

## WHP Cruise Summary Information

WOCE section designation	I08N/I05E
Expedition designation (EXPOCODE)	316N145_7
Chief Scientist(s) and their affiliation	Lynne Talley, SIO
Dates	19950310 - 19950415
Ship	KNORR
Ports of call	Colombo, Sri Lanka to Fremantle, Australia
Number of stations	165
Geographic boundaries of the stations	6°30.14"N 79°35.17"E 0°15.00"S 114°52.45"E
Floats and drifters deployed	20 Floats and 9 Drifters
Moorings deployed or recovered	none
Contributing Authors (In order of appearance)	F. Delahoyde M. Beaupre E. Firing P. Hacker J. Hummon M. Thatcher

## WHP Cruise and Data Information

Instructions: Click on any highlighted item to locate primary reference(s) or use navigation tools above.

<b>Cruise Summary Information</b>	<b>Hydrographic Measurements</b>
Description of scientific program	CTD - general
	CTD - pressure
Geographic boundaries of the survey	CTD - temperature
Cruise track (figure)	CTD - conductivity/salinity
Description of stations	CTD - dissolved oxygen
Description of parameters sampled	
Bottle depth distributions (figure)	Salinity
Floats and drifters deployed	Oxygen
Moorings deployed or recovered	Nutrients
	CFCs
Principal Investigators for all measurements	Helium
Cruise Participants	Tritium
	Radiocarbon
Problems and goals not achieved	CO2 system parameters
Other incidents of note	Other parameters
<b>Underway Data Information</b>	<b>Acknowledgments</b>
Navigation	<b>References</b>
Bathymetry	
Acoustic Doppler Current Profiler (ADCP)	<b>DQE Reports</b>
Thermosalinograph and related measurements	
XBT and/or XCTD	CTD
Meteorological observations	S/O2/nutrients
Atmospheric chemistry data	CFCs
	14C
	<b>Data Status Notes</b>

## Cruise Report - WOCE I08N/I05E

### A. Cruise narrative

#### 1. Highlights

- a. **Expedition:** WOCE I08N/I05E (R/V Knorr 145-7)
- b. **Expocode:** 316N145\_7
- c. **Chief Scientist:** Lynne D. Talley  
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- d. **Ship:** R/V Knorr, Captain C. Swanson
- e. **Ports of Call:** Colombo, Sri Lanka  
Fremantle, Australia
- f. **Cruise dates:** 10 March 1995 - 15 April 1995

#### 2. Cruise summary

- a. **Cruise track** in Fig.1
- b. **Sampling** (Fig. A.2)

165 CTD/36-bottle rosette stations; 155 stations included LADCP

Water sampling through the water column for salinity, oxygen, nitrate, phosphate, silicate, nitrite, CFC's, total CO<sub>2</sub>, alkalinity, C14, helium, tritium, barium. Surface sampling at selected station locations for delta-C13, phytoplankton growth rates and calcite.

Underway sampling programs are listed in section A.5.

Listings of parameters measured at each station are given in the .SUM file.

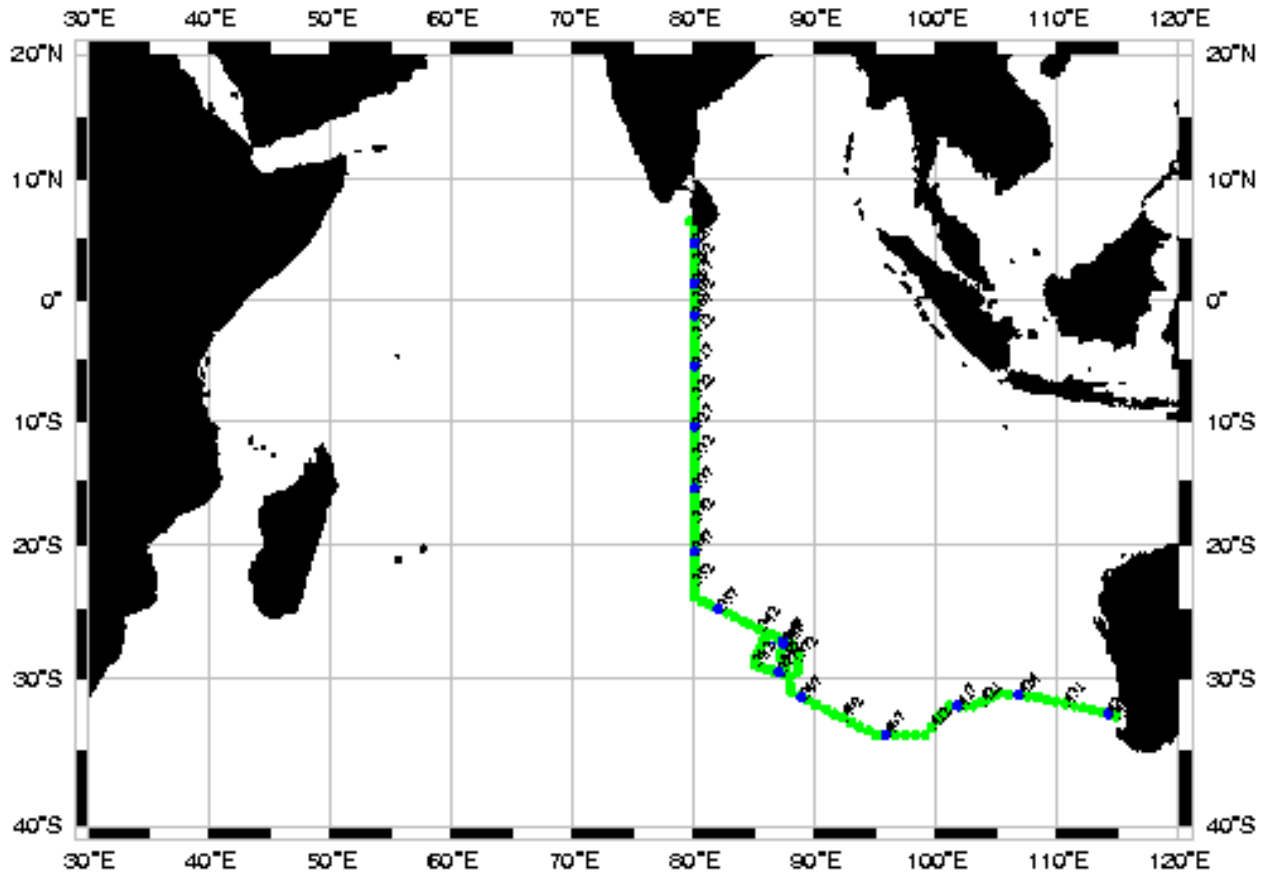


Fig. 1 WOCE I05E/I08N Cruise Track (produced by .SUM files by WHPO)

**c. Floats and drifters deployed (Fig. A.3)**

- 20 ALACE floats
- 9 surface drifters

Identification numbers, locations and times are given in the .SUM file.

**d. No mooring deployments**

### 3. Principal Investigators

William Balch	Surface calcite	U. Miami	balch@rcf.rsmas.miami.edu
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Christopher Winn	Carbon dioxide	U. Hawaii	cwinn@mpl.ucsd.edu

Abbreviations and addresses for tables above and below:

LDEO: Lamont-Doherty Earth Observatory, Palisades, NY 10964

NARA: National Aquatic Resources Agency, Crow Island, Mattakkuliya, Colombo 15, Sri Lanka

NOAA/AOML: National Oceanic and Atmospheric Administration, Atlantic Oceanographic and Marine Laboratory, 4301 Rickenbacker Causeway, Miami, FL 33149

NOAA/PMEL: National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory. Hatfield Marine Science Center, 2115 SE OSU Dr., Newport, OR 97365

OSU: College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331-5503

Princeton: Princeton University, Geology Dept., Guyot Hall, Princeton, NJ 08544

SIO: Scripps Institution of Oceanography, UCSD, La Jolla, CA 92093 USA

SIO/ODF: SIO Oceanographic Data Facility, UCSD, La Jolla, CA 92093-0214 USA

TAMU: Texas A&M University, College Station, TX 77843

U.C. Santa Cruz: Rau address is NASA-Ames, MS239-4 Moffett Field, CA 94035-1000

U.Hawaii: University of Hawaii, 1000 Pope Rd., Honolulu, HI 96822

U. Miami: University of Miami/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33143

WHOI: Woods Hole Oceanographic Institution, Woods Hole, MA 02543

## **4. Scientific Programme and Methods**

### **a. Narrative**

R/V Knorr departed Colombo, Sri Lanka for its seventh leg of cruise 145 on March 10, 1995. This was the third WOCE hydrographic leg on the Knorr in the Indian Ocean. I08N/I05E was supported by the National Science Foundation's Ocean Sciences Division. I08N/I05E was the second WOCE hydrographic leg on the Knorr with basic technical support from Scripps Institution of Oceanography's Oceanographic Data Facility. There were almost no problems with the basic sampling program. The weather was excellent for the most part.

Stations were numbered consecutively from the beginning of the R/V Knorr 145-5 work on I08S/I09N (McCartney, chief scientist). The first station on I08N/I05E was numbered 278 and was a test station. The first complete station was 279. The last station was 442.

The cruise plan called for sampling southward from Sri Lanka along 88 E to 24 S, and then angling southeastward to the junction of the Ninety-East Ridge and Broken Ridge. Then the track was to proceed eastwards nominally following the 1987 section along about 32 S. The goals of the sampling were to obtain a section through the center of the Central Indian Basin, and to repeat the crossing of the northward flow of deep water just to the west of Australia. Particular attention was to be paid to a potential source of deep water for the Central Indian Basin, through a possible sill in the Ninety-East Ridge, located at about 28 S. The cruise was not long enough to allow sampling of another source of slightly less dense water near about 34 S. However, there were enough extra days in the schedule, due to the excellent weather and good condition of the sampling equipment, to allow extra sampling around the 28 S sill. It was also possible to deviate from the 32 S section, and sample in the deep water south of Broken Ridge instead of along the top of the ridge. Between Broken Ridge and Australia we chose to move the section slightly north of the original position of I05E in order to better resolve whether the deep flow splits around Dirck Hartog Ridge.

All stations were to within 10 meters of the bottom and included a rosette/CTD cast. Basic station spacing was 30 nm, closing to 20 nm for 3 S - 1 S and 1 N - 3 N, and to 15 nm for 1 S to 1 N. Station spacing at the Sri Lankan and Australian coasts and various crossings of the NinetyEast Ridge and Broken Ridge was less than 30 nm and dictated by topography.

Sampling was done with a 36-place General Oceanics pylon on a rosette frame with 10-liter bottles and a CTD (SIO/ODF CTD 1), transmissometer, altimeter and pinger. The CTD data stream consisted of elapsed time, pressure, two temperature channels, conductivity, oxygen, altimeter and transmissometer signals. All profiles were full water column depth. Water samples were collected for analyses of salt, oxygen, silica, phosphate, nitrate and nitrite on all stations and of CFC-11, CFC-12, carbon tetrachloride, helium-3, helium-4, tritium, AMS C14, pCO<sub>2</sub>, total dissolved inorganic carbon, alkalinity,

and barium on selected stations. Water sample depths for the basic physical oceanography program are shown in Fig. A.2.

Station times for the CTD/rosette are shown in Fig. A.4. Wire speeds were generally 60 meters/minute for downcasts and 70 meters/minute for upcasts; because of stops for bottle trips and slower speeds in the upper 200 meters, the average wire speed for all stations was 55-58 meters/minute.

On all but 10 stations, one of Eric Firing's RDI lowered acoustic doppler profilers (LADCP) was mounted inside the rosette frame. Two different LADCP's were used, a narrow band operating at 300kHz and a broad band operating at 150kHz. The former was intended to be the principal instrument, but suffered a failure at station 291. The broad band LADCP was mounted at station 294 and used thereafter.

At 100 stations surface water was filtered for particulate organic carbon (Rau) for later isotopic analysis with the resulting  $^{13}\text{C}/^{12}\text{C}$  to be correlated with surface  $\text{CO}_2$ . On 65 stations, 200 liters of surface water were filtered for additional analysis of lipid components.

Particulate organic materials were filtered from the ship uncontaminated seawater supply at twelve stations near the equator. Stable carbon isotopic compositions of phytoplankton will be determined by analyses of individual lipid biomarker compounds in B. Popp's laboratories at the University of Hawaii. The goal of this work is to distinguish the extent to which phytoplankton growth rates influence correlations between the concentration of surface water  $\text{CO}_2$  and isotopic fractionation exhibited by phytoplankton. Approximately 1600-1800 litres of seawater were filtered at each station. Additionally, duplicate 20-mL samples of seawater were collected from the same seawater supply to determine the carbon isotopic composition of total dissolved inorganic carbon.

Underway shipboard ADCP data were logged (Firing). There were problems with the device resulting in no data return between Sri Lanka and 3 N.

Underway measurements included  $\text{pCO}_2$  (Key and Weiss),  $\text{pN}_2\text{O}$  (Weiss), methane (Weiss) and the various variables of the Knorr's IMET system (surface water temperature and conductivity, oxygen, meteorological parameters, GPS navigation, ship's speed and heading). Bathymetry was recorded every 5 minutes from the Knorr's PDR for our own use in constructing vertical sections and as additional input to the overall database (Smith - Geological Data Center at Scripps Institution of Oceanography). We found large problems with the existing Gebco maps in the vicinity of the 28 S sill in the Ninety-East Ridge; this region had not been well surveyed in the past. Preliminary results will be reported in WOCE notes.

**b. Bottle locations** – (Fig. A.2)

### c. Vertical sections

Potential temperature, salinity, oxygen, silicate, nitrate, phosphate, potential density are distributed as an appendix to the report.

### d. Interlaboratory comparisons

No interlaboratory comparisons were made per se on I08N/I05E, but water sample results were compared with preliminary data acquired on I09N (Gordon, chief scientist, R/V Knorr), I08S (McCartney, chief scientist, R/V Knorr), the 1987 occupation of I05 (Toole and Warren), the 1979 cruise at 12 S on the Wilkes, the 1976 cruise at 18 S on the Atlantis II, and the 1978 Geosecs stations along 80 E. Comparisons of I08N/I05E salinity, oxygen, silica, nitrate and phosphate with data from the I08S, 1987 I05, and 12 S cruises and one of the Geosecs stations are shown in Figs. A.5-8.

WHP required accuracies for deep water values

salinity	.002 if corrected for SSW batch
oxygen	1% = .03-.04 ml/l
nitrate	1% = .3-.4 umol/l
phosphate	1% = .02-.03 umol/l
silicate	1% = 1-1.5 umol/l

#### d.1. I08N/I05E compared with I09N (3 N, 80 E) (no figure)

I09N stations (3/95):	276-277	ODF S,O2,nuts/ SSW P126
I08N/I05E stations (3/95):	291-294	ODF S,O2,nuts/ SSW P126

Differences in all properties were within the range of actual variability of the deep waters. These stations occurred within several weeks of each other, and were done by the same technical group although the individual personnel differed.

#### d.2. I08N/I05E compared with Geosecs stations along 80 E (Fig. A.5)

Geosecs stations (4/78):	447-452	ODF S,O2,nuts
I08N/I05E stations (3/95):	groups of three surrounding the Geosecs stations.	ODF S,O2,nuts

The Geosecs stations were spaced 5 latitude apart, so comparisons could only be made with individual stations. The method for measuring phosphate concentration was significantly changed following the Geosecs measurements, and the change accounts for the large offset between the two data sets.

Salinity: there appears to be an offset of about 0.003, with the Geosecs salinity higher.

Oxygen: no offset between the data sets.

Silicate: no offset between the data sets.

Nitrate: no offset between the data sets.

Phosphate: Geosecs is 0.04 - 0.06 umol/l lower.



**d.3. I08N/I05E compared with R/V Wilkes stations along 12 S (Fig. A.6)**

Wilkes stations (4/79): 17-21  
I08N/I05E stations (3/95): 328-332

Both the nitrate and phosphate are more scattered in the 1979 data set, while salinity, oxygen and silicate agree fairly well. The scatter might be due to true variations in properties.

Salinity: no offset

Oxygen: no offset

Silicate: no offset, similar scatter

Nitrate: no offset. Scatter of 12 S data is about 0.7  $\mu\text{mol/l}$  compared with 0.4  $\mu\text{mol/l}$  for I08N/I05E.

Phosphate: no offset. Scatter of 12 S data is about 0.05  $\mu\text{mol/l}$  compared with .02  $\mu\text{mol/l}$  for I08N/I05E.

**d.4. I08N/I05E compared with R/V Atlantis II stations along 18 S (no figure)**

Atlantis II stations (8/76): 2298-2302  
I08N/I05E stations (3/95): 342-344

The All dataset has a large number of fliers, and the overall precision for the bottle data is lower than on I08N/I05E.

Salinity: no offset. Scatter of I08N/I05E data is 0.002. Scatter of All data is greater than 0.005. A number of individual values are more than 0.02 high.

Oxygen: no offset. Scatter of I08N/I05E data is 0.07 ml/l. Scatter of All data is about 0.2 ml/l.

Silicate: no offset. Scatter of I08N/I05E is 2  $\mu\text{mol/l}$ . Scatter of All data is almost 10  $\mu\text{mol/l}$ .

Nitrate: no All data.

Phosphate: All phosphates are 0.08  $\mu\text{mol/l}$  lower than I08N/I05E. This offset is similar to the Geosecs offset and is probably due to the same analytical changes.

**d.5. I08N/I05E compared with R/V Charles Darwin stations along 32 S (Fig. A.7)**

Darwin stations (5/87): 67-69  
I08N/I05E stations (4/95): 377-381

This is a region of large lateral variability. The two data sets are essentially equivalent in every parameter. Even the CTD traces overlay remarkably well, within the precision expected for a single cruise.

**d.6. I08N/I05E compared with I08S (Fig. A.8)**

I08S stations (12/94): 10-12  
I08N/I05E stations (4/95): 405-407

All properties overlay very well. Since the work was carried out by the two different technical groups who will be supporting all of the Indian Ocean WHP, this bodes very well for the overall data set.

**Summary**

Salinity and oxygen accuracy and precision are within WOCE requirements on I08S. Nutrient accuracy and precision are within WOCE requirements. There is no offset between the I08N/I05E values and the I09N values (both collected by SIO/ODF). There is no offset between the I08N/I05E values and the I08S values (the latter salinity and oxygen collected by WHOI and nutrients by Oregon State University).

**5. Underway measurements**

**a. Navigation - GPS. Bathymetry - PDR.**

**b. ADCP - RDI vessel mounted 150kHz ADCP. See comments above.**

**c. Thermosalinograph and meteorological measurements - using the IMET system.**

**d. No XBT's or XCTD's.**

**e. Meteorological observations: weather data logged at each station. Continuous measurements from the IMET system.**

**f. pCO<sub>2</sub>, pN<sub>2</sub>O and methane: in water and air**

**6. Major problems and goals not achieved**

There were no problems resulting in major shortfalls in numbers, spacing, or coverage of the stations. There were no major problems with any of the basic WOCE analyses. The shipboard ADCP was not functioning between Sri Lanka and 3 N.

**7. Other incidents of note - none**

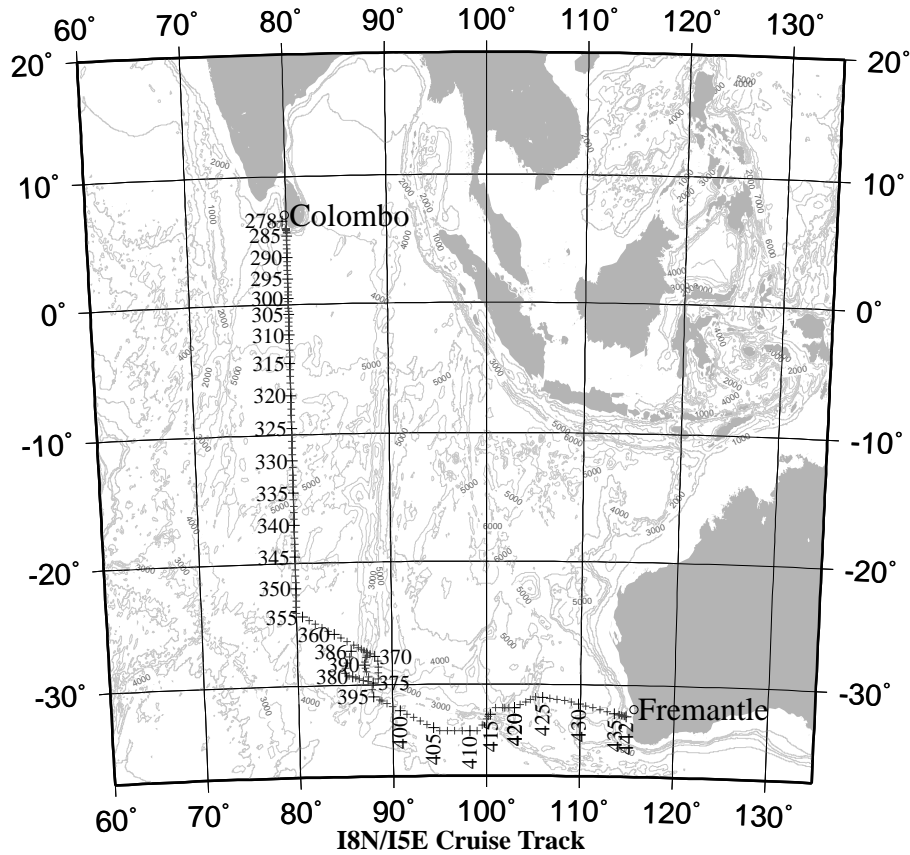
## 8. Cruise Participants:

For addresses, see list following principal investigator table above

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Joshua Curtice	helium and tritium	WHOI	jmc@kopernik.whoi.edu
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David Newton	programmer, deck	SIO	dnewton@ucsd.edu
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**World Ocean Circulation Experiment  
Indian Ocean I8N/I5E  
R/V Knorr Voyage 145 Leg 7  
10 March 1995 - 15 April 1995  
Colombo, Sri Lanka - Fremantle, Australia  
Expocode: 316N145/7**

**Chief Scientist: Dr. Lynne D. Talley  
Scripps Institution of Oceanography**



**Oceanographic Data Facility (ODF)  
Final Cruise Report  
16 July 1998**

*Data Submitted by:*

Oceanographic Data Facility  
Scripps Institution of Oceanography  
La Jolla, CA 92093-0214

# 1. DESCRIPTION OF MEASUREMENT TECHNIQUES AND CALIBRATIONS

## 1.1. Basic Hydrography Program

The basic 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. One test cast plus 166 CTD/rosette casts were made, usually to within 5-10 meters of the bottom. The test cast is not reported. The first cast at station 281 (cast "x1") was aborted for winch problems, then its data were overwritten by the second station 281 cast 1; the first/aborted cast is not reported. Two casts at station 420 are reported: the pylon conductor failed during the first cast after 7 bottles tripped, so a second cast was done after changing winches. 5430 bottles were tripped resulting in 5427 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 Figures 1.1.0 through 1.1.2.

