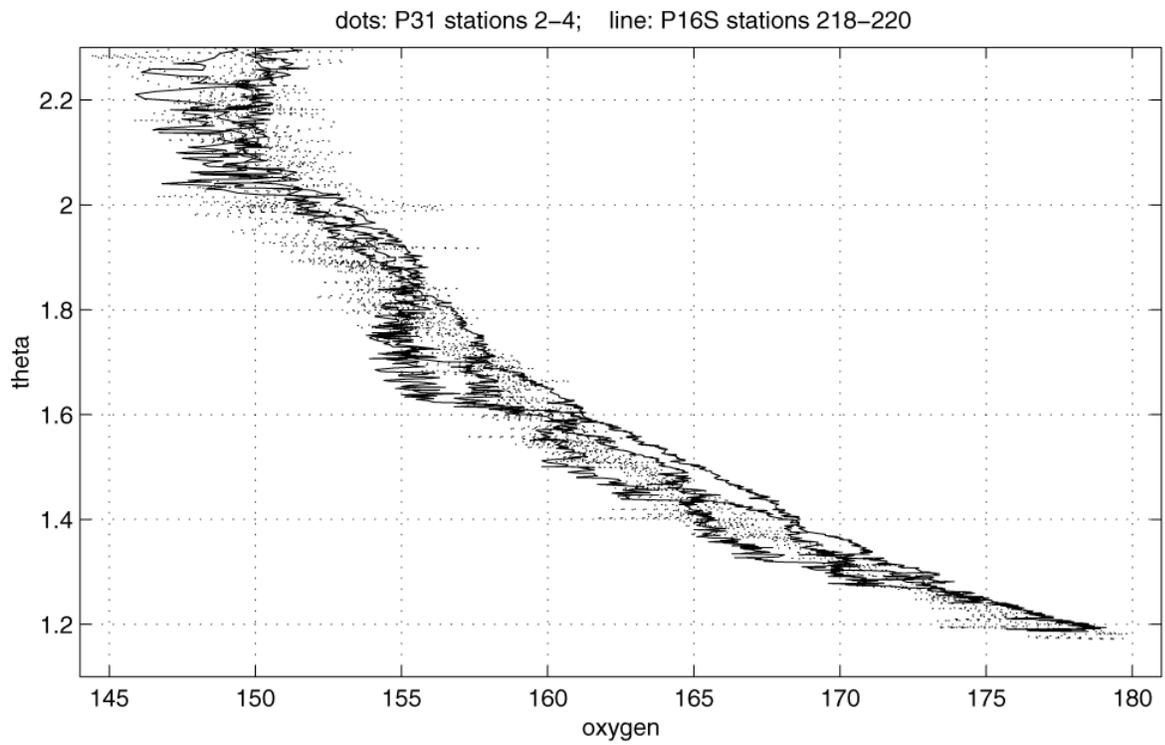
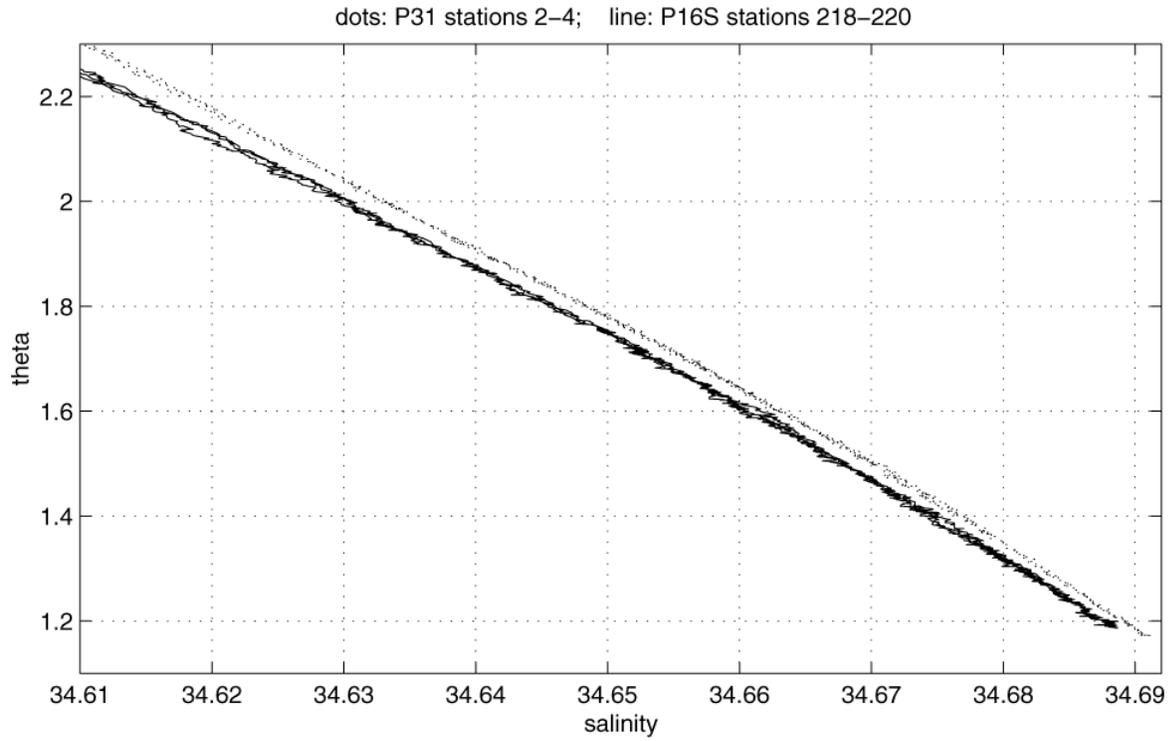