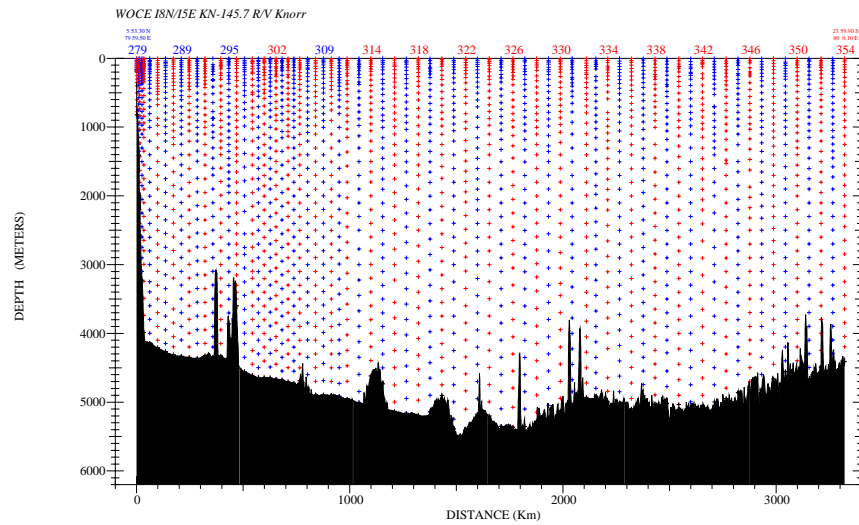


Figure 1.1.0 I8N/I5E sample distribution, stas 279-354

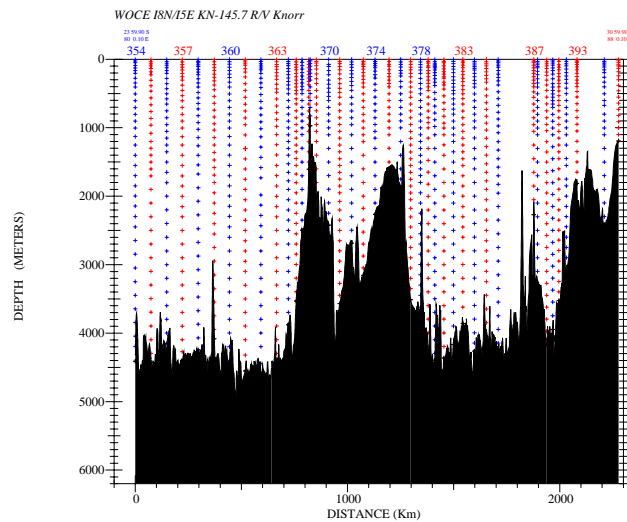
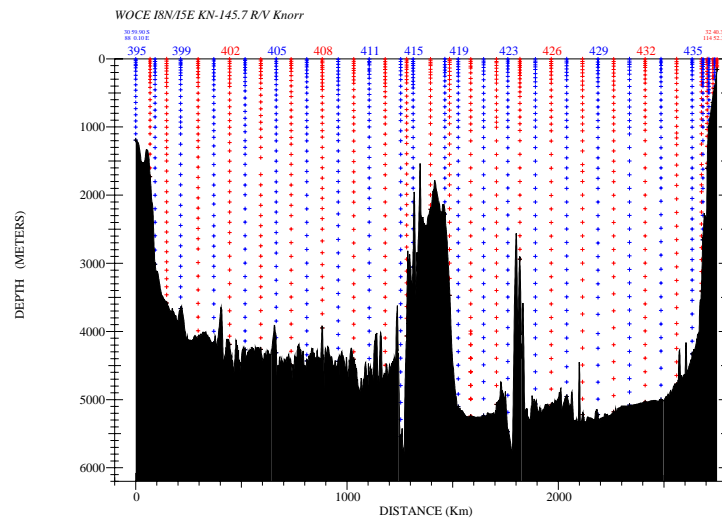


Figure 1.1.1 I8N/I5E sample distribution, stas 354-395



**Figure 1.1.2** I8N/I5E sample distribution, stas 395-442

## 1.2. 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, SeaTech transmissometer (TAMU), RDI LADCP (UofH), Benthos altimeter and Benthos pinger. The CTD was mounted horizontally along the bottom of the rosette frame, with the transmissometer, a Sorsormedics dissolved oxygen sensor and an FSI secondary PRT sensor deployed next to the CTD. The LADCP was vertically mounted to the frame inside the bottle rings. 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 rosette system was suspended from a cast with a precision depth recorder (PDR) in the ship's laboratory. The rosette system was suspended from a three-conductor 0.322" 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. The transmissometer, dissolved oxygen, secondary temperature and altimeter were interfaced with the CTD, and their data were incorporated into the CTD data stream.

The deck watch prepared the rosette approximately 45 minutes prior to each cast. All valves, vents and lanyards were checked for proper orientation. The bottles were cocked and all hardware and connections rechecked. Upon arrival on station, time, position and bottom depth were logged by the console operator. The rosette was deployed from a position on the starboard side of the main deck. Each rosette cast was lowered to within 5-10 meters of the bottom, unless the bottom returns from both the pinger and altimeter were extremely poor or the bottom depth exceeded the range of the instrumentation.

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. There were two stations where the bottles were tripped in a special sequence for freon checks. The trip sequence, deepest to shallowest, was bottles 18-36, then 1-17, at stations 316 and 435.

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.

Recovering the package at the end of deployment was essentially the reverse of the launching with the additional use of air-tuggers for added stabilization. The rosette was moved into the starboard-side (forward) hangar for sampling. The bottles and rosette were examined before samples were taken, and any extraordinary situations or circumstances were noted on the sample log for the cast.

Routine CTD maintenance included soaking the conductivity and CTD  $O_2$  sensors in distilled water between casts to maintain sensor stability. 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 was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed.

The transmissometer windows were cleaned prior to deployment approximately every 20 casts. The air readings were noted in the TAMU transmissometer log book after each cleaning. Transmissometer data were monitored for potential problems during every cast.

The R/V Knorr's port-side Markey CTD winch was used during stations 278 to 281 cast "x1" and 420 cast 2 through 442. A control relay failure during station 281 cast "x1" prompted the initial winch change. The starboard Almon Johnson winch and cable were used on stations 281 cast 1 through 420 cast 1. The pylon conductor failed halfway into the cable on the starboard winch, partway through the up-cast of station 420 cast 1, prompting a switch back to the port-side winch for cast 2. The port-side winch wire was observed during down- and up-casts and stopped as needed, usually during up-casts, to inspect/re-tape a loose strand on the wire about 4060m wire out.

### **1.3. Underwater Electronics Packages**

CTD data were collected with a modified NBIS Mark III CTD (ODF #1). This instrument provided pressure, temperature, conductivity and dissolved  $O_2$  channels, and additionally measured a second temperature (FSI temperature module/OTM) as a calibration check. Other data channels included elapsed-time, altimeter, several power supply voltages and transmissometer. The instrument supplied a 15-byte NBIS-format data stream at a data rate of 25 Hz. Modifications to the instrument included revised pressure and dissolved  $O_2$  sensor mountings; ODF-designed sensor interfaces for  $O_2$ , FSI PRT and transmissometer; 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 1.3.0 summarizes the winches and serial numbers of instruments and sensors used during I8N/I5E.

Station(s)	ODF CTD@ ID#	Sensormedics Oxygen Sensor	SeaTech Transmissometer (TAMU)	Winch	
278-281/1x	1	3-03-10	151D	Port	
281/1-282		"A"		151D	Stbd.
283-288					
289-328		3-03-10			
329-337		"B"			
338-420/1		3-03-10			
420/2-442					Port

NOTE: Oxygen sensor, transm., LADCP serial nos. unverified.  
 1. Orig./aborted sta. 281/1"x" was overwritten by 281/1.  
 2. Assume start with same Oxygen sensor as end of I9N; sensor "B" may be the same sensor as "A".  
 3. Assume TAMU transmissometer 151D, same as end of I9N.  
 4. LADCP (UofH) deployed on all casts except:  
 a. inoperable/malfunctioning for stations 292,293,405?,422,428  
 b. removed from rosette for stas 353,354,406,423-427  
 c. "large" LADCP used after sta 293 - till end of leg?

@ ODF CTD #1 sensor serial numbers:

ODF CTD ID#	Pressure	Temperature		Conductivity NBIS Model
	Paine Model 211-35-440-05 strain gage/0-8850psi	PRT1 Rosemount Model 171BJ	PRT2/(PRS2) FSI OTM/(OPM)	
1	131910	14304	OTM/1322T	09035-00151 5902-F117

**Table 1.3.0** I8N/I5E Instrument/Sensor Serial Numbers

The CTD pressure sensor mounting had been modified to reduce the dynamic thermal effects on pressure. The sensor was attached to a section of coiled stainless-steel tubing that was connected to the end-cap pressure port. The transducer was also insulated. The NBIS temperature compensation circuit on the pressure interface was disabled; all thermal response characteristics were modeled and corrected in software.

The  $O_2$  sensor was deployed in a pressure-compensated holder assembly mounted separately on the rosette frame and connected to the CTD by an underwater cable. The  $O_2$  sensor interface was designed and built by ODF using an off-the-shelf 12-bit A/D converter. The transmissometer interface was a similar design.

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.

The General Oceanics (GO) 1016 36-place pylon was used in conjunction with an ODF-built deck unit and external power supply instead of a GO pylon deck unit. This combination provided generally reliable operation and positive confirmation of all but 9 trip attempts, which succeeded whenever a re-trip was attempted. Some of the NO-confirm bottles closed despite lack of confirmation; all but one of these tripped at the expected pressure. The pylon emitted a confirmation message containing its current notion of bottle trip position, which could be useful in sorting out mis-trips. The acquisition software averaged CTD data corresponding to the rosette trip as soon as the trip was initiated until the trip confirmed, typically 2-4.5 seconds on I8N/I5E.



#### **1.4. Navigation and Bathymetry Data Acquisition**

Navigation data were acquired from the ship's Magnavox MX GPS receiver via RS-232. Data were logged automatically at one-minute intervals by one of the Sun SPARCstations. Underway bathymetry was logged manually from the 12 kHz Raytheon PDR at five-minute intervals, then corrected according to Carter [Cart80] and merged with the navigation data to provide a time-series of underway position, course, speed and bathymetry data. These data were used for all station positions, PDR depths and bathymetry on vertical sections.

#### **1.5. CTD Data Acquisition, Processing and Control System**

The CTD data acquisition, processing and control system consisted of a Sun SPARCstation LX computer workstation, ODF-built CTD and pylon deck units, 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. Two other Sun SPARCstation LX systems were networked to the data acquisition system, as well as to the rest of the networked computers aboard the Knorr. These systems were available for real-time CTD data display and provided for hydrographic data management and backup. Two HP 1200C color inkjet printers provided hardcopy capability from any of the workstations.

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 Sun LX through a bi-directional 300 baud serial line, allowing bottle trips to be initiated and confirmed by the data acquisition software. A bitmapped color display provided interactive graphical display and control of the CTD rosette sampling system, including real-time raw and processed CTD 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 were automatically logged for the beginning of the cast. A backup analog recording of the CTD signal on a VCR tape was started at the same time as the data acquisition. A rosette trip display and pylon control window 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 optimally continuing at a steady rate without any stops during the down-cast. As noted in Section 1.2, the winch may have stopped around 4060m wire out on some of the port-winch down-casts to check the broken-strand area on the wire.

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 deck watch leader assisted the console operator by monitoring the rosette's distance to the bottom using the difference between the rosette's pinger signal and its bottom reflection displayed on the PDR. Around 200 meters above the bottom, depending on bottom conditions, the altimeter typically began signaling a bottom return on the console. The winch speed was usually slowed to ~30 meters/minute during the final approach. The winch and altimeter displays allowed the watch leader to refine the target depth relayed to the winch operator and safely approach to within 5-10 meters of the bottom.

At station 296, the bottom depth was mis-judged and the rosette package hit bottom (~3630m) at full speed. An additional ~200m of wire was let out before the problem was noted. The wire was slowly pulled back in to ~100m above bottom before the first bottle trip. The CTD sensors remained stable throughout the cast, aside from a drop in conductivity and oxygen signals while sitting on the bottom. An inspection of the rosette after the cast indicated no apparent damage to any equipment.

Bottles were closed on the up-cast 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. A bad or suspicious confirmation signal typically resulted in the console operator repositioning the pylon trip arm via software, then re-tripping the bottle, until a good confirmation was received. All tripping attempts were noted on the console log. The console operator then instructed the winch operator to bring the rosette up to the next bottle depth. 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. Usually the console operator also brought the sample log to the rosette room and served as the *sample cop*.

### 1.6. 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:

- Convert raw CTD scans into scaled engineering units, and assign the data to logical channels;
- Filter various channels according to specified filtering criteria;
- Apply sensor- or instrument-specific response-correction models;
- Provide periodic averages of the channels corresponding to the output time-series interval; and
- 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  $O_2$ . Rosette trip data were extracted from this time-series in response to trip initiation and confirmation signals. The calibrated 2 Hz time-series data, as well as the 25 Hz raw data, were stored on disk 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 2.0-db 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 Theta-Salinity comparisons with adjacent stations. The CTD  $O_2$  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 the data stream caused by sea cable or slip-ring problems, or by moisture in the interconnect cable between the CTD and external sensors (i.e.  $O_2$ ). 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 be induced in high-gradient regions by ship-generated vertical motion of the rosette. 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.

The first few seconds of in-water data were excluded from the pressure-series data, since the sensors were still adjusting to the going-in-water transition. However, multiple casts exhibited up to a 0.03 density drop during the top 10 db, or a sharply increasing density gradient in the top few meters of the water column. A time-series data check verified these density features were probably real: the data were consistent over many frames of data at the same pressures. Appendix C details the magnitude of the larger density drops or gradients for the casts affected.

Pressure intervals with no time-series data can optionally be filled by double-quadratic interpolation. The only pressure intervals missing/filled during this leg were at 0 db, caused by chopping off going-in-water transition data at pressure-sequencing.

There is an inherent problem in the internal digitizing circuitry of the NBIS Mark III CTD when the sign bit for temperature flips. Raw temperature can shift 1-2 millidegrees as values cross between positive and negative, a problem avoided by offsetting the raw PRT readings by  $\sim 1.5^{\circ}\text{C}$ . The conductivity channel also can shift by 0.001-0.002 mmho/cm as raw data values change between 32767/32768, where all the bits flip at once. This is typically not a problem in shallow to intermediate depths because such a small shift becomes negligible in higher gradient areas.

Raw CTD conductivity traversed 32767/32768 at  $\sim 1750 \pm 150$  db until about station 310, shifting toward  $\sim 1100 \pm 150$  db by the mid-350's. A +0.001 PSU shift in salinity is only apparent until  $\sim$ station 310, around  $3.3^{\circ}\text{C}$ - $3.4^{\circ}\text{C}$  theta and 34.81 PSU salinity, where raw conductivity values are in the right vicinity and the salinity structure is fairly stable. Because the same digitizer problem has occurred on numerous other cruises, it is unlikely that this offset is real.

A deeper -0.0005 PSU inflection appears around  $1.9^{\circ}\text{C}$  theta and 34.75 PSU salinity on the same casts as the digitizer problem mentioned above. The raw conductivity is nowhere near 32768 in this area, so a CTD problem is not suspected.

Both salinity shifts ( $\sim 3.3$ - $3.4$  and  $\sim 1.9^{\circ}\text{C}$  theta) were also observed from about station 200 to the end of I9N, the leg preceding this one. All of the affected I9N and I8N/I5E casts are north of  $\sim 3^{\circ}$  S latitude.

A down-cast stop/slowdown nearly always caused a problem in fitting CTD oxygen data because the raw oxygen signal shifted as oxygen became depleted in water near the sensor. A small shift was often noted as the winch slowed down for the bottom approach. The signal drop could usually be compensated for by applying a small constant offset to the raw oxygen current values from the stop/slowdown until the bottom of the cast, then re-fitting the oxygen data to the bottles. Raw CTD  $O_2$  offsets that resolved drops at winch stops or slowdowns are noted in Appendix C.

Appendix C contains a table of CTD casts requiring special attention; I8N/I5E CTD-related comments, problems and solutions are documented in detail.

### **1.7. 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.

Pressure and temperature calibrations were performed on CTD #1 at the ODF Calibration Facility in La Jolla. The pre-cruise calibrations were done in December 1994, before five consecutive ODF WOCE legs in the Indian Ocean, and the post-cruise calibrations were done in September 1995.

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 pre-/post-cruise at  $-1.42/+0.01^{\circ}\text{C}$  to a maximum loading pressure of 6080 db, and  $30.41/31.24^{\circ}\text{C}$  to 1400/1190 db. Figures 1.7.0 and 1.7.1 summarize the CTD #1 laboratory pressure calibrations performed in December 1994 and September 1995.

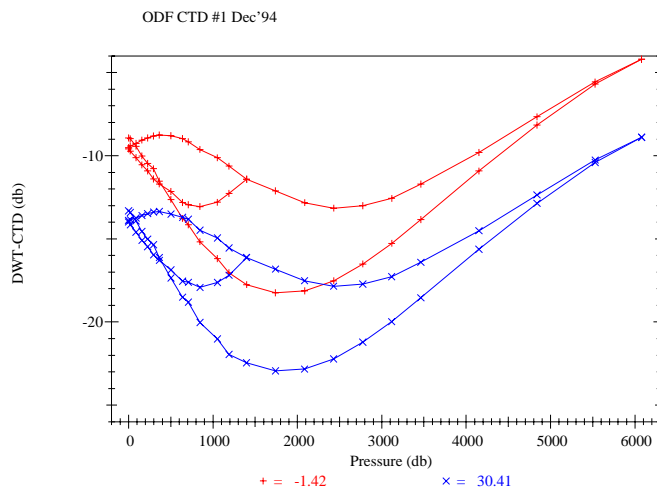


Figure 1.7.0 Pressure calibration for ODF CTD #1, December 1994.

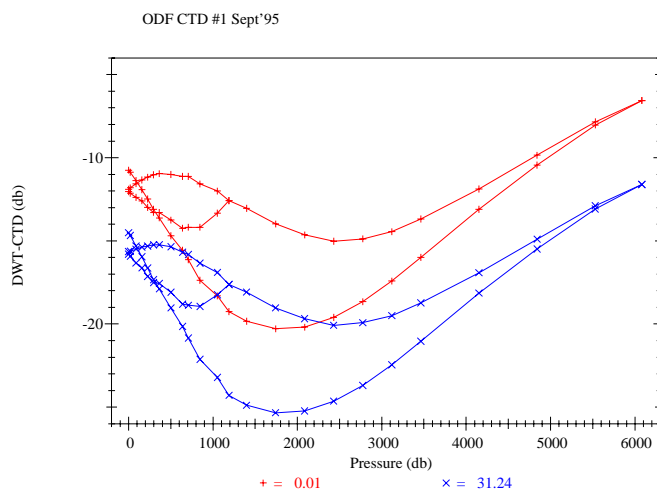


Figure 1.7.1 Pressure calibration for ODF CTD #1, September 1995.

Additionally, dynamic thermal-response step tests were conducted on the pressure transducer to calibrate dynamic thermal effects. These results were combined with the static temperature calibrations to optimally correct the CTD pressure.

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 9 or more different bath temperatures between  $-1.5$  and  $31.3^{\circ}\text{C}$ , both pre- and post-cruise. Figures 1.7.2 and 1.7.3 summarize the laboratory calibrations performed on the CTD #1 primary PRT during December 1994 and September 1995.

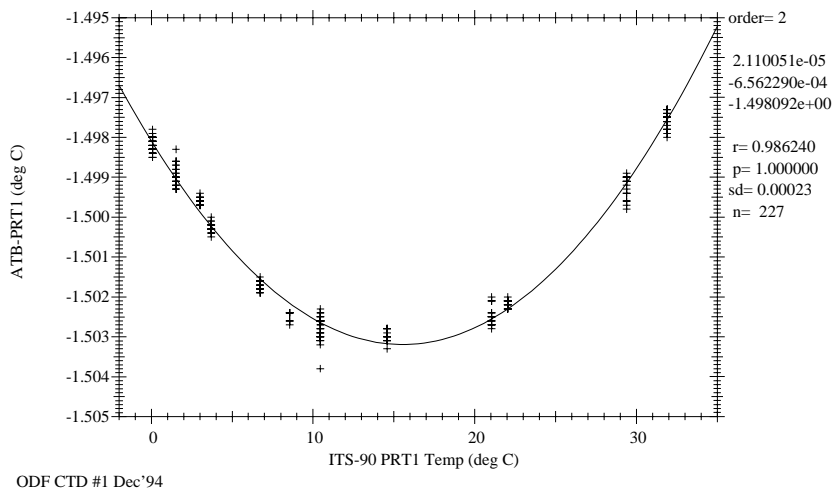


Figure 1.7.2 Primary PRT Temperature Calibration for ODF CTD #1, December 1994.

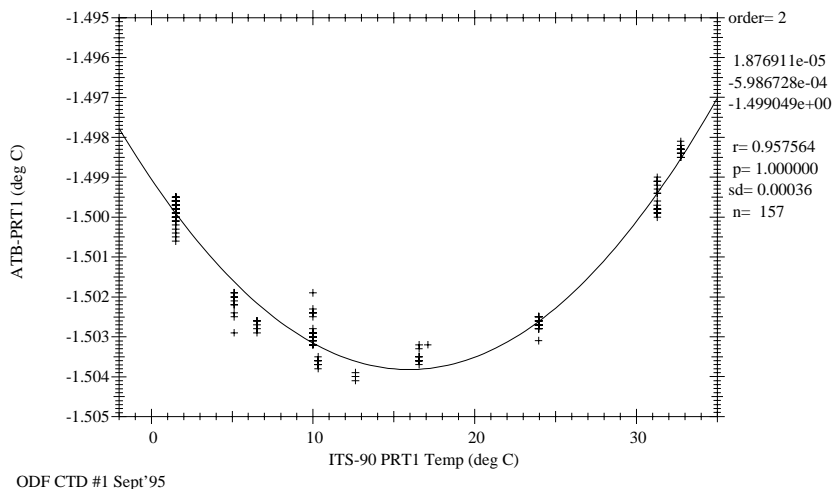


Figure 1.7.3 Primary PRT Temperature Calibration for ODF CTD #1, September 1995.

These 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 were reported using the ITS-90 standard.

## 1.8. CTD Calibration Procedures

This cruise was the second of five consecutive Indian Ocean WOCE legs using ODF CTD #1 exclusively. A redundant PRT sensor was used as a temperature calibration check while at sea. CTD conductivity and dissolved  $O_2$  were calibrated to *in-situ* check samples collected during each rosette cast.

Final pressure, temperature, conductivity and oxygen corrections were determined during post-cruise processing.

### 1.8.1. CTD #1 Pressure

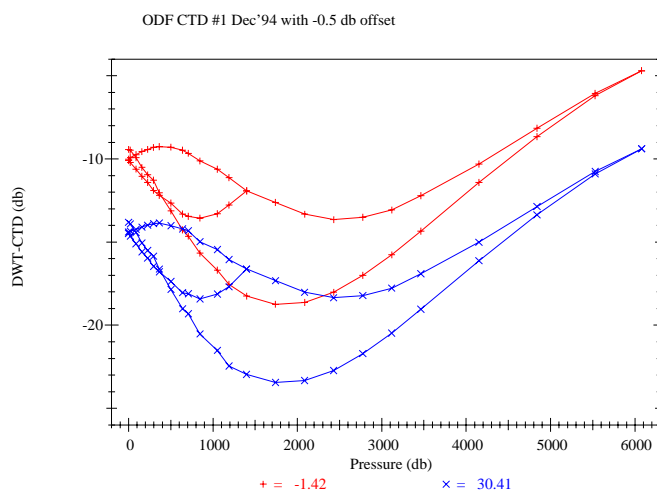
There was a pre- to post-cruise (5 legs over 7.5 months) shift of -2.4 db at shallow and deep pressures in the cold-bath laboratory calibrations for pressure. The warm-bath pressure correction shifted by -1.8 db. Half of the closure

between warm/cold calibrations can be accounted for by different temperatures of the pre-/post-cruise calibrations. There were no significant slope differences between pre- and post-cruise pressure calibrations.

In order to determine when the pressure shift occurred, start-of-cast out-of-water pressure and temperature data from the 5 consecutive ODF legs were compared with similar data from the pre- and post-cruise laboratory calibrations for temperature. The pressure data from the I8N/I5E leg shifted ~0.5 db compared to pre-cruise laboratory data at all temperatures. A -0.5 db offset was applied to the entire pre-cruise pressure calibration. These revised calibration data, plus the dynamic thermal-response correction, were applied to I8N/I5E CTD #1 pressures.

Down-cast surface pressures were automatically adjusted to 0 db as the CTD entered the water; any difference between this value and the calibration value was automatically adjusted during the top 50 decibars. Residual pressure offsets at the end of each up-cast (the difference between the last corrected pressure in-water and 0) averaged 0.5 db, less than half the residual seen shipboard, thus indicating no problems with the final pressure corrections.

Figure 1.8.1.0 shows the offset pre-cruise laboratory calibration used to correct I8N/I5E CTD #1 pressure data.



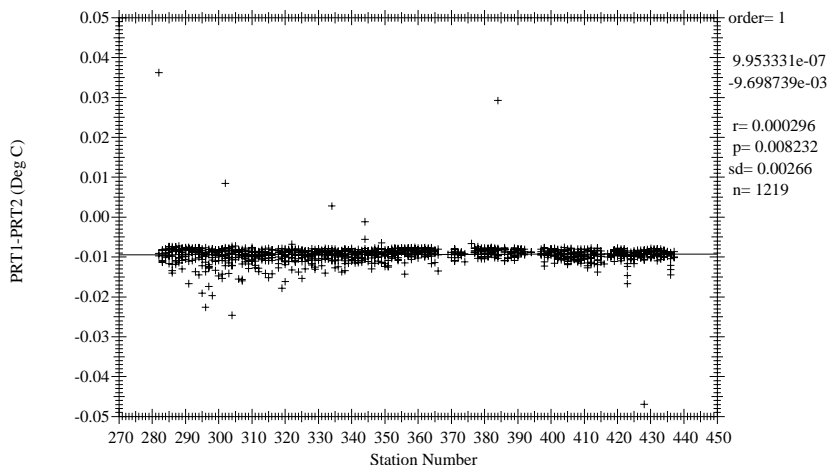
**Figure 1.8.1.0** Pressure correction for ODF CTD #1: December 1994 calibration offset by -0.5 db.

The entire 10-month pre- to post-cruise laboratory calibration shift for the pressure sensor on CTD #1 was less than half the magnitude of the WOCE accuracy specification of 3 db. I8N/I5E CTD pressures should be well within the desired standards.

### 1.8.2. CTD #1 Temperature

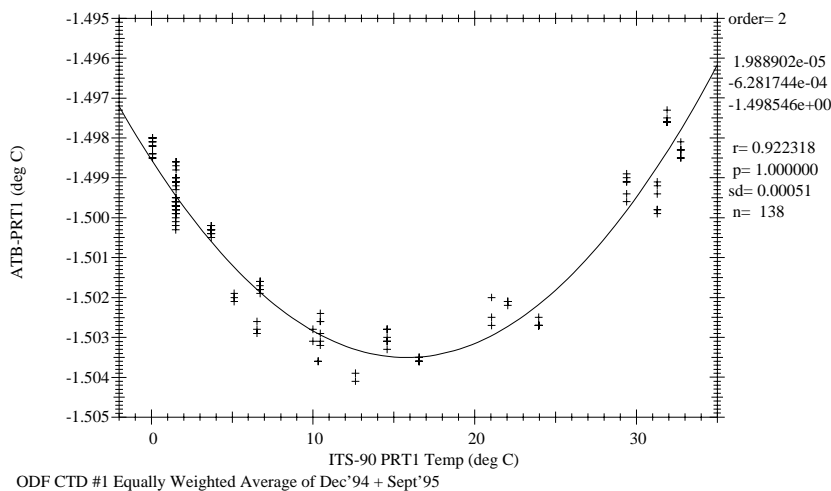
An FSI PRT sensor (PRT2) was deployed as a second temperature channel and compared with the primary PRT channel (PRT1) on all casts to monitor for drift. The response times of the primary and secondary PRT sensors were matched, then preliminary corrected temperatures were compared for a series of standard depths from each CTD down-cast.

The FSI PRT used during the last half of I9N was deployed as the secondary PRT during the entire I8N/I5E leg. The differences between the CTD #1 primary PRT and the FSI PRT drifted slowly during I9N, then stabilized at about -0.01°C by the end of that first leg. The non-zero difference was attributed to drift in the FSI PRT sensor, since a stable conductivity correction indicated no shift in the primary PRT. There was no drift noted in the PRT1-PRT2 differences during I8N/I5E; the differences remained stable at the value observed at the end of I9N. Figure 1.8.2.0 summarizes the comparison between the primary and secondary PRT temperatures.



**Figure 1.8.2.0** Shipboard comparison of CTD #1 primary/secondary PRT temperatures, pressure > 1800 db.

The primary temperature sensor laboratory calibrations indicated a  $-0.001^{\circ}\text{C}$  shift at  $0^{\circ}\text{C}$ , a  $-0.0006^{\circ}\text{C}$  shift at mid-range temperatures, and a  $-0.0014^{\circ}\text{C}$  shift at  $32^{\circ}\text{C}$  from pre- to post-cruise. The pre- and post-cruise temperature calibrations were equally weighted and combined to generate an average temperature correction, which was applied to all CTD casts done during the 5 legs between calibrations. Figure 1.8.2.1 summarizes the average of the pre-/post-cruise laboratory temperature calibrations for CTD #1.



**Figure 1.8.2.1** Primary temperature correction for ODF CTD #1, Dec.94/Sept.95 equally weighted average.

The 10-month pre- to post-cruise laboratory calibration shift for the primary temperature sensor on CTD #1 was less than half the magnitude of the WOCE accuracy standard of  $0.002^{\circ}\text{C}$ . Since an average of the two calibrations was applied to the data, I8N/I5E CTD temperatures should be well within the WOCE accuracy specifications.

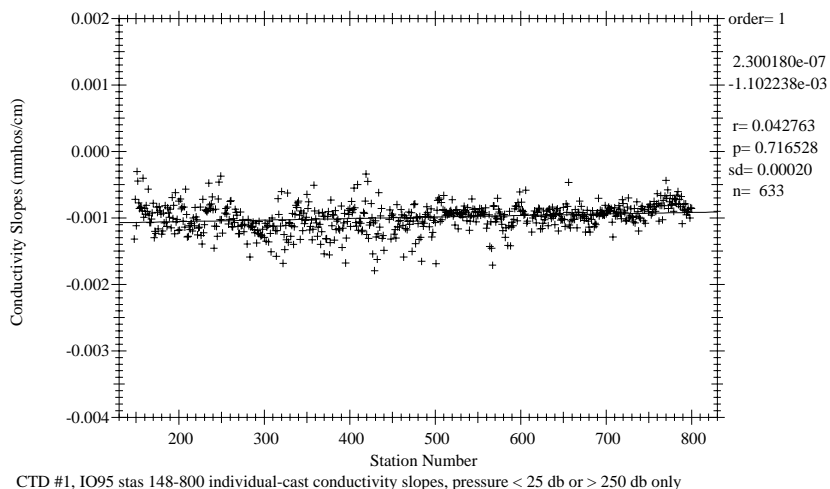
The secondary FSI temperature sensors either failed or drifted during I9N, the leg prior to this one, far more than the primary sensor drifted during the 10 months between laboratory calibrations. The FSI PRT sensors seemed to monitor their own drift better than that of the primary temperature sensor mounted permanently on CTD #1. Any comparison of their pre- and post-cruise calibrations was deemed pointless.

### 1.8.3. CTD #1 Conductivity

The corrected 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. This correction is normally linear for the 3-cm conductivity cell used in the Mark III CTD.

Due to small shifting in CTD conductivity, probably caused by organic matter, the conductivity sensor was swabbed with distilled water prior to station 269 during I9N, then remained stable thereafter. Cast-by-cast comparisons showed minimal conductivity sensor drift during I8N/I5E. However, there was a bottle salinity problem attributed to the Autosal #55-654 used from the start of the leg through station 327, except stations 309-312. Over 20 percent of the deep bottle salinity values from these casts were  $\sim 0.002$  PSU low compared to surrounding casts. These suspicious salinities, including 7 entire casts, were omitted from data used to determine CTD #1 conductivity corrections.

Conductivity differences above and below the thermocline were fit to CTD conductivity for all 5 legs together to determine the conductivity slope. The conductivity slope gradually increased from stations 148 (I9N) to 800 (I7N), after which the conductivity sensor was swabbed with alcohol. Figure 1.8.3.0 shows the individual preliminary conductivity slopes for stations 148-800.

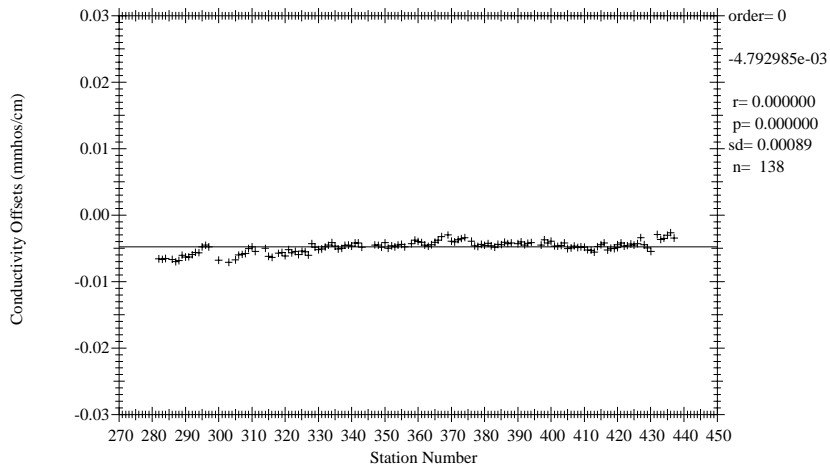


**Figure 1.8.3.0** CTD #1 prelim. conductivity slopes for stations 148(I9N) through 800(I7N).

The conductivity slopes for stations 148-800 were fit to station number, with outlying values (4,2 standard deviations) rejected. Conductivity slopes were calculated from the first-order fit and applied to each I8N/I5E cast.

Once the conductivity slopes were applied, residual CTD conductivity offset values were calculated for each cast using bottle conductivities deeper than 1400 db. Figure 1.8.3.1 illustrates the I8N/I5E preliminary conductivity offset residual values.



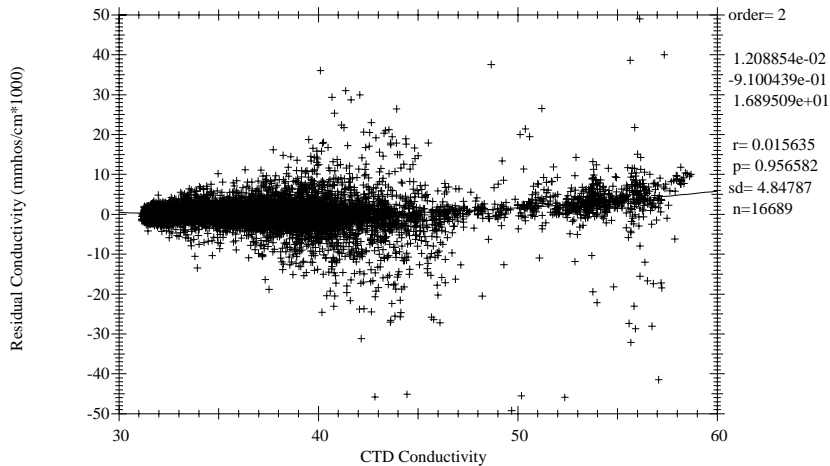


CTD #1, I8N/I5E individual-cast conductivity offsets, pressure > 1400 db only

**Figure 1.8.3.1** CTD #1 preliminary conductivity offsets by station number for I8N/I5E.

Casts were grouped together based on drift and/or known CTD conductivity shifts to determine average offsets. This also smoothed the effect of any cast-to-cast bottle salinity variation, typically on the order of  $\pm 0.001$  PSU. In addition to the 7 suspicious salinity casts mentioned above, 14 casts were omitted from the groups because of known bottle or CTD salinity problems, or because they were shallower than 1400 db. Smoothed offsets were applied to each cast, then some offsets were manually 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.

After applying the conductivity slopes and offsets to each cast, it was determined that surface salinity differences were  $\sim 0.008$  PSU high compared to intermediate and deep differences. After the offset adjustments were made, a mean second-order conductivity correction was calculated for stations 148-800. Figure 1.8.3.2 shows the residual conductivity differences used for determining this correction.

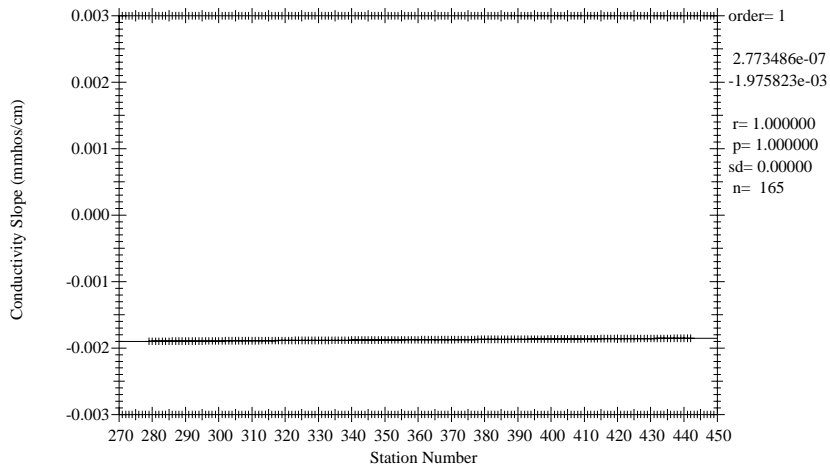


CTD #1, IO95 stas 148-800 residual conductivity slope, after linear corrnxn

**Figure 1.8.3.2** CTD #1 residual non-linear conductivity slope.

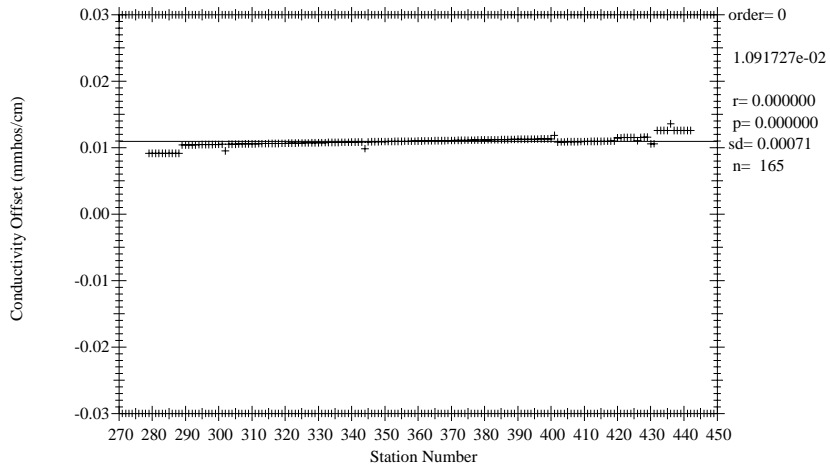
A 4,2-standard deviation rejection of the second-order fit was performed on these differences, then the remaining values were fit to conductivity. This non-linear correction, added to the linear corrections for each cast, effectively pulled in surface differences while having minimal effect on differences below the thermocline/halocline.

The final I8N/I5E conductivity slopes, a combination of the linear coefficients from the preliminary and second-order fits, are summarized in Figure 1.8.3.3. Figure 1.8.3.4 summarizes the final combined conductivity offsets by station number.



CTD #1 final conductivity slopes

**Figure 1.8.3.3** CTD #1 conductivity slope corrections by station number.



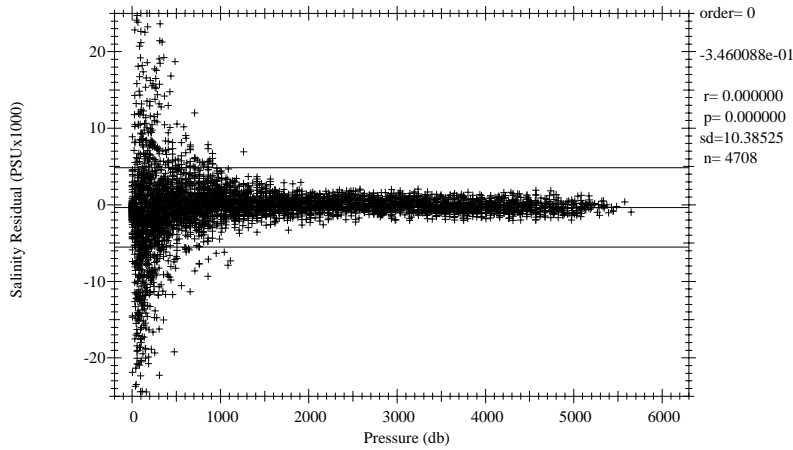
CTD #1 final conductivity offsets

**Figure 1.8.3.4** CTD #1 conductivity offsets by station number.

I8N/I5E temperature and conductivity correction coefficients are also tabulated in Appendix A.