Figure 7: Comparison of P31 with P16S

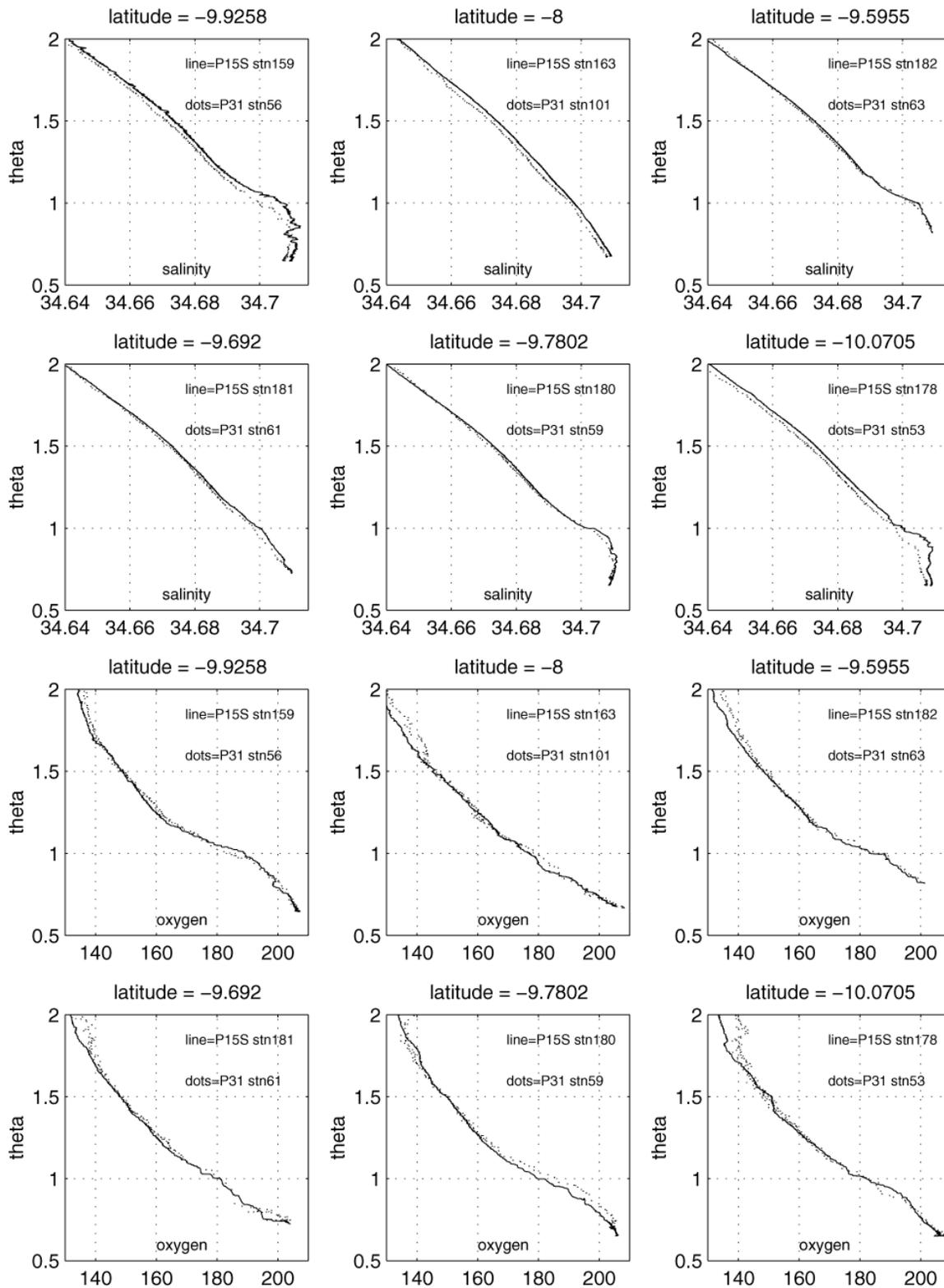


Figure 8: Comparison of P31 with P15S

March 3, 1999

Cruise P31, RV Thomas G. Thompson
January 25, 1994 to February 19, 1994, Papeete, Tahiti to Suva, Fiji
EXPOCODE: 3250031_1
Chief Scientist: Dr. Dean Roemmich
DQE of the discrete data listing for

CTD pressure, temperature, salinity, and oxygen, and bottle data for
salinity, oxygen, silicate, nitrate, nitrite, and phosphate

The evaluation consisted of preparing plots of the parameters to be investigated. All parameters were plotted versus pressure. As necessary, supplement plots of Θ -salinity and salinity-silicate were prepared for individual stations or groups of stations. In addition, plots of phosphate (x-axis) versus nitrate (y-axis) were prepared for each station. From these data, plots of the NO_3/PO_4 ratio and y-intercept versus station number were prepared (attached).

Positions from the .sum file were plotted and appear to be correct. Cast times and dates were checked for consistency. No inconsistencies were found.

Results:

Overall the data look quite good. There are a few "bad" bottle salts. Excluding the phosphate data from early in the cruise, in particular stations 5-11, there are only a few suspect nutrient values. Excluding the surface levels (1st and 2nd bottles) and a few deep values, the CTD-oxygens look very reasonable.