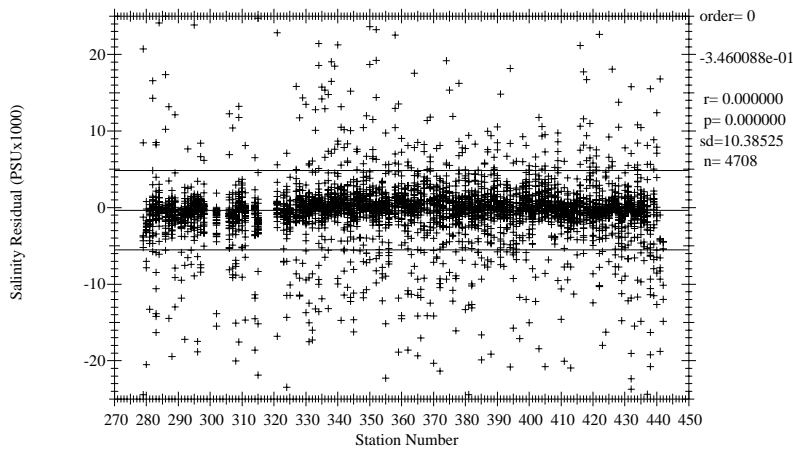
### Summary of Residual Salinity Differences

Figures 1.8.3.5, 1.8.3.6 and 1.8.3.7 summarize the residual differences between bottle and CTD salinities after applying the conductivity corrections. Only CTD and bottle salinities with (final) quality code 2 were used to generate these figures.



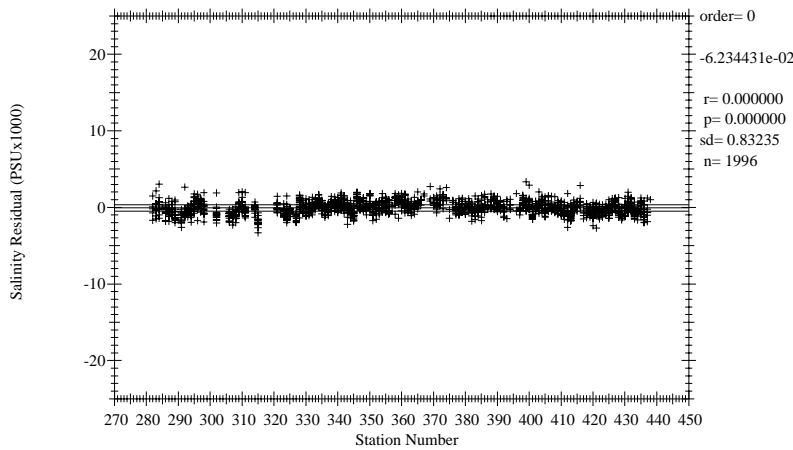
CTD #1, residual salt diffs, after correction, all pressures

**Figure 1.8.3.5** Salinity residual differences vs pressure (after correction).



CTD #1, residual salt diffs, after correction, all pressures

**Figure 1.8.3.6** Salinity residual differences vs station # (after correction).



CTD #1, residual salt diffs, after correction, pressures > 1500 db

**Figure 1.8.3.7** Deep salinity residual differences vs station # (after correction).

The CTD conductivity calibration represents a best estimate of the conductivity field throughout the water column.  $3\sigma$  from the mean residual in Figures 1.8.3.6 and 1.8.3.7, or  $\pm 0.0104$  PSU for all salinities and  $\pm 0.0008$  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 Theta-Salinity. Within most casts (a single salinometer run), the precision of bottle salinities appears to be better than 0.001 PSU. The exception to this would be bottle salinities run on Autosal 55-654 during the first third of the cruise; their precision is probably double the typical value. The precision of the CTD salinities appears to be better than 0.0005 PSU.

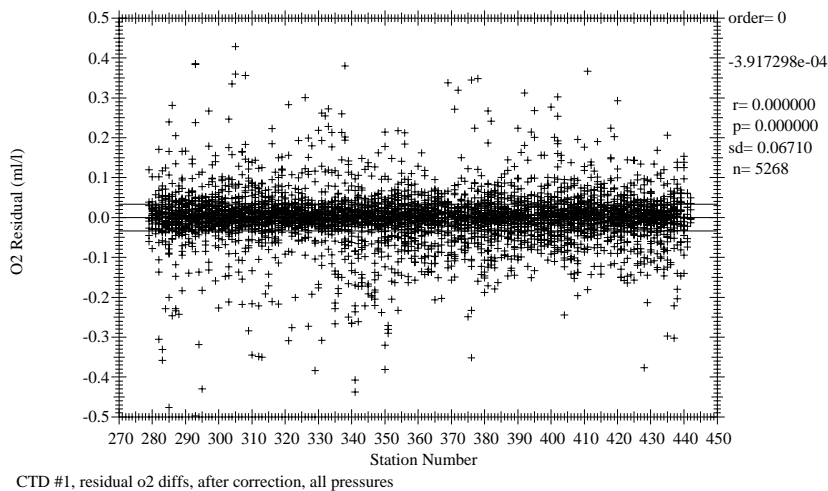
Final calibrated CTD data from WOCE95 I3 and I9N legs were compared with I8N/I5E data. Deep Theta-Salinity comparisons for casts at four positions where the WOCE lines crossed showed less than 0.001 PSU difference for each group of casts. Six stations from GEOSECS were also compared with I8N/I5E casts at the same positions. The GEOSECS data were +0.001 to +0.002 PSU for five casts (-0.001 PSU for the sixth cast) compared to I8N/I5E data. This difference becomes less than  $\pm 0.001$  PSU if GEOSECS salinity values are corrected for standard seawater batch differences [Mant87]. The standard seawater batch from the five consecutive ODF legs has not been compared to other batches. A cross-calibration is planned for mid-1998; however, recent batches from OSI have been quite reliable, requiring, at worst, a  $\pm 0.001$  PSU correction [Mant97].

#### 1.8.4. CTD Dissolved Oxygen

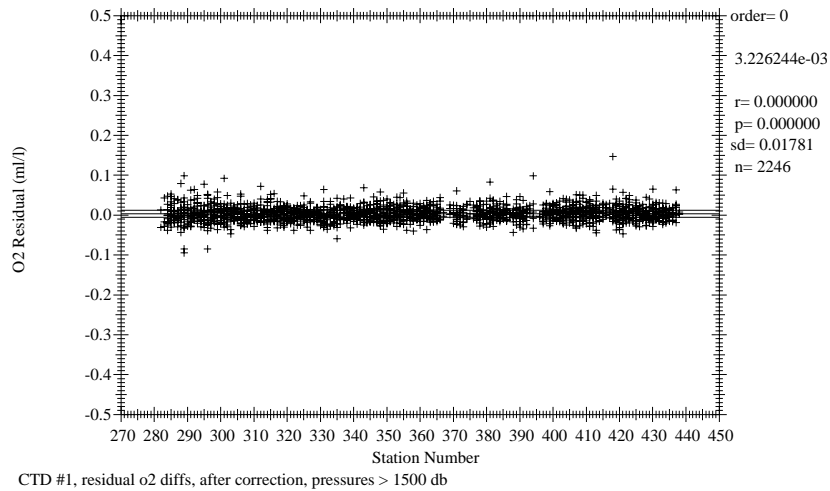
There are a number of problems with the response characteristics of the Sensormedics  $O_2$  sensor used in the NBIS Mark III CTD, the major ones being a secondary thermal response and a sensitivity to profiling velocity. Stopping the rosette for as little as half a minute, or slowing down for a bottom approach, can cause shifts in the CTD  $O_2$  profile. Such shifts could usually be corrected by offsetting the raw oxygen data from the stop or slow-down area to the bottom of the cast. All offset sections, winch stops or slow-downs that affected CTD oxygen data are documented in Appendix C.

Because of these same stop/slow-down problems, up-cast CTD rosette trip data cannot be optimally calibrated to  $O_2$  check samples. Instead, down-cast CTD  $O_2$  data are derived by matching the up-cast rosette trips along isopycnal surfaces. The differences between CTD  $O_2$  data modeled from these derived values and check samples are then minimized using a non-linear least-squares fitting procedure.

The same oxygen sensor was used on all but 2 groups of I8N/I5E CTD casts. Replacement sensors, which were extremely noisy during most casts, were used for stations 283-288 and 329-337. The non-noisy areas of stations 329-337 seem questionable for at least part of the casts: the CTD data do not compare well to bottle data for many of the deep sections. Figures 1.8.4.0 and 1.8.4.1 show the residual differences between the corrected CTD  $O_2$  and the bottle  $O_2$  (ml/l) for each station.



**Figure 1.8.4.0**  $O_2$  residual differences vs station # (after correction).



**Figure 1.8.4.1** Deep  $O_2$  residual differences vs station # (after correction).

The standard deviations of 0.07 ml/l for all oxygens and 0.02 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  $O_2$  data.

The general form of the ODF  $O_2$  conversion equation follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. ODF does not use a digitized  $O_2$  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  $\tau_p$ , and two temperature responses  $\tau_{Ts}$  and  $\tau_{Tf}$  are fitting parameters. The  $O_c$  gradient,  $dO_c/dt$ , is approximated by low-pass filtering 1st-order  $O_c$  differences. This gradient term attempts to correct for reduction of species other than  $O_2$  at the cathode. The time-constant for this filter,  $\tau_{og}$ , is a fitting parameter. Oxygen partial-pressure is then calculated:

$$O_{pp} = [c_1 O_c + c_2] \cdot f_{sat}(S, T, P) \cdot e^{(c_3 P_l + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt})} \quad (1.8.4.0)$$

where:

- $O_{pp}$  = Dissolved  $O_2$  partial-pressure in atmospheres (atm);
- $O_c$  = Sensor current ( $\mu$ amps);
- $f_{sat}(S, T, P)$  =  $O_2$  saturation partial-pressure at S,T,P (atm);
- $S$  = Salinity at  $O_2$  response-time (PSUs);
- $T$  = Temperature at  $O_2$  response-time ( $^{\circ}$ C);
- $P$  = Pressure at  $O_2$  response-time (decibars);
- $P_l$  = Low-pass filtered pressure (decibars);
- $T_f$  = Fast low-pass filtered temperature ( $^{\circ}$ C);
- $T_s$  = Slow low-pass filtered temperature ( $^{\circ}$ C);
- $\frac{dO_c}{dt}$  = Sensor current gradient ( $\mu$ amps/secs).

I8N/I5E CTD  $O_2$  correction coefficients ( $c_1$  through  $c_6$ ) are tabulated in Appendix B.

### 1.9. Bottle Sampling

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

- CFCs;
- $^3\text{He}$ ;
- $\text{O}_2$ ;
- Total  $\text{CO}_2$ ;
- Alkalinity;
- AMS  $^{14}\text{C}$ ;
- Tritium;
- Nutrients;
- Salinity;
- Barium.

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 the 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 SPARCstations for centralized data analysis. The analysts for each specific property were responsible for insuring that their results were updated into the cruise database.

### 1.10. Bottle Data Processing

Bottle data processing began with sample drawing, and continued until the data were considered to be final. One of the most important pieces of information, the sample log sheet, was filled out during the drawing of the many different samples, and was useful both as a sample inventory, and as a guide for the technicians in carrying out their analyses. Any problems observed with the rosette before or during the sample drawing were noted on this form, including indications of bottle leaks, out-of-order drawing, etc. Oxygen draw temperatures recorded on this form were at times the first indicator of rosette bottle-tripping problems. Additional clues regarding bottle tripping or leak problems were found by individual analysts as the samples were analyzed and the resulting data were processed and checked by those personnel.

The next stage of processing was accomplished after the individual parameter files were merged into a common station file, along with CTD-derived parameters (pressure, temperature, conductivity, etc.). The rosette cast and bottle numbers were the primary identification for all ODF-analyzed samples taken from the bottle, and were used to merge the analytical results with the CTD data associated with the bottle. 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. All CTD information from each bottle trip (confirmed or not) was retained in a file, so resolving bottle tripping problems consisted of correlating CTD trip data with the rosette bottles.

Diagnostic comments from the sample log, and notes from analysts and/or bottle data processors were entered into a computer file associated with each station (the "quality" file) as part of the quality control procedure. Sample data from 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. Various property-property plots and vertical

sections were examined for both consistency within a cast and consistency with adjacent stations by data processors, who advised analysts of possible errors or irregularities. The analysts reviewed and sometimes revised their data as additional calibration or diagnostic results became available.

Based on the outcome of investigations of the various comments in the quality files, WHP water sample codes were selected to indicate the reliability of the individual parameters affected by the comments. WHP bottle codes were assigned where evidence showed the entire bottle was affected, as in the case of a leak, or a bottle-trip at other than the intended depth.

WHP water bottle quality codes were assigned as defined in the WOCE Operations Manual [Joyc94] with the following additional interpretations:

- 2 | No problems noted.
- 3 | Leaking. *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 | Did not trip correctly. *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.*
- 5 | Not reported. *No water sample data reported. This is a representative level derived from the CTD data for reporting purposes. The sample number should be in the range of 80-99.*
- 9 | The samples were not drawn from this bottle.

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

- 1 | The sample for this measurement was drawn from the water 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. *The data did 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.*
- 7 | Despiked. *The CTD data have been filtered to eliminate a spike or offset.*

WHP water sample quality flags were assigned to the CTDOXY (CTD  $O_2$ ) parameter as follows:

- 1 | Not calibrated. *Data are uncalibrated.*
- 2 | Acceptable measurement.
- 3 | Questionable 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.*
- 7 | Despiked. *The CTD data have been filtered to eliminate a spike or offset.*
- 9 | Not sampled. *No operational CTD  $O_2$  sensor was present on this cast.*

Note that all CTDOXY values were derived from the down-cast pressure-series CTD data. 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  $O_2$  was not reported.

Table 1.10.0 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 279-442								
	Reported Levels	WHP Quality Codes						
		1	2	3	4	5	7	9
Bottle	5430	0	5383	12	32	0	0	3
CTD Salt	5430	0	5427	2	1	0	0	0
CTD Oxy	5427	0	5188	79	4	3	156	0
Salinity	5416	0	4710	673	33	4	0	10
Oxygen	5415	0	5352	45	18	6	0	9
Silicate	5414	0	5398	0	16	12	0	4
Nitrate	5425	0	5404	5	16	1	0	4
Nitrite	5425	0	5409	0	16	1	0	4
Phosphate	5414	0	5393	5	16	12	0	4

**Table 1.10.0** Frequency of WHP quality flag assignments.

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

### 1.11. 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.

### 1.12. Salinity Analysis

#### Equipment and Techniques

Two Guildline Autosal Model 8400A salinometers were used to measure salinities. The salinometers were modified by ODF and contained interfaces for computer-aided measurement. Autosal #55-654 was used for stations 279-308 and stations 313-327. Autosal #57-396 was used for stations 309-312 and stations 329-442. The salinity analyses were performed when samples had equilibrated to laboratory temperature, usually within 8-20 hours after collection. The salinometers were standardized for each group of analyses (typically one cast, usually 36 samples) using at least



one fresh vial of standard per cast. A computer (PC) prompted the analyst for control functions such as changing sample, flushing, or switching to "read" mode. At the correct time, the computer acquired conductivity ratio measurements, and logged results. The salinometer cell was flushed until two groups of readings met software criteria for consistency, both within and between groups; the two averages of the groups of measurements were then averaged for a final result.

### **Sampling and Data Processing**

Salinity samples were drawn into 200 ml Kimax high-alumina borosilicate bottles, which were rinsed three times with sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to collecting each sample, inserts were inspected for proper fit and loose inserts were replaced to insure an airtight seal. The draw time and equilibration time were logged for all casts. Laboratory temperatures were logged at the beginning and end of each run.

PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The difference (if any) between the initial vial of standard water and one run at the end as an unknown was applied linearly to the data to account for any drift. The data were added to the cruise database. 5416 salinity measurements were made and 364 vials of standard water were used. The estimated accuracy of bottle salinities run at sea is usually better than 0.002 PSU relative to the particular Standard Seawater batch used.

### **Laboratory Temperature**

The temperature stability in the salinometer laboratory was good, with the lab temperature generally 1-2°C lower than the Autosol bath temperature. The bath temperature for 57-396 was at the 24°C set-point when the ambient temperature was below 22°C for part of the cruise.

### **Standards**

IAPSO Standard Seawater (SSW) Batch P-126, was used to standardize the salinometers.

### **Special Problems**

The salinity values on several stations were found to be low by 0.002 PSU to 0.004 PSU when compared to CTD salinity values and bottle values of nearby stations. In the reconstruction of events it appears there may have been a periodic problem with Autosol #55-654. The bottle salinity values on these stations were coded as "questionable" and the problem was noted in the Bottle Quality Comments, Appendix D. Stations 312 and 357 were run on Autosol #57-396 and have similar, unresolved offsets due to other causes. The stations judged to have these problems are:

Station	Offset (PSU)
285	0.003
290	0.003
299	0.003
300	0.002
301	0.004
303	0.003
304	0.003
305	0.002
312	0.004
313	0.004
316	0.0025
317	0.003
318	0.003
319	0.002
320	0.003
322	0.003
326	0.002
357	0.002

Note that the listed values need to be added to bottle salinities to bring them in agreement with CTD salinity and bottle values on nearby stations.

### 1.13. Oxygen Analysis

#### Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF used 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 or dilution error. Reagent/distilled water blanks were determined, to account for presence of oxidizing or reducing materials.

#### Sampling and Data Processing

Samples were collected for dissolved oxygen analyses soon after the rosette sampler was brought on board, and after samples for CFC and helium were drawn. Using a Tygon drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed twice with minimal agitation, then filled 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 precipitate, once immediately after drawing, and then again after about 20 minutes. The samples were usually analyzed within a few hours of collection and the data were then merged with the cruise database.

Thiosulfate normalities were calculated from each standardization and corrected to 20°C. The 20°C 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 as a function of time, if warranted. 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 for this calculation was not available. Aberrant drawing temperatures provided an additional flag indicating that a bottle may not have tripped properly.

5415 oxygen measurements were made, with no major problems with the analyses. The auto-titrator generally performed very well. One minor problem noted on the expedition was that there was a gradual decrease in the UV detector output voltage. It was discovered later that the window material between the lamp and detector was slowly becoming opaque. At the time, the oxygen analysts were able to overcome the voltage drop by increasing a gain control.

### **Volumetric Calibration**

Oxygen flask volumes were determined gravimetrically with degassed deionized water 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. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

### **Standards**

Potassium iodate standards, nominally 0.44 gram, were pre-weighed in ODF's chemistry laboratory to  $\pm 0.0001$  grams. The exact normality was calculated at sea after the volumetric flask volume and dilution temperature were known. Potassium iodate was obtained from Johnson Matthey Chemical Co. and was reported by the supplier to be >99.4% pure. All other reagents are "reagent grade" and are tested for levels of oxidizing and reducing impurities prior to use.

## **1.14. Nutrient Analysis**

### **Equipment and Techniques**

Nutrient analyses (phosphate, silicate, nitrate and nitrite) were performed on an ODF-modified 4-channel Technicon AutoAnalyzer II, generally within a few hours after sample collection. Occasionally samples were refrigerated up to a maximum of 6 hours at 4°C. All samples were brought to room temperature prior to analysis.

The methods used are described by Gordon *et al.* [Gord92], Hager *et al.* [Hage72], Atlas *et al.* [Atla71]. The analog outputs from each of the four channels were digitized and logged automatically by computer (PC) at 2 second intervals.

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

A modification of the Armstrong *et al.* [Arms67] procedure was used for the analysis of nitrate and nitrite. For the nitrate analysis, the seawater sample was passed through a cadmium reduction column where nitrate was quantitatively reduced to nitrite. Sulfanilamide was introduced to the sample stream followed by N-(1-naphthyl)ethylenediamine dihydrochloride which coupled to form a red azo dye. The stream was then passed through a 15mm flowcell and the absorbance measured at 540nm. The same technique was employed for nitrite analysis, except the cadmium column was not present, and a 50mm flowcell was used for measurement.

Phosphate was analyzed using a modification of the Bernhardt and Wilhelms [Bern67] technique. An acidic solution of ammonium molybdate was 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 was

heated to ~55°C to enhance color development, then passed through a 50mm flowcell and the absorbance measured at 820m.

### **Sampling and Data Processing**

Nutrient samples were drawn into 40 ml polypropylene, screw-capped centrifuge tubes. The tubes were cleaned with 10% HCl and rinsed with sample twice before filling. Standardizations were performed at the beginning and end of each group of analyses (typically one cast, usually 36 samples) with an intermediate concentration mixed nutrient standard prepared prior to each run from a secondary standard in a low-nutrient seawater matrix. The secondary standards were prepared aboard ship by dilution from dry, pre-weighed primary standards. Sets of 5-6 different standard concentrations were analyzed periodically to determine the deviation from linearity as a function of concentration for each nutrient.

After each group of samples was analyzed, the raw data file was processed to produce another file of response factors, baseline values, and absorbances. Computer-produced absorbance readings were checked for accuracy against values taken from a strip chart recording. The data were then added to the cruise database. 5425 nutrient samples were analyzed. No major problems were encountered with the measurements, other than a continuing difficulty in holding the lab temperature constant. The pump tubing was changed three times. An aliquot from a large volume of stored deep seawater was run with each set of samples as a substandard. The efficiency of the cadmium column used for nitrate reduction was monitored throughout the cruise and ranged from 99.8-100.0%.

Nutrients, reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in-situ* salinity, and an assumed laboratory temperature of 25°C.

### **Standards**

$Na_2SiF_6$ , the silicate primary standard, was obtained from Fluka Chemical Company and Fisher Scientific and was reported by the suppliers to be >98% pure. Primary standards for nitrate ( $KNO_3$ ), nitrite ( $NaNO_2$ ), and phosphate ( $KH_2PO_4$ ) were obtained from Johnson Matthey Chemical Co. and the supplier reported purities of 99.999%, 97%, and 99.999%, respectively.

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## Appendix A

### WOCE95-I8N/I5E: CTD Temperature and Conductivity Corrections Summary

Sta/ Cast	PRT Response Time (secs)	ITS-90 Temperature Coefficients			Conductivity Coefficients		
		corT = t2*T <sup>2</sup> + t1*T + t0			corC = c2*C <sup>2</sup> + c1*C + c0		
		t2	t1	t0	c2	c1	c0
279/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89844e-03	0.00914
280/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89816e-03	0.00914
281/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89788e-03	0.00914
282/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89761e-03	0.00914
283/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89733e-03	0.00914
284/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89705e-03	0.00914
285/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89678e-03	0.00914
286/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89650e-03	0.00914
287/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89622e-03	0.00914
288/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89594e-03	0.00914
289/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89567e-03	0.01040
290/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89539e-03	0.01041
291/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89511e-03	0.01041
292/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89483e-03	0.01042
293/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89456e-03	0.01043
294/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89428e-03	0.01044
295/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89400e-03	0.01045
296/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89372e-03	0.01046
297/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89345e-03	0.01046
298/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89317e-03	0.01047
299/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89289e-03	0.01048
300/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89262e-03	0.01049
301/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89234e-03	0.01050
302/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89206e-03	0.00951
303/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89178e-03	0.01051
304/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89151e-03	0.01052
305/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89123e-03	0.01053
306/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89095e-03	0.01054
307/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89067e-03	0.01055
308/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89040e-03	0.01056
309/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.89012e-03	0.01057
310/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88984e-03	0.01057
311/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88956e-03	0.01058
312/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88929e-03	0.01059
313/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88901e-03	0.01060
314/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88873e-03	0.01061
315/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88846e-03	0.01062
316/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88818e-03	0.01062
317/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88790e-03	0.01063
318/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88762e-03	0.01064

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
319/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88735e-03	0.01065
320/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88707e-03	0.01066
321/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88679e-03	0.01067
322/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88651e-03	0.01067
323/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88624e-03	0.01068
324/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88596e-03	0.01069
325/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88568e-03	0.01070
326/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88540e-03	0.01071
327/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88513e-03	0.01072
328/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88485e-03	0.01072
329/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88457e-03	0.01073
330/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88429e-03	0.01074
331/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88402e-03	0.01075
332/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88374e-03	0.01076
333/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88346e-03	0.01077
334/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88319e-03	0.01077
335/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88291e-03	0.01078
336/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88263e-03	0.01079
337/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88235e-03	0.01080
338/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88208e-03	0.01081
339/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88180e-03	0.01082
340/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88152e-03	0.01083
341/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88124e-03	0.01083
342/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88097e-03	0.01084
343/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88069e-03	0.01085
344/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88041e-03	0.00986
345/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.88013e-03	0.01087
346/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87986e-03	0.01088
347/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87958e-03	0.01088
348/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87930e-03	0.01089
349/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87903e-03	0.01090
350/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87875e-03	0.01091
351/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87847e-03	0.01092
352/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87819e-03	0.01093
353/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87792e-03	0.01093
354/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87764e-03	0.01094
355/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87736e-03	0.01095
356/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87708e-03	0.01096
357/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87681e-03	0.01097
358/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87653e-03	0.01098
359/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87625e-03	0.01098
360/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87597e-03	0.01099
361/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87570e-03	0.01100
362/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87542e-03	0.01101



Sta/ Cast	PRT Response Time (secs)	ITS-90 Temperature Coefficients			Conductivity Coefficients		
		corT = t2*T <sup>2</sup> + t1*T + t0			corC = c2*C <sup>2</sup> + c1*C + c0		
		t2	t1	t0	c2	c1	c0
363/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87514e-03	0.01102
364/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87486e-03	0.01103
365/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87459e-03	0.01104
366/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87431e-03	0.01104
367/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87403e-03	0.01105
368/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87376e-03	0.01106
369/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87348e-03	0.01107
370/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87320e-03	0.01108
371/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87292e-03	0.01109
372/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87265e-03	0.01109
373/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87237e-03	0.01110
374/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87209e-03	0.01111
375/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87181e-03	0.01112
376/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87154e-03	0.01113
377/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87126e-03	0.01114
378/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87098e-03	0.01114
379/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87070e-03	0.01115
380/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87043e-03	0.01116
381/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.87015e-03	0.01117
382/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86987e-03	0.01118
383/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86960e-03	0.01119
384/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86932e-03	0.01119
385/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86904e-03	0.01120
386/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86876e-03	0.01121
387/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86849e-03	0.01122
388/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86821e-03	0.01123
389/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86793e-03	0.01124
390/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86765e-03	0.01124
391/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86738e-03	0.01125
392/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86710e-03	0.01126
393/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86682e-03	0.01127
394/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86654e-03	0.01128
395/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86627e-03	0.01129
396/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86599e-03	0.01130
397/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86571e-03	0.01130
398/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86544e-03	0.01131
399/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86516e-03	0.01132
400/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86488e-03	0.01133
401/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86460e-03	0.01184
402/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86433e-03	0.01085
403/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86405e-03	0.01085
404/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86377e-03	0.01086
405/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86349e-03	0.01087
406/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86322e-03	0.01088

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
407/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86294e-03	0.01089
408/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86266e-03	0.01090
409/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86238e-03	0.01090
410/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86211e-03	0.01091
411/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86183e-03	0.01092
412/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86155e-03	0.01093
413/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86127e-03	0.01094
414/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86100e-03	0.01095
415/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86072e-03	0.01095
416/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86044e-03	0.01096
417/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.86017e-03	0.01097
418/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85989e-03	0.01098
419/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85961e-03	0.01099
420/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85933e-03	0.01150
420/02	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85933e-03	0.01150
421/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85906e-03	0.01151
422/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85878e-03	0.01151
423/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85850e-03	0.01152
424/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85822e-03	0.01153
425/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85795e-03	0.01154
426/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85767e-03	0.01105
427/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85739e-03	0.01156
428/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85711e-03	0.01156
429/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85684e-03	0.01157
430/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85656e-03	0.01058
431/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85628e-03	0.01059
432/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85601e-03	0.01259
433/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85573e-03	0.01259
434/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85545e-03	0.01259
435/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85517e-03	0.01259
436/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85490e-03	0.01359
437/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85462e-03	0.01259
438/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85434e-03	0.01259
439/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85406e-03	0.01259
440/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85379e-03	0.01259
441/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85351e-03	0.01259
442/01	.34	1.9889e-05	-6.2817e-04	-1.4986	1.14690e-05	-1.85323e-03	0.01259

## Appendix B

### Summary of WOCE95-I8N/I5E CTD Oxygen Time Constants

Temperature		Pressure	$O_2$ Gradient
Fast( $\tau_{Tf}$ )	Slow( $\tau_{Ts}$ )	( $\tau_p$ )	( $\tau_{og}$ )
1.0	400.0	24.0	16.0

### WOCE95-I8N/I5E: Conversion Equation Coefficients for CTD Oxygen

(refer to Equation 1.8.4.0)

Sta/ Cast	$O_c$ Slope ( $c_1$ )	Offset ( $c_2$ )	$P_f$ coeff ( $c_3$ )	$T_f$ coeff ( $c_4$ )	$T_s$ coeff ( $c_5$ )	$\frac{dO_c}{dt}$ coeff ( $c_6$ )
279/01	8.52318e-04	4.04337e-03	1.43663e-04	4.41632e-02	-7.30479e-02	-4.01772e-07
280/01	3.64533e-03	-2.29321e-01	-4.43843e-04	1.70664e-02	-9.41911e-02	3.62236e-06
281/01	2.05888e-03	-8.97479e-02	-1.43960e-04	1.14174e-02	-6.66599e-02	-1.45558e-06
282/01	1.64245e-03	-7.23028e-02	-9.16307e-06	1.24447e-02	-5.85163e-02	3.86605e-06
283/01	9.64614e-04	1.53467e-02	1.35408e-04	1.45939e-02	-4.14754e-02	8.76354e-06
284/01	1.00199e-03	1.59438e-02	1.28032e-04	2.14580e-02	-4.61350e-02	1.44789e-06
285/01	9.59996e-04	1.63145e-02	1.38566e-04	6.59338e-03	-3.22591e-02	2.67224e-06
286/01	9.69846e-04	9.60806e-03	1.44486e-04	2.87690e-03	-2.89184e-02	2.85749e-06
287/01	9.96152e-04	2.00691e-02	1.30353e-04	4.77111e-03	-2.97393e-02	8.95523e-06
288/01	9.47606e-04	2.14528e-02	1.42339e-04	-1.61170e-03	-2.37201e-02	5.95008e-07
289/01	1.18668e-03	-5.98167e-02	1.48829e-04	1.43432e-02	-5.01994e-02	7.00972e-07
290/01	1.08392e-03	-5.08259e-02	1.69658e-04	3.41896e-03	-3.40652e-02	-3.72869e-07
291/01	1.08746e-03	-4.95038e-02	1.67751e-04	4.25811e-03	-3.53692e-02	2.74384e-06
292/01	9.99243e-04	-1.39607e-02	1.59445e-04	1.15520e-02	-3.97919e-02	-1.38786e-06
293/01	9.94947e-04	-1.61381e-02	1.61297e-04	8.97191e-03	-3.76099e-02	1.49741e-06
294/01	1.05294e-03	-3.64365e-02	1.64245e-04	2.95560e-03	-3.40427e-02	1.32924e-06
295/01	1.06256e-03	-3.74152e-02	1.64156e-04	4.67164e-03	-3.72985e-02	-2.81086e-07
296/01	1.08736e-03	-3.77890e-02	1.54847e-04	8.64275e-03	-3.95368e-02	6.47843e-07
297/01	1.04384e-03	-2.96960e-02	1.59643e-04	6.15222e-03	-3.69691e-02	-2.83577e-06
298/01	1.03358e-03	-1.92658e-02	1.53508e-04	5.35137e-03	-3.61750e-02	-2.34867e-06
299/01	1.05557e-03	-3.17310e-02	1.57956e-04	5.86220e-03	-3.60030e-02	-1.09147e-07
300/01	1.05697e-03	-2.94770e-02	1.55111e-04	3.96796e-03	-3.66467e-02	2.54063e-06
301/01	1.08237e-03	-4.35011e-02	1.60532e-04	5.67574e-03	-3.74594e-02	-1.86012e-06
302/01	1.06255e-03	-2.94582e-02	1.54099e-04	6.53854e-03	-3.66762e-02	2.94676e-06
303/01	1.06716e-03	-3.42525e-02	1.56949e-04	1.53546e-02	-4.42526e-02	2.63533e-06
304/01	1.04649e-03	-3.52538e-02	1.62802e-04	1.05099e-02	-4.08511e-02	-2.41519e-06
305/01	1.03430e-03	-2.72022e-02	1.58393e-04	1.39780e-02	-4.32988e-02	-3.58098e-06
306/01	1.08019e-03	-5.40741e-02	1.68350e-04	6.06480e-03	-3.73507e-02	-2.44443e-06
307/01	1.04480e-03	-3.96287e-02	1.65634e-04	9.93304e-03	-3.95943e-02	1.45873e-06
308/01	1.01169e-03	-2.61166e-02	1.61807e-04	9.88584e-03	-3.94402e-02	-2.37924e-06
309/01	1.01905e-03	-2.64224e-02	1.60790e-04	6.61109e-03	-3.66759e-02	1.36790e-06
310/01	1.04860e-03	-4.67079e-02	1.70855e-04	3.99216e-03	-3.50318e-02	9.99414e-07
311/01	1.06226e-03	-5.49055e-02	1.74076e-04	6.25556e-03	-3.58645e-02	-1.70843e-06

Sta/ Cast	$O_c$ Slope ( $c_1$ )	Offset ( $c_2$ )	$P_I$ coeff ( $c_3$ )	$T_I$ coeff ( $c_4$ )	$T_s$ coeff ( $c_5$ )	$\frac{dO_c}{dt}$ coeff ( $c_6$ )
312/01	1.03564e-03	-3.28531e-02	1.62293e-04	2.96234e-03	-3.29868e-02	-2.71325e-06
313/01	1.04568e-03	-4.31850e-02	1.67791e-04	5.86271e-03	-3.59947e-02	8.17007e-07
314/01	1.05592e-03	-4.13119e-02	1.62772e-04	4.57435e-03	-3.54332e-02	-2.16138e-06
315/01	1.05696e-03	-3.41119e-02	1.59750e-04	4.89518e-04	-3.31453e-02	2.63423e-07
316/01	1.06387e-03	-4.67391e-02	1.66631e-04	7.27067e-03	-3.83840e-02	-4.49783e-06
317/01	1.04154e-03	-4.49332e-02	1.70005e-04	4.14567e-03	-3.39997e-02	2.06047e-06
318/01	1.05633e-03	-4.33619e-02	1.65022e-04	5.42878e-03	-3.77299e-02	-3.89447e-06
319/01	1.02186e-03	-3.26170e-02	1.64306e-04	9.09271e-03	-4.10371e-02	2.25375e-07
320/01	1.08667e-03	-6.13795e-02	1.72916e-04	4.06638e-03	-3.62081e-02	-1.46380e-06
321/01	1.04886e-03	-3.70881e-02	1.62834e-04	7.89293e-03	-3.89794e-02	5.27406e-07
322/01	1.05805e-03	-4.92201e-02	1.70079e-04	1.57975e-03	-3.48230e-02	1.40272e-06
323/01	1.02985e-03	-3.43462e-02	1.65197e-04	2.59205e-03	-3.85251e-02	-2.76844e-06
324/01	1.02125e-03	-3.10034e-02	1.62513e-04	7.16791e-03	-3.73877e-02	-4.41064e-06
325/01	1.03789e-03	-4.12716e-02	1.67632e-04	5.29079e-03	-3.63241e-02	-2.88477e-07
326/01	9.33069e-04	2.03401e-02	1.42174e-04	8.48215e-03	-3.68887e-02	-6.20940e-06
327/01	1.00289e-03	-1.15489e-02	1.52162e-04	1.32141e-04	-3.30415e-02	4.53405e-06
328/01	9.92062e-04	1.50570e-03	1.48479e-04	-2.47955e-03	-3.23551e-02	-3.91634e-07
329/01	9.79453e-04	2.00164e-02	1.40599e-04	1.40796e-03	-2.85774e-02	5.14726e-06
330/01	9.71023e-04	3.08286e-02	1.33713e-04	5.35858e-03	-3.05715e-02	-1.23754e-06
331/01	9.53090e-04	1.78314e-02	1.57833e-04	1.67913e-03	-2.80144e-02	4.71647e-06
332/01	9.10399e-04	2.85856e-02	1.59629e-04	1.79658e-03	-2.57604e-02	7.17955e-04
333/01	8.93699e-04	3.20194e-02	1.57675e-04	-1.42557e-03	-2.27319e-02	4.63448e-05
334/01	8.99988e-04	2.62650e-02	1.64845e-04	7.63326e-04	-2.30695e-02	1.04963e-06
335/01	8.82728e-04	2.00206e-02	1.72501e-04	-2.29555e-03	-1.94200e-02	1.00208e-05
336/01	8.88639e-04	2.75129e-02	1.64985e-04	-3.89094e-03	-2.03204e-02	1.00218e-05
337/01	8.63598e-04	3.32731e-02	1.67723e-04	3.52259e-04	-2.11163e-02	6.49190e-06
338/01	1.04140e-03	-4.27848e-02	1.65154e-04	8.65657e-03	-3.90887e-02	-1.52167e-06
339/01	1.03843e-03	-3.54616e-02	1.64211e-04	3.15363e-03	-3.53254e-02	5.61760e-06
340/01	1.04370e-03	-3.24554e-02	1.60599e-04	4.09755e-03	-3.57563e-02	8.96981e-07
341/01	1.02441e-03	-2.45304e-02	1.60146e-04	9.26060e-03	-3.67453e-02	5.81798e-06
342/01	1.02879e-03	-1.80826e-02	1.53163e-04	5.99476e-03	-3.50380e-02	-3.79633e-06
343/01	1.05166e-03	-3.20432e-02	1.59723e-04	9.10186e-03	-3.81464e-02	4.12087e-06
344/01	1.03029e-03	-1.27765e-02	1.51397e-04	4.39564e-03	-3.41266e-02	3.70848e-06
345/01	1.01608e-03	-7.35059e-03	1.48896e-04	8.29663e-03	-3.62023e-02	2.53184e-05
346/01	1.04470e-03	-2.80450e-02	1.58349e-04	9.49466e-03	-3.80047e-02	1.33981e-06
347/01	1.04971e-03	-3.02061e-02	1.57525e-04	8.56635e-03	-3.73016e-02	5.86762e-06
348/01	1.04345e-03	-2.42341e-02	1.56656e-04	-1.31520e-03	-3.32498e-02	-7.40282e-07
349/01	1.01526e-03	-1.20021e-02	1.53395e-04	6.73658e-03	-3.61178e-02	1.36365e-06
350/01	1.04170e-03	-2.58945e-02	1.57589e-04	9.29864e-03	-3.74947e-02	3.83706e-07
351/01	1.01645e-03	-1.73846e-02	1.55370e-04	8.40531e-03	-3.50534e-02	5.30775e-06
352/01	1.01296e-03	-1.58326e-02	1.58095e-04	4.24103e-03	-3.35689e-02	4.61468e-06
353/01	1.03692e-03	-1.75282e-02	1.51974e-04	1.05901e-02	-3.81984e-02	-1.59109e-05
354/01	1.02385e-03	-1.73969e-02	1.55351e-04	6.41028e-03	-3.49347e-02	6.61776e-07
355/01	1.03653e-03	-2.59947e-02	1.58127e-04	4.19934e-03	-3.49718e-02	-5.74657e-07

Sta/ Cast	$O_c$ Slope ( $c_1$ )	Offset ( $c_2$ )	$P_I$ coeff ( $c_3$ )	$T_I$ coeff ( $c_4$ )	$T_s$ coeff ( $c_5$ )	$\frac{dO_c}{dt}$ coeff ( $c_6$ )
356/01	1.06392e-03	-4.55890e-02	1.66078e-04	6.53038e-03	-3.77363e-02	5.82517e-07
357/01	1.02719e-03	-2.97143e-02	1.62580e-04	1.85659e-04	-3.30351e-02	-3.50872e-06
358/01	1.02581e-03	-1.47199e-02	1.52692e-04	4.59718e-03	-3.46057e-02	-1.88832e-06
359/01	1.03465e-03	-2.25724e-02	1.54988e-04	7.77884e-04	-3.22090e-02	2.46734e-06
360/01	1.00294e-03	-7.89930e-03	1.53379e-04	3.46888e-03	-3.32753e-02	3.47849e-07
361/01	9.99206e-04	-1.42886e-02	1.57477e-04	2.17508e-03	-3.20480e-02	6.04259e-07
362/01	1.02396e-03	-3.06383e-02	1.65762e-04	3.14972e-03	-3.38994e-02	-3.66414e-06
363/01	1.04658e-03	-3.60516e-02	1.62602e-04	1.07879e-03	-3.39874e-02	3.56257e-07
364/01	9.70671e-04	-7.50010e-03	1.61931e-04	2.04978e-04	-3.08245e-02	-5.15948e-06
365/01	1.02460e-03	-8.80079e-03	1.46197e-04	1.00038e-02	-3.77468e-02	-1.12506e-06
366/01	8.20423e-04	3.87757e-02	1.72106e-04	2.53874e-03	-2.30226e-02	2.13467e-06
367/01	8.81846e-04	-2.51906e-02	2.54330e-04	-1.80904e-03	-2.46001e-02	-1.89703e-06
368/01	9.31617e-04	1.43499e-01	-3.47045e-06	5.73919e-03	-3.15032e-02	-1.36113e-08
369/01	8.88794e-04	2.96812e-02	1.54024e-04	3.66036e-03	-2.72780e-02	-2.28554e-06
370/01	8.97128e-04	1.08922e-02	1.71876e-04	-1.84879e-03	-2.40132e-02	-4.30155e-06
371/01	1.07389e-03	-2.91161e-02	1.54042e-04	-3.28907e-03	-3.20120e-02	2.50067e-06
372/01	8.73904e-04	3.44162e-02	1.62630e-04	6.31408e-04	-2.46183e-02	2.18257e-06
373/01	9.23544e-04	3.04299e-02	1.44982e-04	4.72514e-03	-3.04786e-02	6.02030e-07
374/01	8.89353e-04	8.80877e-03	1.82477e-04	3.87527e-03	-2.74343e-02	4.02201e-06
375/01	8.25705e-04	3.57947e-02	1.74524e-04	-5.80312e-04	-2.23592e-02	-1.70328e-06
376/01	9.41350e-04	-2.70934e-02	2.03194e-04	-6.07999e-03	-2.44833e-02	2.76055e-07
377/01	1.02119e-03	-1.80942e-02	1.54225e-04	-4.26957e-04	-3.41325e-02	2.98076e-06
378/01	1.02124e-03	-2.61431e-02	1.60546e-04	5.64444e-03	-3.61640e-02	-2.78503e-07
379/01	1.01466e-03	-1.31267e-02	1.52435e-04	6.69160e-03	-3.58598e-02	2.47331e-06
380/01	1.02508e-03	-2.81974e-02	1.62646e-04	4.80296e-03	-3.46597e-02	6.57995e-06
381/01	1.01564e-03	-2.06249e-02	1.57452e-04	-1.80742e-03	-3.06700e-02	-9.40179e-07
382/01	1.00165e-03	-2.36846e-02	1.64074e-04	-3.10258e-03	-3.00824e-02	-3.40456e-06
383/01	1.03028e-03	-3.04194e-02	1.60445e-04	8.44393e-03	-3.83596e-02	7.44252e-07
384/01	1.01506e-03	-2.15578e-02	1.58562e-04	-5.92014e-04	-3.17031e-02	1.27020e-06
385/01	9.91673e-04	-2.00930e-02	1.64256e-04	3.22954e-03	-3.18648e-02	-5.91359e-06
386/01	1.02027e-03	-1.82012e-02	1.53284e-04	4.01180e-03	-3.41552e-02	6.89912e-07
387/01	8.86070e-04	-6.50824e-03	1.89090e-04	3.25052e-04	-2.77795e-02	1.18260e-06
388/01	9.80692e-04	-5.32410e-03	1.52603e-04	5.45175e-03	-3.25377e-02	-2.49030e-06
389/01	9.63360e-04	-2.40638e-03	1.57455e-04	5.43451e-03	-3.32001e-02	-3.16022e-06
390/01	9.81339e-04	4.80023e-03	1.47337e-04	1.02463e-02	-3.52005e-02	-3.01350e-06
391/01	1.00870e-03	-2.04449e-02	1.62000e-04	1.13585e-03	-3.16626e-02	-1.83329e-07
392/01	9.28419e-04	3.80705e-03	1.65616e-04	5.02759e-03	-3.12686e-02	7.15368e-07
393/01	8.73469e-04	-4.98334e-04	1.92085e-04	1.40783e-03	-2.64689e-02	1.17892e-06
394/01	8.54438e-04	1.86209e-02	1.80606e-04	-4.06576e-04	-2.43376e-02	-2.06638e-06
395/01	1.77948e-03	-1.48922e-02	-1.72589e-04	-2.31574e-03	-5.79207e-02	-1.65631e-06
396/01	1.11257e-03	-3.40443e-02	1.29552e-04	-1.28578e-03	-3.58044e-02	-1.39503e-06
397/01	9.87369e-04	-8.98119e-03	1.60764e-04	3.27300e-04	-3.06843e-02	8.55015e-06
398/01	1.03996e-03	-3.20442e-02	1.60485e-04	-4.51736e-03	-3.16962e-02	-3.54980e-06
399/01	9.71810e-04	-4.93114e-03	1.57385e-04	5.90244e-03	-3.46241e-02	-1.20793e-05