In the DQE report on the CTD data for this cruise (Rosenberg, 1998), the following comment was made: "Numerous bottle salinity values have been flagged '3' in the .sea file even though $\Delta S/is < 0.003$. In most cases I think this residual is too small to justify the '3' flag, and I recommend these values be resurrected to a flag value of '2' (page 2)." I agree with this conclusion. In the halocline, values that fall on the pressure-salinity curve but disagree with the CTD salinity have often been flagged 3 or even 4. In the deep water it was not uncommon for salinities that differed from the CTD value by less than 0.003 p.s.u. to be flagged 3. In both cases, I think those involved in the original processing were a bit harsh. The attached listing suggests that many of the 4's be changed to 3's and many of the 3's be changed to 2's. Mark's suggestions regarding these data have been incorporated into this listing.

In the Cruise Report there are several paragraphs devoted to the problems of collecting and processing CTD oxygen data. The following statement appears: "Therefore the usefulness of data in the top 100 decibars should be carefully considered (page 11)." This is very true, not just for this cruise but most recent cruises on which CTD oxygen data have been taken and processed. Notwithstanding, an effort has been made to review and annotate the CTD oxygen data. The following approach was taken in assigning quality 2 control flags: in the upper 100 db of the water column, if the CTD oxygen value disagreed by ~ 10 or more $\mu\text{moles/kg}$ from the bottle oxygen, these could be flagged either 3 or 4 depending on the magnitude of the difference. If the CTD oxygen data indicated maxima or minima not seen in the bottle data or suggested by the data on adjacent stations, these would be flagged. For

example, if the bottle data showed a true mixed layer in the first three levels of the cast and the CTD oxygen trace showed a pronounced maximum at the second level, this CTD oxygen value would be flagged 3 or 4. Mark Rosenberg's suggestions regarding these data have also been incorporated into this listing.

Data from this cruise were compared with data from the following:
(station position plot attached)

P31 Station No.	Cruise	Date	Station No.
5	P16C	(October of 1973)	223
3	P21E	(May of 1985)	165
	CRUISE P21E HAS YET TO BE DQEd		
4	P16S	(March of 1989)	220
101	P15S	(February of 1986)	163
59	P15S	(February of 1986)	180

Before detailing the comparisons, particularly in the values below 2000 db, it should be noted that the data from cruise P21E have yet to be DQEd. This work is now underway. It should also be noted that the nutrient data from P21E are in units of $\mu\text{moles/liter}$. In making the station comparisons, the data from P21E have been converted to $\mu\text{moles/kg}$ by dividing the per liter unit by 1.0236, the density of water with salinity of 35 p.s.u. and a lab temperature of 25°C.

The CTD salinity data from P31 agree quite well with data from the comparison stations. The CTD salinity data appear to be offset 0.003 p.s.u. lower than the data from P21E. Compared to P16S, the salinity data are offset higher by 0.0015 p.s.u. For all other stations, the salinity data are within ± 0.002 p.s.u with no obvious offset.

The oxygen data agree quite well with the data from the comparison stations with the profiles from P31 typically showing less scatter than on the other cruises. The data from P31 are within $\pm 1 \mu\text{mole/kg}$ of the data from the other cruises. On cruise P16S there appears to be an approximately 1 $\mu\text{mole/kg}$ offset between the two data sets, with the P31 data being lower [at a conc. of 170.0, 1 $\mu\text{mole/kg}$ is 0.6%].

The silicate data agree quite well with the data from the other cruises, typically within 1.5 $\mu\text{moles/kg}$ [at a conc. of 124.0, 1.5 $\mu\text{moles/kg}$ is 1.2%]. However, compared with P16S, the data appear to be offset $\sim 3 \mu\text{moles/kg}$ lower.

The nitrate data agree quite well with the data from the other cruises, but are typically low. The offsets range between 0.2 and 0.7 $\mu\text{moles/kg}$ [at a conc. of 34.0, 0.5 $\mu\text{moles/kg}$ is 1.5%].

As pointed out in the Cruise Report, (Appendix D) there were problems with the phosphate analyses which were corrected by Station 12. These problems are very apparent in the data, particularly stations 5-11 where there was a reagent problem. For stations 1 through 12, that sampled as deep as 4500 db, the nitrate data ($\sim 33 \mu\text{moles/kg}$) show a range of approximately 0.6%; at these same stations, the phosphates range 3.5% to 11.3% higher than station 12, (see attached plots).

The effects of the “bad” molybdate solution appear to be two fold: one, the phosphate values are typically high and two, the data tend to show somewhat more scatter than on later stations. The problem is also apparent in the plot of the NO_3/PO_4 ratio by station number. For the affected stations, the ratios are typically low by up to 1 $\mu\text{mole/kg}$.

At stations 101 & 59, the phosphate data are typically 0.02 $\mu\text{moles/kg}$ lower than the data from P15S while at stations 3 and 4, the phosphate data are ~ 0.00 to ~ 0.02 $\mu\text{moles/kg}$ higher. [At a conc. of 2.50, 0.02 $\mu\text{moles/kg}$ is 0.8%].

In the final cruise report (Appendix D, page 1), station 001, bottle 114, the following note appears: “Footnote CTD salinity questionable, value is probably good on its own merit just not to compare with the bottle data. No CTDO is calculated because the CTD Salinity is coded bad.”