Sta/ Cast	$O_c$ Slope ( $c_1$ )	Offset ( $c_2$ )	$P_I$ coeff ( $c_3$ )	$T_I$ coeff ( $c_4$ )	$T_s$ coeff ( $c_5$ )	$\frac{dO_c}{dt}$ coeff ( $c_6$ )
400/01	1.00277e-03	-2.10191e-02	1.61605e-04	4.20136e-04	-3.28615e-02	-1.41640e-06
401/01	1.01500e-03	-2.80314e-02	1.63432e-04	4.95730e-03	-3.52418e-02	-3.95473e-07
402/01	1.05551e-03	-3.69151e-02	1.61119e-04	-8.27702e-03	-3.37281e-02	-1.41699e-06
403/01	1.00573e-03	-1.24233e-02	1.53923e-04	8.88181e-03	-3.82373e-02	4.94276e-06
404/01	9.84862e-04	-9.74446e-03	1.57481e-04	8.76472e-03	-3.65011e-02	4.21206e-07
405/01	9.74993e-04	6.12476e-04	1.53664e-04	2.76102e-03	-3.41589e-02	-4.21993e-06
406/01	9.86408e-04	-1.42047e-02	1.60914e-04	1.54106e-03	-3.28346e-02	-4.93489e-06
407/01	9.90133e-04	-1.28966e-02	1.58788e-04	9.48479e-03	-3.88345e-02	-6.56106e-06
408/01	1.01700e-03	-2.63961e-02	1.63127e-04	1.78238e-03	-3.65663e-02	3.96754e-06
409/01	9.69506e-04	-5.53079e-03	1.58415e-04	6.85656e-04	-3.28321e-02	-2.22603e-06
410/01	1.00408e-03	-2.60642e-02	1.65205e-04	5.39250e-04	-3.32779e-02	-4.02666e-06
411/01	1.02627e-03	-2.86111e-02	1.62451e-04	6.45501e-03	-3.76061e-02	6.08891e-07
412/01	1.00683e-03	-1.88567e-02	1.59409e-04	5.68216e-03	-3.66846e-02	-5.74619e-06
413/01	1.04781e-03	-3.00057e-02	1.58332e-04	6.14629e-03	-3.98318e-02	-3.89584e-06
414/01	1.01774e-03	-3.01136e-02	1.65001e-04	8.40089e-03	-3.85160e-02	-1.40599e-06
415/01	9.75623e-04	-1.18112e-03	1.52518e-04	1.27211e-02	-3.89634e-02	1.48734e-06
416/01	1.02076e-03	-2.95602e-02	1.67557e-04	6.87556e-03	-3.87863e-02	-1.28551e-07
417/01	8.84167e-04	1.34733e-02	1.74079e-04	1.19905e-03	-2.92011e-02	-1.83884e-07
418/01	9.94331e-04	-7.50508e-03	1.54183e-04	1.29907e-02	-3.99842e-02	1.69047e-06
419/01	1.04607e-03	-2.49970e-02	1.55462e-04	9.02237e-03	-3.93008e-02	-7.59427e-06
420/01	1.02328e-03	-1.91011e-02	1.56428e-04	8.33631e-03	-3.77065e-02	3.95575e-06
420/02	1.05667e-03	-3.69862e-02	1.61798e-04	1.25093e-02	-4.13881e-02	3.27329e-06
421/01	1.02968e-03	-2.07166e-02	1.55598e-04	3.55479e-03	-3.47545e-02	2.94570e-06
422/01	1.06143e-03	-4.52267e-02	1.66175e-04	6.01757e-03	-3.86456e-02	-5.46583e-06
423/01	1.08653e-03	-5.21053e-02	1.66013e-04	1.18134e-02	-4.32037e-02	-3.08955e-06
424/01	9.55597e-04	-5.24552e-03	1.64049e-04	5.97484e-03	-3.39257e-02	1.49584e-06
425/01	9.82609e-04	-1.16778e-02	1.58609e-04	5.59794e-03	-3.48328e-02	-4.85971e-06
426/01	1.00736e-03	-2.39704e-02	1.62762e-04	7.80778e-04	-3.35500e-02	3.24174e-06
427/01	1.03299e-03	-3.79965e-02	1.65714e-04	7.71112e-03	-3.77836e-02	-6.71502e-06
428/01	1.02076e-03	-2.77672e-02	1.62498e-04	1.12249e-02	-4.02223e-02	3.94843e-06
429/01	1.04673e-03	-3.50824e-02	1.61518e-04	4.24369e-03	-3.62437e-02	1.14639e-05
430/01	9.98055e-04	-1.67936e-02	1.60029e-04	1.54201e-03	-3.34126e-02	-5.37280e-06
431/01	9.70177e-04	-2.58558e-04	1.52598e-04	5.85572e-03	-3.37701e-02	-6.36960e-06
432/01	1.01316e-03	-2.27551e-02	1.61129e-04	4.09204e-03	-3.47461e-02	2.05722e-06
433/01	1.08778e-03	-5.84491e-02	1.68632e-04	2.11092e-03	-3.68270e-02	-2.25204e-06
434/01	1.08929e-03	-6.67766e-02	1.76557e-04	4.70281e-03	-3.79299e-02	5.33393e-07
435/01	9.62709e-04	-5.46080e-03	1.59130e-04	5.47514e-03	-3.28101e-02	-2.09338e-07
436/01	9.68754e-04	-7.69380e-03	1.63413e-04	-1.53111e-03	-2.94909e-02	-8.83548e-07
437/01	8.56481e-04	2.66360e-02	1.66443e-04	6.44383e-03	-2.57234e-02	5.27124e-07
438/01	9.14425e-04	-1.75937e-02	2.03695e-04	8.86095e-03	-3.16521e-02	-5.17207e-06
439/01	1.47398e-03	1.56284e-01	-2.68494e-04	5.02208e-03	-4.91193e-02	1.80989e-06
440/01	1.46596e-03	1.46999e-01	-3.16534e-04	2.52959e-03	-4.62666e-02	-7.94729e-06
441/01	1.16374e-02	-6.71017e+00	-1.65709e-03	-1.68724e-02	-9.58936e-02	1.19745e-06
442/01	2.08058e-04	2.41444e+00	6.06142e-04	4.40482e-02	-8.67905e-02	7.70288e-06

## Appendix C

### WOCE95-I8N/I5E: CTD Shipboard and Processing Comments

Key to Problem/Comment Abbreviations	
AB	(backup) ctdoxy sensor A or B used this cast; see Table 1.2.0 for details
CO	conductivity offset
CN	ctd conductivity signal noisy
DG	density gradient in top 6db, data consistent/smooth in time-series CTD; possibly real
DI	density inversion in top 6db, data consistent/smooth in time-series CTD; possibly real
OB	bottom ctdoxy signal drop coincides with slowdown for bottom approach
OF	ctdoxy fit off more than 0.02 ml/l compared to bottle data (and/or nearby ctd casts)
OH	ctdoxy fit high near surface: high raw ctdoxy signal
OL	ctdoxy fit low near surface: either slow cast start or low ctdoxy signal
ON	ctdoxy signal unusually noisy
OS	raw ctdoxy signal shifts
SB	surface bottle oxy value(s) missing or questionable, not used for ctdoxy fit
SS	probable sea slime on conductivity sensor
WS	winch slowdown/stop, potential shift in ctdoxy signal
Key to Solution/Action Abbreviations	
BF	backup ctdoxy sensor (B) may be faulty: data look suspect even in non-noisy areas
DO	despiked raw ctdoxy, despiked data ok unless otherwise indicated
DS	despiked salinity, changed temperature and/or conductivity - see .ctd file codes
NA	no action taken, used default quality code 2
NR	cast not processed, not reported with final data
O3	quality code 3 oxygen in .ctd file for pressures specified
O4	quality code 4 oxygen in .ctd file for pressures specified
OA	averaged bottle oxy values from nearby casts to determine surface ctdoxy fit
OC	offset conductivity channel to account for shift/offset
RO	offset raw ctdoxy data to account for signal drop caused by slowdown/stop/yoyo; usually DO in transition area above offset

Cast	Problem/Comment	Solution/Action
278/01	TEST cast, bottles all tripped same pressure	NR
280/01	ctdoxy bulges low near surface, looks suspect	O3 22-64db
281/x1	relay problems on Port winch; ABORT cast ~400m	NR
281/01	switched to Stbd winch prior to cast; overwrote aborted cast with these data	NA
282/01	ctdoxy signal spiky/out 1974db down to ~900db up	DO/O4 1978-2596db
283/01	replaced ctdoxy sensor prior to cast; DI/-0.027	NA
	AB/ON 1658-3270db/btm: big ctdoxy spikes	DO/O3 1550-2262db, 2480-2740db
	1658-2262db, 2480-2606db	
284/01	replaced cable to ctdoxy sensor prior to cast; AB/ON	DO 1600-4044db/btm
285/01	DG/+0.17; AB/ON	NA; DO 1850-4202db/btm
286/01	AB/ON	DO 2100-4272db/btm
287/01	SB; AB/ON	OA; DO 550-4328db/btm
288/01	DI/-0.021; AB/ON	NA; DO 500-4376db/btm

Cast	Problem/Comment	Solution/Action
289/01	switched back to primary ctdoxy sensor prior to cast OB	RO +1 4390-4398db/btm
290/01	DG/+0.19 OH, espec. 0-10db; then ctdoxy bulges low, looks suspect	NA DO/O3 0-46db
291/01	DG/+0.32	NA
293/01	DI/-0.026; OB	NA; RO +1 4400-4408db/btm
294/01	SB; OB	OA; RO +2 4388-4394db/btm
295/01	DG/+0.15	NA
296/01	DI/-0.031 misjudged bottom depth: rosette hit bottom, then 240m excess wire out before noticed drops at bottom in ctdoxy/conductivity signals  first bottle tripped ~100m above bottom	NA pulled wire back in slowly, no apparent damage to rosette/CTD truncate cast 0.5 db above bottom "hit", 3822db maxp now vs. 3824db used average value from 4 nearby casts for bottom ctdoxy fit
297/01	OB	RO +1 4522-4598db, RO +2 4600-4626db/btm
298/01	OB SS/CO	RO +2 4626-4644db, RO +3 4646-4682db/btm OC +.001 mmho/cm 2358-4682db
299/01	OB	RO +2 4692-4700db, RO +4 4702-4712db/btm
300/01	DG/+0.20 OB	NA RO +1 4700-4706db, RO +2 4708-4714db/btm
301/01	SB; OB	OA; RO +2 4710-4718db/btm
302/01	OB	RO +1 4692-4740db/btm
303/01	OB	RO +1 4726-4750db/btm
304/01	DI/-0.017	NA
305/01	DG/+0.14; OB	NA; RO +2 4798-4802db/btm
306/01	DG/+0.13; SB	NA; OA
308/01	DI/-0.020; OB	NA; RO +3 4954-4974db/btm
309/01	DI/-0.015; OB	NA; RO +1 4932-4976db/btm
311/01	OB	RO +1 4988-4996db/btm
312/01	OL to top of thermocline; OB	DO/O3 0-54db; RO +1 5034-5038db/btm
313/01	DI/-0.022 OB	NA RO +1 5046-5062db, RO +2 5064-5088db/btm
314/01	OB	RO +2 4658-4684db, RO +4 4686-4692db/btm
315/01	DG/+0.17	NA
316/01	OB	RO +1 5218-5220db/btm
317/01	DI/-0.028; OB	NA; RO +1 5202-5248db/btm
318/01	DG/+0.11; SS/cond. offsets to match up at 5184db OB/WS 1 min. at 5184-5188db	NA; OS +.001 PSU 0-5182db RO +1 5180-5278db/btm
319/01	DG/+0.32 OB	NA RO +1 5182-5220db, RO +2 5222-5230db/btm
320/01	DG/+0.10 OB	NA RO +1 4970-4978db, RO +2 4980-4984db/btm
321/01	SB OB	OA RO +1 5460-5464db, RO +2 5466-5486db/btm
322/01	OB/WS 1 min. at 5492-5496db	RO +1 5414-5422db, RO +2 5424-5500db/btm
323/01	DG/+0.17 OB	NA RO +1 5236-5260db, RO +2 5262-5266db/btm



Cast	Problem/Comment	Solution/Action
324/01	SB; OB	OA; RO +1 5274-5292db/btm
325/01	DI/-0.020	NA
	OB	RO +1 5410-5438db, RO +3 5440-5444db/btm
326/01	ON/big ctodoxy spikes 714-1008db, 1146-1276db, 1376-1540db, 1778-1798db	DO/O3 704-1462db
	OB	RO +1 5448-5460db/btm
327/01	ON/big ctodoxy spikes 536-848db, 890-1098db, 1184-1364db, 1434-1544db	DO/O3 680-1206db
328/01	OH/short warmup, ctodoxy sensor not stabilized before cast in water, WS 1 min. at 0-4db	DO/O3 0-66db
	OB	RO +1 5408-5426db/btm
329/01	replaced ctodoxy sensor prior to cast	
	SS/CO	OC +.001 mmho/cm 4254-4666db
	AB/ON 3898-4456db, 5136-5376db/btm	DO 3898-5376db
	OB	RO +1 5350-5362db, RO +3 5364-5376db/btm
330/01	AB/ON 800db-bottom, espec. 3476-4186db, 5052-5112db	DO
	OB	RO +1 5198-5216db/btm
331/01	SS/CO	OC +.002 mmho/cm 1942-2444db
	AB/ON espec. 3522-3972db; OB	DO; RO +1 5052-5126db/btm
332/01	DI/-0.016; OL/WS 1 min. at 2-6db	NA; DO/O3 0-38db
	AB: OF, ON espec. 3700-5012db/btm	BF/O3 2350-3500db, DO
333/01	DI/-0.022; OL/slow transit through surface area	NA; DO/O3 0-48db
	AB/OF	BF/O3 3800-4800db
334/01	AB/OF	BF/O3 3150-3650db
	AB/ON intermittent starting 3800db, steady 4600-5084db/btm	DO 3700-5012db
	OB	RO +1 5072-5084db/btm
335/01	AB/OF	BF/O3 2700-4050db
	ON intermittent from 3950db, steady 4274-4918db	DO/ok below 4050db 3950-4918db
	OB	RO +1 5080-5100db/btm
336/01	AB/OF	BF/O3 2736-4510db
	ON smaller than previous casts, 3850-5100db, increasing with depth	DO/ok below 4510db 3850-5100db
337/01	AB/ON smaller than previous casts, still OF	BF/O3 2850-4992db
338/01	switched back to primary ctodoxy sensor with new cable prior to cast	
	OB	RO +1 5108-5120db/btm
339/01	OB	RO +1 5066-5086db, RO +2 5088-5106db/btm
340/01	ON intermittent 900-2200db, 4000-5124db/btm	DO 900-5124db/btm
	OB/WS 1 min. at 5120-5124db	RO +4 5120-5124db/btm
341/01	DI/-0.026	NA
	ON intermittent 3750-4022db + 4650-4798db, steady 4120-4622db	DO/OF/O3 4420-4774db
	OB	RO +2 5178-5180db/btm
342/01	DI/-0.017; OB	NA; RO +1 5158-5168db/btm
343/01	DI/-0.015; OB	NA; RO +1 5070-5146db/btm
344/01	OB	RO +1 5028-5032db/btm
345/01	OB	RO +2 4926-4938db, RO +3 4940-4944db/btm

Cast	Problem/Comment	Solution/Action
346/01	OB	RO +1 4926-4932db, RO +2 4934-4942db/btm
347/01	WS/OS	RO +2 4774-4796db
	OB	RO +1 4886-4892db, RO +3 4894-4904db/btm
348/01	DI/-0.018; OB	NA; RO +3 4680-4742db/btm
349/01	ON intermittent deep, biggest segment 4000-4060db	DO 4000-4060db
	OB	RO +1 4618-4630db/btm
350/01	OB	RO +2 4640-4686db, RO +5 4688-4694db, RO +4 4696-4718db/btm
351/01	DI/-0.024; OB	NA; RO +1 4758-4790db/btm
352/01	OL/top 10 db; OB	DO; RO +2 4448-4566db/btm
353/01	OH/top 10 db; OB	DO/O3 0-14db; RO +3 4478-4484db/btm
354/01	OB	RO +2 4434-4450db, RO +3 4452-4482db/btm
355/01	OB	RO +3 4478-4486db, RO +4 4488-4500db/btm
356/01	OB	RO +1 4292-4306db/btm
357/01	OB	RO +1 4474-4478db, RO +2 4480-4488db/btm
358/01	OB	RO +2 4308-4312db/btm
359/01	~3km off planned station posn. to avoid seamount new end termination prior to cast; DI/-0.015	NA
	OB	RO +1 3948-4088db, RO +2 4090-4120db, RO +4 4122-4138db, RO +5 4140-4146db/btm
360/01	OB	RO +2 4562-4686db/btm
361/01	OF/spike in ctDOxy signal near cast bottom; OB	DO/O3 4586-4630db; RO +4 4598-4630db/btm
362/01	bottom bottle oxy value high/questionable	used nearby cast values to determine bottom ctDOxy fit
	ctDOxy still drifts high near bottom	O3 4576-4740db
	OB	RO +2 4664-4684db, RO +4 4686-4718db, RO +5 4720-4740db/btm
363/01	OB	RO +4 4432-4438db, RO +5 4440-4460db/btm
364/01	OB	RO +3 3904-3936db/btm
365/01	DI/-0.019	NA
	OB	RO +1 3484-3526db, RO +3 3528-3572db, RO +4 3574-3584db/btm
366/01	OS	RO +3 2506-2522db
367/01	WS/1 min. at 1618-1622db/btm	NA
369/01	DI/-0.018	NA
370/01	OB	RO +3 2420-2450db/btm
372/01	OB	RO +5 2708-2720db/btm
373/01	OB	RO +5 3186-3200db/btm
375/01	OB	RO +6 1592-1606db/btm
376/01	OB	RO +5 1888-1996db, RO +7 1998-2002db/btm
377/01	OB	RO +2 3554-3562db/btm
378/01	OB	RO +4 3804-3812db/btm
379/01	OB	RO +2 4422-4428db/btm
380/01	~6km short of original station posn. to avoid seamount	
381/01	OB	RO +2 4430-4436db/btm
382/01	OB	RO +1 4198-4208db, RO +2 4210-4234db/btm
383/01	OH/short warmup, ctDOxy sensor not stabilized before cast in water	DO 0-18db
	OB	RO +3 3806-3822db, RO +4 3824-3916db/btm

Cast	Problem/Comment	Solution/Action
384/01	OB	RO +4 4306-4324db, RO +2 4326-4332db/btm
385/01	OB	RO +1 4078-4084db, RO +4 4086-4110db/btm
386/01	OB	RO +4 4288-4302db/btm
388/01	WS/OS	RO +3 3326-3344db
389/01	~7km past original station posn.	
390/01	DI/-0.019	NA
391/01	OB	RO +1 3540-3546db, RO +3 3548-3578db/btm
392/01	OB	RO +5 3000-3090db/btm
395/01	OB	RO +2 1196-1202db/btm
396/01	OB	RO +3 1720-1748db/btm
397/01	OL/slow transit through surface area	DO 0-58db
398/01	OB	RO +2 3600-3612db, RO +3 3614-3636db/btm
399/01	OH, bottle matches sta.398, ctodoxy matches sta.400	DO 0-18db
400/01	OB	RO +2 3708-3712db, RO +4 3714-3718db/btm
401/01	SS/CO, WS/0.5 min. at 4232-4236db	RO +4 4136-4158db, RO +5 4160-4170db/btm
402/01	DI/-0.018	OC +.002 mmho/cm 1964-4228db
	OB	RO +3 4220-4240db/btm
	ctodoxy low compared to bottles, espec. 150-550db	NA
	OB	NA/ok 0-600db: ctodoxy matches 4 nearest casts
403/01	OB	RO +2 4256-4258db/btm
404/01	DI/-0.017; OB	RO +1 4318-4340db/btm
406/01	odd ctodoxy inflections throughout cast, even in well-mixed areas	NA; RO +2 4314-4334db/btm
	OB	NA
407/01	OB	RO -1 4566-4572db/btm
408/01	WS/1 min. at 266-270db	RO +1 4466-4510db/btm
	small rise in ctodoxy near bottom	NA
	OB	DO/O3 3934-4016db
412/01	SS/CO; OB	RO +1 3934-4016db/btm
413/01	SB	DS 1038-1058db; RO +2 4694-4738db/btm
	OB	OA
414/01	OF?/ctodoxy low relative to bottle data, but ok compared to nearby ctodoxy data	RO +1.5 5598-5610db, RO +2.5 5612-5630db, RO +1.5 5632-5652db/btm
	OB	O3 1960-2356db: visible breaks in ctodoxy, data may be ok
415/01	OB	RO +1 3948-4124db, RO +4 4126-4134db/btm
416/01	OB	RO +3 3002-3026db, RO +5 3028-3096db/btm
419/01	OB	RO +2 2228-2232db/btm
420/01	white (pylon) conductor short to seawater on Stbd winch, no bottles tripped above 4050db	RO +2 5174-5198db/btm
420/02	back to Port winch; OB	ABORT on up-cast above 4070db, use cast 2 bottle values to fit ctodoxy above 4050db
421/01	OB	RO +1 5326-5332db, RO +3 5334-5344db/btm
422/01	OB	RO +1 5186-5334db/btm
423/01	DI/-0.020	RO +2 5160-5162db/btm
	OH, then jagged ctodoxy to top of thermocline	NA
424/01	OB	DO/O3 0-56db
426/01	OB	RO +2 2978-2980db/btm
427/01	OB	RO -1 5168-5172db/btm
		RO +3 5028-5044db/btm

Cast	Problem/Comment	Solution/Action
428/01	WS/1 min. at 4100db for wire check; OB	RO +1 5280-5318db/btm
429/01	OL: off from bottles top ~180db but ctodoxy matches nearby casts below 16db	O3 0-16db
	OB	RO +2 5296-5306db, RO +3 5308-5320db/btm
430/01	SB	OA
431/01	DI/-0.021; OB	NA; RO +2 5170-5174db/btm
432/01	OB	RO +3 5112-5128db/btm
433/01	SB; OH	OA; DO
	OS; OB	RO +1 4962-5038db; RO +2 5078-5090db/btm
434/01	OB	RO +1 4834-4846db, RO +2 4848-4860db/btm
435/01	OB	RO +2 4388-4400db/btm
436/01	CN 2000-3458db/btm (intermittent sm.offsets up-cast)	DS
	OB	RO +1 3420-3458db/btm
437/01	DI/-0.021	NA
438/01	DI/-0.016	NA
439/01	DI/-0.023; OB	NA; RO +3 1010db/btm
440/01	DI/-0.021; OB	NA; RO +8 636-646db/btm
441/01	OB	RO +5 418-440db/btm

## Appendix D

### WOCE95-I8N/I5E: Bottle Quality Comments

Remarks for deleted samples, missing samples, PI data comments, and WOCE codes other than 2 from WOCE I8N/I5E KN-145.7. 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, Nitrite, and Phosphate. The first number before the comment is the cast number (CASTNO) times 100 plus the bottle number (BTLNBR).

#### Station 279

Cast 1 No comments on the Sample Log.

#### Station 280

Cast 1 No comments on the Sample Log.

116-117 CTD OXY processor: "CTDoxy bulges low near surface, looks suspect." Footnote CTD oxy uncertain.

110 Delta-S at 203db is -0.0336. Autosal diagnostics do not indicate a problem. CTD shows a lot of change at this trip level. Salinity and other data are acceptable.

102 Bottle oxygen value a little high (.03 ml/l) compared to adjacent stations and CTD oxygen. Footnote oxygen uncertain.

#### Station 281

Cast 1 Sample Log: "No leakers."

#### Station 282

126 Sample Log: "Leaky bottle, (air leak)." Delta-S 0.0544 high at 94db. High gradient. Other water samples also look okay.

103 Delta-S at 2221 db is 0.025. All water samples appear to be from about 1900db. Footnote bottle leaking and samples bad.

101-104 Console Ops: "O2 sensor went out near 2000m, replaced O2 sensor at end of station." Footnote CTD Oxy bad.

#### Station 283

Cast 1 Console Ops: "O2 malfunction near 1750m." No comments on the Sample Log.

107-110 CTD OXY processor: "Big ctdoxy spikes." Footnote CTD OXY questionable.

104-106 CTD OXY processor: "CTDoxy fit suspect." Footnote CTD OXY questionable.

101 O2 analyst: "two stir bars". Oxygen value appears 0.055 ml/l high compared to adjacent station and CTD o2. Footnote oxygen questionable.

#### Station 284

126 Sample Log: "Leaks a lot, with air vent closed." Delta-S at 222db is 0.0013 low. Nutrients also okay. Samples are acceptable. Oxygen crossed off sample log, not run, assume not drawn.

113 Delta-S at 1563db is 0.0030. This agrees with adjacent stations. See 111-113 Sample Log comment. Salinity is acceptable.

111-113 Sample Log: "O2 leak when sampled." Delta-Ss 0.0007, 0.0007, and 0.0030 high, respectively. Other water samples also okay.

101 Salinity sample lost. Salt bottle broken per salinity data sheet. Salinity: "Transferred to another salt bottle." This did not work out, the salinity was 0.03 high.

101-112 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 285**

Cast 1 No comments on the Sample Log. Shipboard Processor: "Delta-S ~0.003 PSU low, (bath temp)." There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. The salinities are also lower than adjacent stations. All salinity values are flagged as questionable.

101-113 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

101-136 All bottle salinity values are judged to be 0.003 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 286**

111 PO4 0.07 high, NO3 0.5 high, SiO3 5.5 low. Same value as 13 two levels above. Duplicate draw? Footnote nutrients bad.

108 Sample Log: "Water leak (lot)-vent not closed." Delta-S at 2935db is -0.0008. O2 and nutrients also okay. May be error on sample log note. The comment from the Sample Log apparently refers to bottle 7.

107 Oxy not sampled. No note on sample log. ODF O2 sampler said bottle bad. Salt and nuts okay. Further review of Sample Log sheet indicates that there was a mixup on recording of comment on Sample Log. The comment for bottle 8 apparently refers to this bottle.

102 Delta-S at 4159db is -0.0022. Autosal diagnostics do not indicate a problem. Also lower than adjacent stations except higher than 285, however, 285 is coded questionable. Footnote salinity questionable.

101-112 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 287**

Cast 1 No comments on the Sample Log.

136 Oxygen analyst: "Small Bubble." O2 value 0.1 ml/l higher than adjacent stations. Footnote oxygen questionable.

110 Oxygen low by 0.05 ml/l compared to stations 286 and 288. Footnote oxygen questionable.

109 Oxygen a little high compared to stations 286, 287 and CTD oxy at this level. Value same as NB08, could be duplicate draw. Footnote oxygen questionable.

102 Oxygen a little high compared to station 286 and CTD oxy at this level (.03ml/l). Footnote oxygen questionable.

101-124 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 288**

136 Sample Log: "Comes up untripped." Footnote samples not drawn from this bottle.

106-135 Sample Log: "Mistrip on bottle 6, 6-35 off by 1." No water samples at intended depth 3492db. All CTD trip data was removed this level and all bottles tripped one level higher than intended. Footnote bottle did not trip correctly.

101-112 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 289**

- 108 Sample Log: "Air vent not tightly closed." Delta-S at 2931db is -0.0006. Other water samples also okay.
- 102 Delta-S at 4156db is -0.0021. Autosal diagnostics do not indicate a problem. Variation between adjacent stations, value for this station are 0.0015 low. Out of WOCE spec of measurement. Footnote salinity questionable.

**Station 290**

- Cast 1 There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. Bottle salinities look 0.003 psu low when compared to adjacent stations and CTD salinity. All salinity values are flagged as questionable.
- 135-136 CTDO Processor: "High raw oxy signal, then value bulges low. Looks suspect." Footnote CTDO questionable.
- 101-136 All bottle salinity values are judged to be 0.003 psu low, footnote as questionable.

**Station 291**

- Cast 1 No comments on the Sample Log.
- 135 Oxygen sample accidentally lost before titration.
- 103 Delta-S at 4003db is -0.0046. Autosal diagnostics do not indicate a problem. Lower (~0.002~0.003) as compared with adjacent stations. Other data are acceptable. Footnote salinity bad.
- 102 Delta-S at 4207db is -0.0032. Autosal diagnostics do not indicate a problem. Lower (~0.002) as compared with adjacent stations. Other data are acceptable. Footnote salinity questionable.

**Station 292**

- Cast 1 No comments on the Sample Log.
- 115 Delta-S at 1565db is 0.0026 which is 0.004 high. Autosal run okay. Other water samples look okay. CTD up trace looks okay. May just be normal gradient this level.

**Station 293**

- 126 Sample log: "Bottom lanyard looped around 27." Delta-S at 648db is 0.0011. Other water samples also okay.
- 123 Sample Log: "Leaking bottom end cap (reseated end cap fixed)." Delta-S is -0.0003 at 879. Other water samples also look okay. Two other bottles were tripped at this level. The oxygen from this bottle is ~0.02 low. Footnote oxygen questionable.

**Station 294**

- 136 Oxygen value appears 0.1 ml/l high compared to adjacent stations and CTD Oxy value. No analyst notes to indicate a problem. Footnote Oxygen uncertain.
- 135 Oxygen value appears 0.2 ml/l high compared to adjacent stations and CTD Oxy value. No analyst notes to indicate a problem. Footnote Oxygen uncertain.
- 120 Sample log: "O2 870 not full of NaOH." looks good compared to CTDO.

**Station 295**

- 135 Sample log: "Leak." Delta-S at 15db is -0.0026. Other water samples also look okay.
- 109 Sample log: "Leak." Delta-S at 2328db is 0.0001. Other water samples also look okay.

**Station 296**

- Cast 1 Sample log: "Rosette touched bottom during down cast."

- 107 Sample log: "Air vent open." Delta-S at 2883db is 0.0010. Other water samples also okay.
- Station 297**
- Cast 1 No comments on the Sample Log.
- Station 298**
- Cast 1 No comments on the Sample Log.
- Station 299**
- Cast 1 Shipboard Processor: "Delta-S 0.003 PSU low: autosal bath temp." Standard dial is lower than adjoining stations, 7-8 units, and the autosal output indicates a little drift, < 0.001, which is within specs of the measurement. There is some other problem. The standard dial value was manually entered into the system, and no handwritten copy was made to double-check that the entry was done correctly. We could only justify adding 0.00004 to the conductivity ratios. This amounts to about 0.001 PSU. To change it any more we would have to assume that the Standard dial was off and that the ending worm was wrong too. There is not a definitive answer for adjusting these values. All salinity values are flagged as questionable.
- 102 Sample log: "Unusually warm when O2 was drawn (7.7)." Delta-S at 4569db is 0.3765. Other water samples also appear to be from about 250m. Footnote bottle leaking, samples bad.
- 101-136 All bottle salinity values are judged to be 0.003 psu low, footnote as questionable.
- Station 300**
- Cast 1 No comments on the Sample Log. Shipboard Processor: "All Delta-S 0.002 PSU low (bath temp?)." There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.
- 113 O2 Missing, okay on Sample log, not on O2 data printout. No notes. Titrator doesn't recall problem. Footnote oxygen lost.
- 110 PO4 all (08-10) 0.02 low. Footnote PO4 questionable.
- 109 Peaks good and definitely a little low. Footnote PO4 questionable.
- 108-110 Nutrient Analyst's note: "PO4 peaks good but definitely a little low." Footnote po4 questionable.
- 102 Oxygen value appears 0.4 ml/l low. Value almost same as NB03, may be double draw. Footnote oxygen bad.
- 101-136 All bottle salinity values are judged to be 0.002 psu low, footnote as questionable.
- Station 301**
- Cast 1 No comments on the Sample Log. Shipboard Processor: "Delta-S 0.004 PSU low (bath temp?)." There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.
- 135-136 Oxygen Analyst's note: "Bubble". O2 value 0.15 ml/l higher than stations 300 and 302. Footnote oxygen questionable.
- 101-136 All bottle salinity values are judged to be 0.004 psu low, footnote as questionable.
- Station 302**
- Cast 1 No comments on the Sample Log.
- 108 Delta-S at 3289db is -0.0021. Appears to agree with adjacent stations, but difficult to accept this value, since there are problems on the other stations. Footnote salinity questionable.
- 104 Delta-S at 4106db is -0.0046. Out of WOCE spec of measurement. Footnote salinity questionable.



**Station 303**

- Cast 1 There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. Lots of variation in adjacent stations. All salinity values are flagged as questionable.
- 136 Sample log: "Closed above surface." Water samples were taken from this bottle and appear acceptable.
- 126 Sample log: "O2 drawn after bottle 27." Some confusion in drawing. O2 data from 26 & 27 look fine.
- 119 Delta-S at 1161db is 0.0064. Autosal diagnostics indicate 5 tries to get a good reading, indicating a problem with the samples. Footnote salinity bad.
- 114 Delta-S at 2173db is -0.0041. Autosal diagnostics indicate 3 tries to get a good reading, indicating a problem with the samples. Footnote salinity bad.
- 107 Delta-S at 3597db is 0.0194. Other water samples also off. O2 & SiO3 from about same level, 2200-2800db, but NO3 & PO4 either from deeper or much shallower. Footnote bottle leaking, samples bad.
- 101-136 All bottle salinity values are judged to be 0.003 psu low, footnote as questionable unless otherwise noted as bad.

**Station 304**

- Cast 1 No comments on the Sample Log. There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.
- 101-136 All bottle salinity values are judged to be 0.003 psu low, probably due to autosal problems. Footnote as questionable.

**Station 305**

- Cast 1 No comments on the Sample Log. Shipboard Processor: "Delta-S 0.002 PSU low (bath temp?)." There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.
- 115 Delta-S at 2021db is 0.0359. Other water samples okay. Autosal run okay. No notes. Same value as 17 two levels above. Probably duplicate draw from 17 since both are bottles on the inner ring. Footnote Salinity bad.
- 101-136 All bottle salinity values are judged to be 0.002 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 306**

- Cast 1 No comments on the Sample Log.
- 136 Oxygen value looks 0.15 ml/l higher than nearby stations. No analyst's notes. Footnote oxygen questionable.
- 103 Delta-S at 4364db is -0.0023. Autosal diagnostics do not indicate a problem. Higher than Station 305 and lower than Stations 307 and 308. Out of WOCE spec of measurement. Footnote salinity questionable.

**Station 307**

- 135 Sample log: "Bottom end cap leaking. Reseated, okay." Samples appear to be okay. Delta-S at 21db is -0.1069. Autosal diagnostics do not indicate a problem. Salinity acceptable.
- 114 Delta-S at 2014db is -0.0023. Autosal diagnostics do not indicate a problem. Gradient area, salinity agrees with adjacent stations. Salinity is acceptable. Oxygen value appears 0.03 ml/l

high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

102 Delta-S at 4670db is -0.0027. Autosal run okay. Other water samples okay. Lower than adjacent stations. Footnote salinity questionable.

**Station 308**

136 Delta-S at 3db is 0.285. Autosal diagnostics do not indicate a problem. Salinity is higher than adjoining stations. Footnote salinity questionable.

134 Salinity must not have been drawn. No comments made by salinity analyst even though Sample Log indicates it should have been drawn. 35 and 36 salinity difference (with CTD) are large, but these could not have been a sampling mixup.

124 Sample log: "Dripping from bottom end cap. Reseated okay. Thought it was 26." Samples OK on this bottle.

116 Delta-S at 1920db is 0.0137. All water samples appear to be from about 100m higher than intended. Footnote bottle leaking, samples bad. Exact pressure that bottle tripped at cannot be determined.

**Station 309**

119 See 118-120 salinity comment. Suspect that analyst got confused with this sample and there is no resolve on its disposition. Delta-S is 0.003 high. Oxygen as well as other samples are acceptable. Footnote salinity questionable.

118-120 Salinity: "Questionable bottle order 18, 19, 20 in case in wrong order, reran." Analyst appears to have gotten the order straightened out, except for 19, it is questionable.

110 Bottle oxygen 0.10 ml/L higher than CTDO and adjacent stations at 3031db. Other water samples okay. Note on oxygen data sheet "small bubble". Apparent drawing problem. Footnote O2 bad.

105 Sample log: "Air-vent not closed." Delta-S at 4043db is 0.0005. Other water samples also okay. Salinity is acceptable.

**Station 310**

119-121 See 109 Sample Log, O2 comments. O2 is acceptable.

118 See 109 Sample Log, O2 comments. Footnote O2 not drawn.

110-117 See 109 Sample Log, O2 comments. O2 is acceptable.

109 Sample Log: "Oxy drawing problem." Apparent drawing order mixup. Data indicate: 1) No O2 drawn from 9 & 18. 2) Samples recorded for 110 thru 117 drawn one level higher than intended. 3) Samples recorded for 119 & 120 drawn two levels higher than intended. 4) Sample recorded for 119 has value 0.03 higher than reassigned 121 level but doesn't match any other level any closer. 5) Sample recorded for 121 has value 0.04 lower than reassigned 123 level and doesn't match any other level any closer. O2 data are in assumed order. Footnote O2 not drawn.

**Station 311**

Cast 1 No comments on the Sample Log.

**Station 312**

- Cast 1 Shipboard Processor: "Delta-S 0.004 PSU low (bath temp?)." Standard dial is 35 units lower than other 3 runs this Autosol(57-396). Drift +0.00010. New operator told to run second worm if std dial this far off. By assuming no drift and adding +0.00010 or ~0.002 PSU to the salinity values the salinity is lower than Station 311, but higher than Station 313 which is higher than the CTD. This autosal was used 17 stations later and had essentially the same standard dial reading. And, the later station agrees with the CTD salinity profile. After applying a correction to compensate for a suspected bad beginning SSW, we still see a Delta-S of ~-0.004 which is lower than the CTD. Will leave the data as originally analyzed. All salinity values are flagged as questionable.
- 134-136 CTDO Processor: "CTDOXY fit low to top of thermocline." Footnote CTDO questionable."
- 111 Sample log: "Might have been open before O2." Bottle oxygen matches CTDO and adjacent stations. Delta-S at 2705db is -0.0047.
- 101-136 All bottle salinity values are judged to be 0.004 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 313**

- Cast 1 No comments on the Sample Log. Shipboard Processor: "Delta-S 0.003 PSU low (bath temp?)." There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. Salinities are lower than adjacent stations. All salinity values are flagged as questionable.
- 105 Oxygen value appears 0.03 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.
- 101-136 All bottle salinity values are judged to be 0.004 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 314**

- 118 Sample log: "Water valve open." Bottle oxy matches CTDO and adjacent stations. Other water samples also okay.
- 104 Sample log: "Water valve open." Bottle oxy matches CTDO and adjacent stations. Other water samples also okay.
- 103 Sample log: "Water valve open." Bottle oxy matches CTDO and adjacent stations. Other water samples also okay.
- 102 Sample log: "Water valve open." Bottle oxy matches CTDO and adjacent stations. Other water samples also okay.
- 101 Sample log: "Water valve open." Bottle oxy matches CTDO and adjacent stations. Other water samples also okay.

**Station 315**

- Cast 1 No comments on the Sample Log.
- 136 Deck log: "Found lanyards mixed on 35 & 36 while cocking" before Station 316. Delta-S at 2db is -0.0219. All water sample values same for 135 & 136. CTD S & O2 essentially mixed these levels. Unable to tell if bottles tripped correctly or both at same level. Footnote did not trip correctly.
- 135 Deck log: "Found lanyards mixed on 35 & 36 while cocking" before Station 316. Delta-S at 32db is 0.0046. All water sample values same for 135 & 136. CTD S & O2 essentially mixed these levels. Unable to tell if bottles tripped correctly or both at same level. Footnote did not trip correctly.
- 111 Delta-S at 2733db is -0.0023. Autosal diagnostics do not indicate a problem. Salinity agrees with Station 317, but 317 salinities judged questionable. Footnote salinity questionable.

108 Delta-S at 3343db is -0.0028. Salinity agrees with Station 316, but salinity at this level were judged questionable. Footnote salinity questionable.

103 Delta-S at 4365db is -0.0034. Autosal diagnostics do not indicate a problem. Lower than Stations 314 and 316. Footnote salinity questionable.

**Station 316**

Cast 1 Sample Log: "Bottles fired starting at 18 (deepest)-36, 1-17 (shallowest) for freon blank test." There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.

101-136 All bottle salinity values are judged to be 0.0025 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

123 Oxygen value appears 0.03 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

**Station 317**

Cast 1 There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.