In this case as on several other stations, it would be preferable to calculate the corresponding CTD oxygen value, list it, and allow it to be evaluated with the rest of the CTD oxygen data. Recalculating this value after the fact is probably more of a nuisance than its worth. Perhaps the processing program could be modified so even when a CTD salt is flagged 3 or even 4, the CTDO value would be calculated and listed. If it turns out to be “bad”, it could be flagged appropriately. In cases where the CTD salinity falls on the salinity/pressure curve, it is recommended that the CTD salinity flag be changed to 2, because the CTD “value is good on its own merit...”

In the final cruise report (Appendix D, page 3), station 015, bottle 101 - 102, the following note appears: ‘ “CTD data processor: “CTD oxygen values questionable 4850 to 4934 db.”’ Based on this, it appears as though the CTD oxygen values for bottles 102 and 101 were flagged 3. However, the CTD and bottle oxygens agree within 0.6 and 1.4 $\mu\text{moles/kg}$ respectively which should be acceptable. It may be that the CTDO processor’s remarks are used to flag data in the discrete data listing without evaluating the quality of the points with respect to the values from the discrete samples. This has been done on other stations on this cruise, e.g. station 27, bottle 102.

Attached are listed changes to be considered by the data originator with some explanations. Most of these changes involve the CTD and bottle data for salinity and oxygen. These “changes-to-be-considered” have not been separately annotated because they reflect the comments made in the text above. A few suggestions have been made regarding other data. These have been explained in this listing.

George C. Anderson
DQ Evaluator

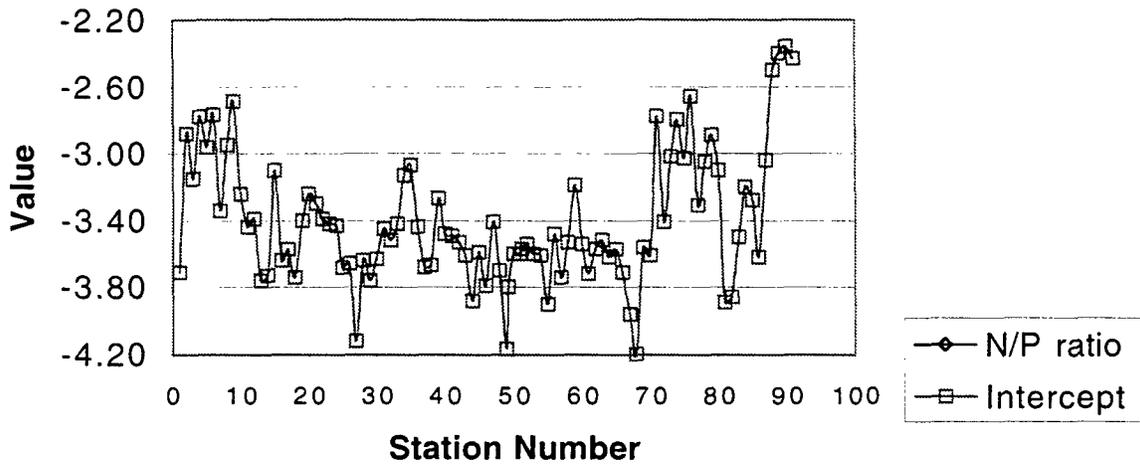
References:

DQE Evaluation of CTD data...Mark Rosenberg, November 1998
Oceanographic Data Facility (ODF) Final Cruise Report, 18 July 1997

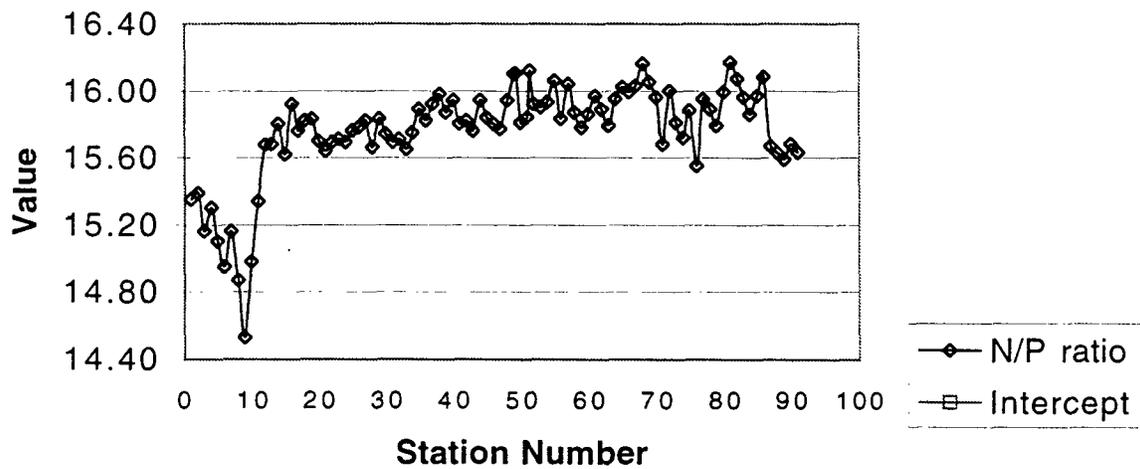
List of plots:

plots of the NO₃/PO₄ ratio, and y-intercept versus station number
positions of comparison stations
nitrate and phosphate data, stations 1 - 12, concentrations vs. pressure

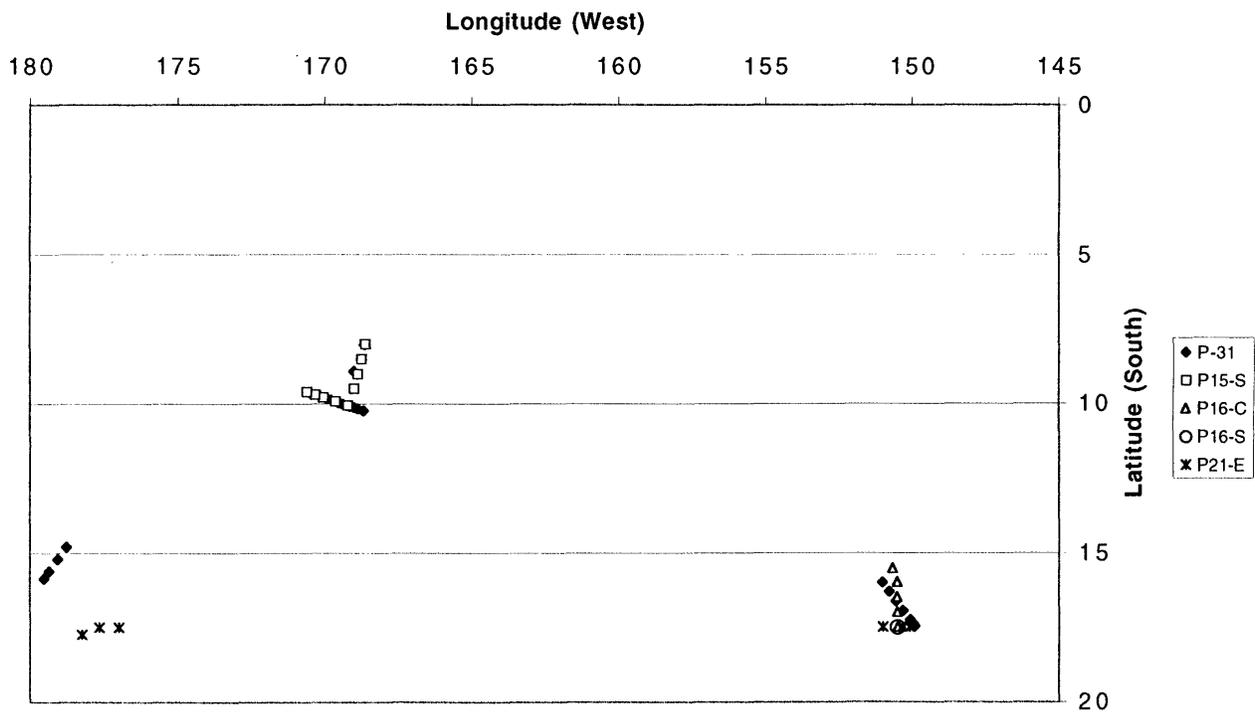
NO₃/PO₄ Intercept Values: WOCE Cruise P31



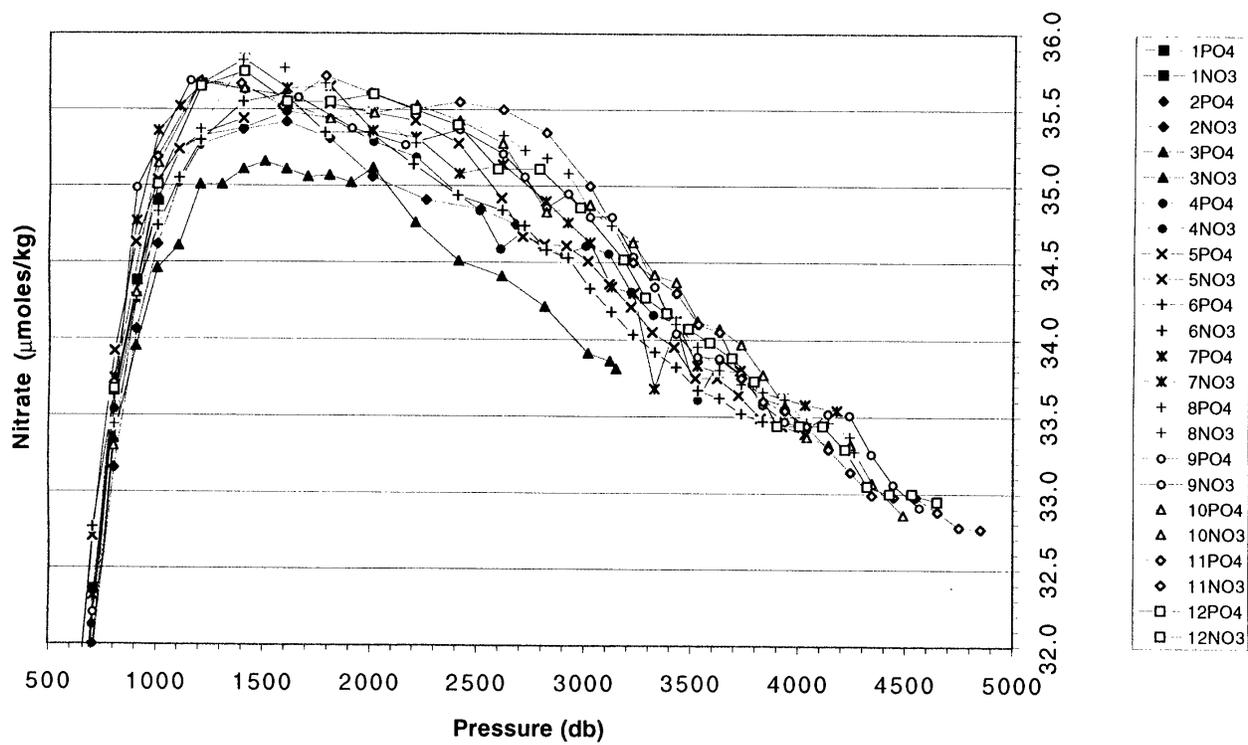
NO₃/PO₄ Ratio Values: WOCE Cruise P31



P31 Comparison Stations



P31: Nitrate vs Pressure Stations 1-12



DQE Comments Cruise P31

Stat.	Bottle No.	Depth (db)	CTD		Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
1	14	45.5	X								3	2	CTD salt appears to be acceptable.
	13	80.3		X							2	4	
	12	105.5		X							2	4	
	9	257.0		X							2	3	
	3	808.5		X							2	4	
2	21	105.1		X							2	4	
	7	1404.5		X							2	3	
	1	2679.8		X							3	4	
3	30	2.1		X							2	4	
	29	15.1		X							2	4	
	20	801.8		X							2	3	
	19	902.4		X							2	4	
	8	2008.1			X						3	2	
5	36	2.0		X							2	4	
	28	605.1		X							2	3	
	16	2409.7				X					2	3	Silicate value high; falls off silicate-theta &-salinity plots
	2	3925.6			X						4	3	
6	25	804.3		X							2	4	
7	34	55.9		X							2	3	
	27	705.6		X							2	4	
	24	1006.5		X							2	4	
	9	3328.5					X				2	3	NO3 low, NO2 very high; maybe a problem with nutrient sample tube
	9	3328.5						X			2	4	If NO2 value is added to NO3 value, NO3 value would be reasonable
8	36	2.0		X							2	3	
	32	206.0		X							2	4	
9	36	2.3		X							2	4	
	35	16.5		X							2	4	
	2	4442.9		X							3	2	

Stat.	Bottle No.	Depth (db)	CTD		Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
9	1	4565.4		X							3	4	
10	34	56.6		X							2	4	
	15	2821.2					X				2	3	Silicate value low; falls off silicate-theta &-salinity plots
	3	4243.7			X						3	2	
12	31	305.0		X							2	3	
	6	4114.2											Temperature value looks high; needs to be checked.
	3	4428.7			X						3	2	
13	25	1201.4		X							2	3	
	1	4429.8		X							3	2	
14	26	1252.2		X							2	3	
	14	3729.9			X						2	3	
	1	5113.5		X							2	3	
15	36	1.0		X							2	3	
	34	54.0		X							2	4	
	2	4855.3		X							3	2	See note in DQE write up regarding these two levels
	1	4933.6		X							3	2	
16	35	13.9		X							2	4	
	6	4545.4			X						3	2	
	6	4545.4					X				2	3	Silicate value low; falls off silicate-theta &-salinity plots
	4	4747.8		X							2	3	
	1	5017.4			X						3	2	
18	36	0.6		X							2	4	
19	36	2.9		X							2	4	
	35	13.8		X							2	4	
	16	3633.2			X						3	2	
	2	5060.3		X							2	3	
20	36	3.0		X							2	4	
	35	16.3		X							2	4	
	22	2263.2			X						3	2	
21	36	1.7		X							2	4	
	35	15.7		X							2	4	
22	31	306.0	X								4	2	

Stat.	Bottle No.	Depth (db)	CTD		Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
22	28	805.5		X							3	2	
	25	1507.6		X							2	3	
	5	4748.1			X						3	2	
23	35	12.9		X							2	4	
	16	3634.1			X						3	2	
	4	5519.8		X							2	3	
24	36	3.1		X							2	4	
	35	15.9		X							2	4	
	34	56.8		X							2	4	
	32	205.0	X								4	2	
25	15	3830.3			X						3	2	
	36	2.0		X							3	2	
	35	15.4		X							3	2	
26	36	1.9		X							3	2	
	35	11.5		X							3	2	
	34	56.1	X								4	2	
	33	106.4		X							3	2	
	32	205.7		X							3	4	
	13	3820.9		X							2	3	
27	2	4853.7		X							3	2	
28	33	105.3		X							3	2	
	13	2708.8			X						3	2	
29	24	3.2		X							3	4	
	23	14.1		X							3	2	
	22	54.0		X							3	2	
	21	103.7		X							3	2	
	20	204.0		X							3	2	
	4	2310.3		X							2	3	
30	25	1.6		X							2	3	
	23	55.1		X							2	3	
	22	105.2		X							2	4	
	12	1206.3		X							2	3	

Stat.	Bottle No.	Depth (db)	CTD		Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
31	3	2412.1		X							2	3	
32	24	10.2		X							2	3	
	23	55.5	X								4	2	
	1	2619.7		X							2	3	
34	26	15.0		X							3	4	
	25	55.2		X							3	4	
	25	55.2			X						4	3	
	10	2225.8			X						3	2	
	9	2327.3			X						3	2	
	51	2731.7			X	X	X	X	X	X			Report states bottle may have leaked; values look acceptable. Change bottle code 3 to 2; all prop codes from 4 to 2
	2	2937.3			X						3	2	
35	33	3.0		X							3	2	
	32	16.3		X							3	2	
	31	55.6		X							3	2	
35	30	106.1		X							3	2	
36	28	506.8				X					4	2	
	27	607.7				X					4	2	
	25	809.5				X					4	2	
	19	1821.6				X					4	2	
	14	2838.3			X						3	2	
37	51	3142.5			X	X	X	X	X	X			Report states bottle may have leaked; values look acceptable. Change bottle and sample codes to 2; salinity and silicate to 3.
38	36	3.2		X							2	4	
39	36	3.6		X							2	4	
	34	56.1	X								4	2	
	33	106.3	X								4	2	
	32	206.3	X								4	2	
40	36	3.0	X								4	2	
	34	56.2	X								4	2	
	1	4817.6		X							3	2	
41	33	106.5		X							3	4	

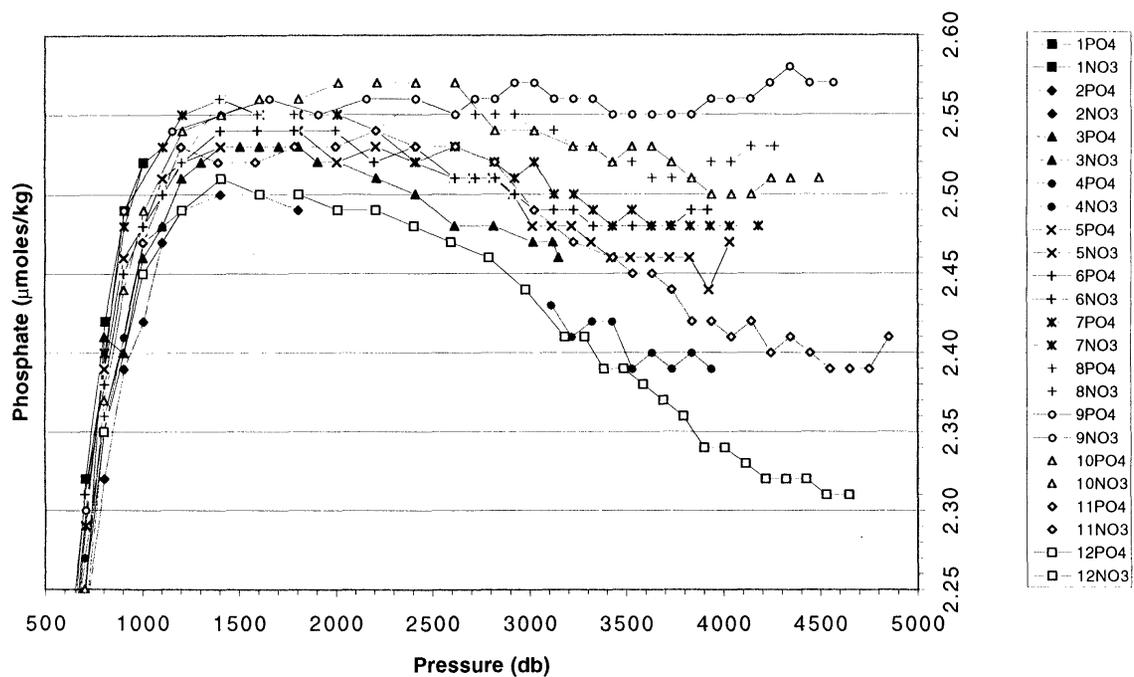
Stat.	Bottle No.	Depth (db)	CTD		Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
42	36	2.5		X							2	3	
43	30	2.3		X							2	4	
44	31	15.4		X							2	4	
	14	2225.4					X				2		Silicate looks high; not on salt/theta curves; other nutrients OK.
	10	2836.3									3	2	
45	31	16.2		X							2	4	
	12	2628.8					X				3	2	
	7	3123.5					X				3	2	
	2	3641.7								X	2	3	PO4 value appears high; falls below NO3/PO4 curve
46	33	2.6		X							3	4	
	28	307.5	X								4	2	
	8	3042.2					X						Silicate looks ~1 unit low; not on salt/theta curves; other nuts OK.
47	35	2.9		X							2	3	
48	36	2.4		X							2	3	
	35	17.2		X							2	4	
	1	4282.1		X							2	3	
49	36	3.2		X							2	4	
	34	55.5		X							2	4	
50	35	16.0		X							2	3	
51	36	6.5		X							2	3	
	17	3031.5					X				3	2	
	15	3451.3					X				3	2	
	4	4465.3					X				3	2	
	3	4532.8					X				3	2	
	2	4643.7					X				3	2	
	1	4700.6					X				3	2	
52	35	16.9		X							2	4	
	23	1771.7					X				4	3	
53	10	4348.8					X				3	2	There is a slight inflection over this depth range in other properties
	9	4424.8					X				3	2	Data compare satisfactorily with silicates on stations 52 & 54.
	8	4501.4					X				3	2	

Stat.	Bottle No.	Depth (db)	CTD		Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
54	36	4.2		X							3	4	
	35	17.6		X							3	2	
	34	57.1		X							3	2	
	2	5196.2		X							3	2	
55	35	12.4		X							2	3	
	34	57.4	X								4	2	
	31	308.1	X								4	2	
	27	1251.1		X							2	3	
57	16	3963.6			X	X	X	X	X	X	4	2	Silicate is high, but other properties satisfactory; accept data
	2	5195.7		X							3	2	
58	36	4.3		X							3	2	
	35	17.9		X							3	4	
	34	57.2		X							3	2	
59	23	2022.9		X							2	3	
60	34	56.2	X								4	3	
	2	4265.0		X							2	3	
61	35	11.7		X							2	4	
	34	56.4	X								4	3	
	51	4218.1		X							3	2	
62	36	3.4		X							2	4	
63	35	16.4		X							2	4	
	6	3885.3				X					3	2	
101	34	58.9		X							2	3	
	23	2026.7			X						3	2	
	10	4362.4			X						3	2	
	3	5080.7		X							3	2	
102	33	108.2			X						4		If key entry error assumed, 35 vis 36, values fits property curve
	32	208.2			X						3	2	
	15	3657.5			X						4	3	
	14	3759.6			X						4	2	
64	31	108.0			X						4	2	
	30	208.4			X						4	2	

Stat.	Bottle No.	Depth (db)	CTD			Bottle			Data			Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2		
64	29	308.3			X							4	2	
	25	711.8		X								2	3	
65	33	3.6		X								3	4	
	32	17.2		X								3	2	
	31	57.0		X								3	2	
	14	2433.0		X								2	3	
	2	3808.0			X							3	2	
66	21	711.4		X								2	3	
	2	3452.5		X								3	2	
67	1	3904.3		X								2	3	
68	23	703.5		X								2	3	
69	25	609.5		X								2	3	
72	1	4239.8		X								3	2	
74	34	56.7	X									4	2	
77	30	3.3		X								2	4	
	22	611.2		X								2	3	
	13	2024.4			X							3	2	
78	27	2.4		X								2	4	
	1	3381.6		X								3	2	
79	31	2.5		X								2	3	
	4	3550.1					X					2	3	
80	24	1009.1		X								2	3	
	23	1213.9		X								2	3	
	22	1410.8		X								2	3	
	1	4018.3		X								3	2	
81	1	3943.0		X								3	2	
82	7	2631.2		X								2	3	
83	25	106.8	X									4	2	
	24	207.4	X									4	2	
	1	3129.3			X							3	2	
84	2	2938.7		X								2	3	
85	26	48.1		X								2	3	

Stat.	Bottle No.	Depth (db)	CTD		Bottle		Data				Q Flags		Comments
			Salt	O2	Salt	O2	SIL	NO3	NO2	PO4	1	2	
86	17	105.1	X								4	2	
88	4	2617.4		X							3	2	
	2	2617.5		X							3	2	
	6	2617.6		X							3	2	
	1	2617.9		X							3	2	
	3	2618.0		X							3	2	
	5	2618.1		X							3	2	
89	1	2215.7		X							3	2	
90	23	9.5		X							2	3	
	1	2392.9				X					2	3	
91	1	1461.9		X							3	2	

P31: Phosphate vs Pressure Stations 1-12



DATA STATUS NOTES

1998.08.14 SCD: CTD data replaced with new files from ODF.

1998.11.17: SCD: new bottle data file from ODF (Rosenberg was working on *non-final* data) These data are FINAL.

20 August 1997

FINAL quality-coded WHP-format PTCO CTD Data release for WOCE94-P31

The file named p31whp.ctd.tar.Z contains the files listed below, which were tarred and compressed for easier transmission via ftp.

To expand these files into the directory "./p31whp.ctd", use the following UNIX command:

```
uncompress -c p31whp.ctd.tar.Z | tar xvpf -
```

The file named "p31ctd.zip" was created with the UNIX zip utility for the benefit of PC users. The data can be expanded into the directory "./p31whp.ctd" using "unzip" or "pkunzip" utilities.

Note that pkunzip 2.04g/unzip 5.0p1 (or later versions) must be used to extract files produced by pkzip 2.04 or zip 2.0.1. Earlier versions are not compatible.

CONTENTS of the directory ./p31whp.ctd (approximately 12 Mbytes, 2 of which are documentation):

README.ctd	comments regarding data release and documentation
DOC	final ODF processing documentation
p31odf.sum	WOCE-format station-cast description file (ODF version) (a more up-to-date version may be available from the P.I.)
sssc.ctd	stations 1-91,101,102 ctd data files: 93 total casts (sss = station number cc = cast number) NOTE: stations 101 & 102 are non-WOCE Samoa Passage stations

The documentation is dated July 18, 1997 to match the date CTD PTCO data were finalized. The files in DOC with a ".ps" suffix can be printed out on a postscript printer. The complete document is in DOC/p31doc.ps or DOC/p31doc.asc. The postscript version has also been broken down into parts, as listed below, for those desiring only one section of the document:

ascii documentation:

DOC/p31doc.asc	entire document minus figures postscript documentation:
DOC/p31doc.ps	entire document (also in 3 parts, listed below)
DOC/p31cover.ps	cover sheet with cruise info & track map
DOC/p31body.ps	main body of document, including references

DOC/p31apps.ps appendices A-D with tables of CTD temperature & conductivity corrections, CTD oxygen corrections, CTD processing comments, and bottle data quality comments.

For those without postscript capability, the documentation should be printed out using DOC/p31doc.asc. Note that figures in the document can only be printed with postscript and do not appear in the ascii version. Also, the ascii file is intended to be printed out at 80 lines per page with a minimum 90-character page width – typically elite print. The right margin of the ascii version is staggered and lines do not begin with any white space at the request of P.I.s who merged parts of the ascii file into their final cruise documentation.

QUESTIONS:

These data may not be released without permission from the Chief Scientist/PI:

Dr. Dean Roemmich
Scripps Institution of Oceanography
University of California, San Diego
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(619) 534-2307

Questions regarding the CTD data should be directed to:

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