134 Sample Log: "Some air in 1st shot MnCl<sub>2</sub>. Tilted bottle for rest of samples." Bottle O<sub>2</sub> looks okay compared to CTDO. Is in high gradient level.

132 Sample Log: "Lower valve open" Delta-S at 126db is -0.0093. This is in a high gradient area. Bottle O<sub>2</sub> looks okay compared to CTDO. Nutrients also okay. Data are acceptable.

101-136 All bottle salinity values are judged to be 0.003 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 318**

Cast 1 No comments on the Sample Log. There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.

101-136 All bottle salinity values are judged to be 0.003 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 319**

Cast 1 No comments on the Sample Log. There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.

101-136 All bottle salinity values are judged to be 0.002 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 320**

Cast 1 No comments on the Sample Log. There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.

101-136 All bottle salinity values are judged to be 0.003 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 321**

136 Oxygen Analyst's Note: "small bubble." O<sub>2</sub> value appears 0.15 ml/l high compared to adjacent stations and CTD o<sub>2</sub> value. Footnote oxygen questionable.

- 135 Oxygen Analyst's Note: "small bubble." O2 value appears 0.2 ml/l high compared to adjacent stations and CTD o2 value. Footnote oxygen questionable.
- 116 Oxygen value appears 0.02 ml/l low compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.
- 109 Sample log: "Air vent open." Delta-S at 3546db -0.0006. Other water samples also look okay. SiO3 max. Data are acceptable.

**Station 322**

- Cast 1 There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.
- 126 Salinity: "No water in bottle." No comment regarding a problem on Sample Log. Other salinity samples agree with CTD. This appears to be a sampling error. Footnote salinity not drawn.
- 101-136 All bottle salinity values are judged to be 0.003 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 323**

- Cast 1 No comments on the Sample Log.
- 106 Delta-S at 4007db is 0.0075. Four Autosal runs to get agreement. Second accepted run higher than first. Other water samples okay. No notes. Possible salt crystal contamination when cap removed. Footnote Salinity bad.
- 102 Oxygen value appears 0.02 ml/l low compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

**Station 324**

- Cast 1 Sample Log: "15 Sub stands drawn from 5 for Autosal check."
- 136 Oxygen value appears 0.20 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.
- 120 Delta-S at 1112db is 0.0064. Autosal diagnostics do not indicate a problem. Salinity is lower than adjoining stations. Footnote salinity questionable.
- 112 Salinity is ~0.0015 high compared with CTD for the station. Three Autosal runs for agreement. Second run higher than first, possible contamination when cap opened. Value is 0.0005 lower than level above so also possible duplicate draw from 13. Other water samples okay. Delta-S at 2629db is 0.0015. This is within WOCE specs, salinity is acceptable.
- 107 Delta-S at 3798db is -0.0022. Autosal diagnostics do not indicate a problem. Salinity is lower than adjoining stations. Footnote salinity questionable.

**Station 325**

- Cast 1 No comments on the Sample Log.

**Station 326**

- Cast 1 There appears to be a problem with the deep salinity samples. There is no obvious problem with the run, but the shipboard processor suspects a problem with the autosal. All salinity values are flagged as questionable.
- 136 Sample Log: "No water for salt and Barium." Footnote Salinity not drawn.
- 119-124 Footnote CTD oxy questionable. See 118 comment.
- 118 CTDO Processor: "CTD oxy signal unusually noisy." Footnote CTD oxy questionable.
- 112 Sample Log: "Water leaking when Barium was sampled." Delta-S at 2679db is 0.0002. Other water samples also okay.

102 Oxygen value appears 0.025 ml/l low compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

101-136 All bottle salinity values are judged to be 0.002 psu low, probably due to autosal problems. Footnote all bottle salinities questionable unless otherwise noted.

**Station 327**

Cast 1 No comments on the Sample Log.

124-125 Footnote CTD oxy questionable. See 120 comment.

120 CTDO Processor: "CTD oxy signal unusually noisy." Footnote CTD oxy questionable.

102 Delta-S at 5186db is -0.0021. Autosal diagnostics do not indicate a problem. Salinity is lower than adjacent stations. Footnote salinity questionable.

**Station 328**

134-136 CTD OXY processor: "CTDOxy sensor not stabilized before cast in water." Footnote CTD oxy questionable.

118 Sample Log: "Bottom end cap leaking after air vent open. Reseated, okay." Delta-S at 1615db is 0.0015. Other water samples also okay.

107 NO3 0.2 low at 3948db. Other nutrients, oxy & salt okay. Good peak but definitely low. Brown tube also 0.2 low on Station 331. NO3 definitely low this level starting Station 332. NO3 this level this station could be real. See Station 331 comment. Footnote Nitrate questionable.

104 Oxygen value appears 0.02 ml/l low compared to adjacent stations when compared to potential temp. Also off compared to CTD oxy values. Footnote oxygen questionable.

102 Oxygen value appears 0.02 ml/l low compared to adjacent stations when compared to potential temp. Also off compared to CTD oxy values. Footnote oxygen questionable.

**Station 329**

131 Salinity data sheet: "Salt bottle 31 broken while running salts." No bottle salinity. Footnote Salinity lost.

123 Sample Log: "Bottom endcap leaks after air vent open." Reseated, okay. Salinity agrees with CTD. Other water samples also okay.

101-107 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 330**

Cast 1 No comments on the Sample Log.

101-123 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 331**

Cast 1 No comments on the Sample Log.

107 NO3 0.1 low at 3828db. Brown tube also low as on Station 328. However, subsequent stations show definite NO3 lowering this level, so NO3 this level this station could be real. Hint of lowering this level on Stations 329 & 330 so 328 value could also be good. Footnote Nitrate questionable.

106-107 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 332**

- 135-136 CTDO Processor: "CTDOXY fit low near surface: low raw oxy signal. Footnote CTD oxy questionable.
- 134 Salt data sheet: "34 bottle slipped out & broke, no sample." Footnote Salinity lost.
- 128 Sample Log: "Dripping from spout after sample drawn." Replaced water valve o-ring after sampling. Delta-S at 286db is 0.001. Other data look reasonable in area of high gradients and inversions. Bottle O2 & S match CTDO & CTD S.
- 108-114 CTDO Processor: "CTDoxy off from bottles > 0.02 ml/l; suspect sensor problem.
- 101-107 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 333**

- 135-136 CTDO Processor: "CTDOXY fit low near surface: low raw oxy signal. Footnote CTD oxy questionable.
- 128 Sample Log: "Still drips from spigot after sampling." Changed middle o-ring on spigot. Delta-S at 328db is 0.0128. High gradients and inversions in all properties this level, but bottle oxygen and salts follow CTD trace so data look okay.
- 101-105 CTDO Processor: "CTD oxy off from bottles > 0.02 ml/l." Footnote CTD oxy questionable.

**Station 334**

- Cast 1 No comments on the Sample Log.
- 126 PO4 0.7 high. NO3 10 high. SiO3 30 high. All nutrients same value as 25 below. Other water samples okay. Assume duplicate draw from 25. Footnote nutrients bad.
- 107-109 CTDO Processor: "CTD oxy off from bottles > 0.02 ml/l. Suspect sensor problem." Footnote CTD oxy questionable.
- 102-105 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 335**

- Cast 1 No comments on the Sample Log.
- 107-109 CTDO Processor: "CTD oxy off from bottles > 0.02 ml/l. Suspect sensor problem." Footnote CTD oxy questionable.
- 102-105 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 336**

- 122 Sample Log: "Water leak - air vent" Is this air leak? -Yes per JW. Delta-S is 0.0002 at 988db. Other water samples also look okay.
- 118 Delta-S at 1618db is 0.0091. All water samples indicate 18 closed about 4000db. Footnote bottle leaking, samples bad. Exact pressure that bottle tripped at cannot be determined.
- 105-112 CTDO Processor: "CTD oxy off from bottles > 0.02 ml/l. Suspect sensor problem." Footnote CTD oxy questionable.
- 101-104 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 337**

- Cast 1 No comments on the Sample Log.
- 115 Nutrient sample inadvertently not run. Footnote nutrients lost.

101-111 CTDO Processor: "CTD oxy off from bottles > 0.02 ml/l. Suspect sensor problem." Footnote CTDO oxy questionable.

**Station 338**

Cast 1 No comments on the Sample Log.

**Station 339**

Cast 1 No comments on the Sample Log.

114 Delta-S at 2327db is 0.0021. Autosal diagnostics indicate 5 tries to get a good reading, indicating a problem with the samples. Footnote salinity questionable.

**Station 340**

Cast 1 No comments on the Sample Log.

101-123 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 341**

133 Delta-S at 127db is 0.0773. All bottle values wildly off from adjacent stations. No reason readily apparent. Footnote bottle leaking samples bad.

130 All bottle values wildly off from adjacent stations. No reason readily apparent. Footnote bottle leaking samples bad.

121 Sample Log: "Air leak, vent not tight." Delta-S is 0.0007 at 990db. Other water samples also okay.

106-107 CTDO Processor: "CTD oxy signal unusually noisy." Footnote CTDO oxy questionable.

103-104 CTDO Processor: "CTD oxy signal unusually noisy." Footnote CTDO oxy questionable.

**Station 342**

112 Sample Log: "Leaking at bottom end cap after air vent open." Reseated, okay. Delta-S at 2431db is 0.0027. Other water samples also okay. Lower than Station 340, higher than 343 and 344, agrees with 341. Footnote salinity questionable.

107 Delta-S at 3703db is 0.0022. Autosal diagnostics do not indicate a problem. High compared with adjacent stations, except agrees with 341. Footnote salinity questionable.

**Station 343**

135 Sample Log: "Air leak." Delta-S at 45db is 0.0275. High gradient area. Other water samples also look okay.

124-125 Sample Log: "Tripped at same depth."

**Station 344**

110-111 Oxygen: "Out of order." Analyst resolved any problem this may have caused. Used flask and bottle number as recorded on sample log. Oxygen is acceptable.

**Station 345**

136 Oxygen Analyst's note: "big bubba". Oxygen value appears 0.30 ml/l off compared to adjacent stations and CTDO oxy values. Footnote oxygen bad.

126 Sample Log: "Flask 635 (26) broke during 2nd shake. No oxygen sample 26." Footnote O2 lost.

122 Sample Log: "Leaking from bottom end cap after air vent opened. Reseated, okay." Delta-S at 888db is 0.0037. Other water samples also look okay.

105-106 Sample Log: "Nuts: water emptied." Not sure what the comment on the sample log refers to, all samples were collected.



101 Oxygen value appears 0.02 ml/l low compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

**Station 346**

113 Delta-S at 2529db is 0.0022. Autosal diagnostics do not indicate a problem. Salinity agrees with Station 345 both are lower than Station 344 and higher than 347. Footnote salinity questionable.

103 Sample Log: "Leaks on bottom end cap after air vent open. Reseated, okay." Delta-S is 0.0013 at 4569db. Other water samples also okay.

**Station 347**

113 Sample Log: "Water leak - air vent." Assume air leak. Delta-S is 0.0002 at 2349db. Other water samples also okay.

**Station 348**

Cast 1 No comments on the Sample Log.

**Station 349**

Cast 1 No comments on the Sample Log.

105-106 CTDO Processor: "CTDO signal unusually noisy, despiked raw CTDO, backup ctdoxy sensor used, data okay unless otherwise indicated. Code CTDO despiked."

**Station 350**

Cast 1 No comments on the Sample Log.

116 Delta-S at 1717db is -0.0054. Down CTD T not same as up T. Other water samples okay. Salinity: "Bottle less than half full." Footnote salinity bad.

113 Delta-S at 2223db is 0.0021. Autosal diagnostics do not indicate a problem. Salinity is higher than adjacent stations. Footnote salinity questionable.

111 Delta-S at 2631db is 0.0021. Autosal diagnostics do not indicate a problem. Salinity agrees with adjacent stations. Stations 349 and 351 did not sample at this level, but Station 352 does have sampling at this level. Footnote salinity questionable.

110 Trip problem starting 9 level. Two sets of CTD trip data at 3036db, but data indicate only one bottle tripped this level. Corrected trip information file. Autosal runs okay. Other water samples okay. Delta-S at 2833db is 0.0021. Salinity agrees with Station 352, both are slightly higher than 351 and ~0.002 higher than 348. Footnote salinity questionable.

101 Delta-S at 4716db is 0.0037. 3 Autosal runs to get agreement, otherwise Autosal run okay, no notes. Other water samples okay. Salinity also higher than adjacent stations. Footnote salinity bad.

**Station 351**

111 Sample Log: "1182 was 1/2 empty. Small crack at bottom of o2 flask. Replaced by spare flask 641." Footnote O2 lost.

110 O2 appears 0.08 high at 2935db. Calc okay. Low detector voltage but not enough to cause this difference. Other water samples okay. Footnote O2 questionable.

**Station 352**

126 Sample Log: "Water leak." Delta-S at 438db is -0.009 in high gradient. Other water samples also okay.

**Station 353**

Cast 1 No comments on the Sample Log.

136 CTDO Processor: "CTDOXY fit high near surface: high raw oxy signal. Footnote CTD oxy questionable.

109 Delta-S at 2935db is 0.0026. Five Autosol runs to get agreement. 2nd accepted run 0.00004 2CR higher than 1st. Assume salt crystal from cap contaminated sample. Other water samples okay. Operator said salt bottle was chipped. Footnote Salinity bad.

**Station 354**

Cast 1 Deep salinities 0.002 high. Autosol drift +0.00009 2CR. Standard dial reading high. Apparently first Wormley reading a little off. Corrected data by subtracting 0.00009 for the data values and assuming no drift. Salinity are acceptable after data corrected.

134 Sample Log: "Air vent loose." Delta-S at 52db is -0.0122 in high gradient area. Other water samples also okay.

117 Oxygen value appears 0.2 ml/l high compared to adjacent stations. No apparent reason. Footnote O2 bad.

**Station 355**

Cast 1 No comments on the Sample Log.

104 O2 0.13 high at 3954db. Calc okay, no notes. CTDO down & up traces both smooth. Salinity is acceptable and agrees with CTD and Nutrients look good. Footnote O2 bad.

**Station 356**

Cast 1 No comments on the Sample Log.

**Station 357**

Cast 1 No comments on the Sample Log. There appears to be a problem with the deep salinity samples. Salinity: "At end needed 3 tries to run wormley. Standard dial reading is strange on printout, on machine it read 6338." Even though salinity operator made this comment, ending standard was finally okay and indicated a drift of 0.00004 which if the beginning standard were incorrect would make a difference of < 0.001 in salinity. All salinity values are flagged as questionable.

102-136 Except for NB01, all bottle salinity values are judged to be 0.002 psu low, probably due to autosol problems. A jump in the Autosol standby number is first noted on NB02. NB01 salinity OK, Footnote all other bottle salinities questionable unless otherwise noted.

**Station 358**

109 Sample Log: "Bottom end cap leaking after air vent open. Reseated, okay." Delta-S at 2705db is 0.0023. Other water samples okay. Out of WOCE specs, footnote salinity questionable.

107 Delta-S at 3113db is 0.0028. Autosol diagnostics do not indicate a problem. Out of WOCE specs, footnote salinity questionable.

**Station 359**

Cast 1 No comments on the Sample Log.

**Station 360**

125 Sample Log: "Exceptionally cold - major discovery of I8N." Delta-S at 709db is 0.068. All water samples indicate 25 closed at about 4000db. Footnote bottle leaking and samples bad. Exact pressure that bottle tripped at cannot be determined.

120 Salinity must not have been drawn. No comments made by salinity analyst even though Sample Log indicates it should have been drawn.

**Station 361**

132 Sample Log: "Leaking in bottom end cap after air vent open. Reseated, okay." Delta-S at 137db is -0.003. Other water samples also okay.

109 Oxygen value appears 0.05 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

101 CTDO Processor: "CTD oxy off from bottle > 0.02 ml/l. Spike in signal." Footnote CTD oxy questionable.

**Station 362**

118 Sample Log: "Bottom end cap leaking after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Nutrient also look okay. Oxygen appears 0.05 high, same value as 17. CTDO shows slight feature here but possible duplicate oxy draw from 17. Footnote O2 questionable.

105 Delta-S at 3853db is 0.0049. Same value as 27. Possible duplicate draw. Other water samples okay. Footnote salinity bad.

101 O2 appears 0.06 high at 4740db. Titration okay. No change at bottom in other parameters. No notes. Footnote O2 questionable.

**Station 363**

Cast 1 No comments on the Sample Log.

135 Sample drawn okay per Sample log but not analyzed. Oxygen analyst not sure what happened. Footnote O2 lost.

116 Salinity: "Loose thimble." Delta-S at 1716db is 0.0024. This is high. Footnote salinity questionable.

**Station 364**

Cast 1 No comments on the Sample Log.

123 Salinity: "Loose thimble." Salinity is ~0.003 high. This is usable so do not code.

106 Oxygen value appears 0.10 ml/l off compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

**Station 365**

128 Delta-S at 357db is -0.1059. CTD has normal salinity gradient. Other water samples okay. Autosal run okay. Same value as 27 at level below. Assume duplicate draw. Footnote Salinity bad.

126 Sample Log: "Air leak - minor." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 366**

109 Sample Log: "Leaking from bottom end cap after air vent open." Delta-S at 1009db is 0.0018. Other water samples also okay.

**Station 367**

109 Sample Log: "Leaked in bottom end cap after air vent open." Delta-S at 658db is 0.0034. Other water samples also look okay.

**Station 368**

Cast 1 No comments on the Sample Log.

**Station 369**

Cast 1 No comments on the Sample Log.

**Station 370**

Cast 1 No comments on the Sample Log.

**Station 371**

118 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 372**

Cast 1 No comments on the Sample Log.

102 Oxygen value appears 0.04 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

**Station 373**

115 Sample Log: "Dripping from bottom end cap after air vent open." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 374**

120 Salinity: "Bad cap." Salinity does appears slightly high compared with CTD, but agrees with adjacent stations. Salinity is acceptable.

112 Sample Log: "Air Leak. Air vent closed." Salinity agrees with CTD and station profile. Other water samples also okay.

109 Sample Log: "Leaking from bottom end cap. Reseated, okay." Delta-S at 960db is 0.0032. This is a little high, but acceptable for shallower water salinity. Other water samples also look okay.

108 Sample Log: "Air Leak. Air vent closed." Delta-S at 1061db is 0.0026. This is a little high, but acceptable for shallower water salinity. Other water samples also look reasonable.

102 Salinity: "Bad cap." Salinity is acceptable.

**Station 375**

Cast 1 No comments on the Sample Log.

**Station 376**

Cast 1 Sample Log: "CO2 tried to sample more than they wanted - gave up."

**Station 377**

115 Sample Log: "Water leak." Where the leak occurred on the bottle was not recorded. Salinity agrees with CTD and station profile. Other water samples also okay.

110-117 Sample Log: "Had air bubble appear in NaOH dispenser. I think most were okay." All bottle oxygens look good compared CTDO and adjacent stations. O2 is acceptable.

**Station 378**

126 Sample Log: "Air leak." Salinity is acceptable. Other water samples also look okay.

125 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also look okay.

116 Delta-S at 1616db is 0.0217. Autosol run okay. T, S & O2 inversions this area, but down & up CTD S traces show nothing this large. No notes. Footnote salinity questionable.

106 O2 appears 0.1 high at 3038db. CTDO has smooth gradient down & up. No notes. Other water samples okay. Footnote O2 bad.

**Station 379**

127 Sample Log: "Leaking from bottom end cap, reseated, okay." Salinity: "Loose cap." Salinity agrees with CTD and station profile. Other water samples also okay.

126 Sample Log: "Air leak w/ vent closed. Reseated top end cap, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

- 125 Sample Log: "Leaking from bottom end cap." Salinity agrees with CTD and station profile. Other water samples also okay.
- 109 Sample Log: "Leaking from end cap (bottom)." Salinity agrees with CTD and station profile. Other water samples also look okay.
- 104 Sample Log: "Dripping from end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also look okay.
- 101 Oxygen value appears 0.03 ml/l low compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.
- Station 380**
- 131 Delta-S at 126db is -0.0331. Autosal diagnostics do not indicate a problem. Variation in the CTD at the bottle trip. Salinity is acceptable.
- 115 Sample Log: "Leaking from bottom end cap. Grooved bottom." Salinity agrees with CTD and station profile. Other water samples also okay.
- Station 381**
- Cast 1 No comments on the Sample Log.
- Station 382**
- Cast 1 No comments on the Sample Log.
- Station 383**
- 135-136 CTDO Processor: "CTDOXY fit high near surface: high raw oxy signal. Code CTDO despiked."
- 112 Sample Log: "Water leak." Delta-S at 1870db is 0.0046. Four Autosal runs to get agreement, accepted values differ by 0.00004 2CR. Other water samples look okay. Salinity: "Erratic, caps okay, bottle neck okay." Footnote salinity bad.
- Station 384**
- Cast 1 Sample Log: "Batch sample taken." Not certain what the note on the sample log refers to.
- 115 Sample Log: "Leaking from bottom end cap after air vent open." Delta-S is 0.0007 at 1615db. Other water samples also look okay.
- Station 385**
- 128 Sample Log: "Bottom leaks when air vent open. Still drips." Salinity agrees with CTD and station profile. Other water samples also look okay.
- Station 386**
- 130 Delta-S at 216db is 0.0452. Autosal diagnostics do not indicate a problem. Gradient area, lots of variation in the CTD profile while stopped at this level to trip the bottle. Salinity is acceptable.
- 122 Sample Log: "Air leak - Air vent not closed." Delta-S at 880db is 0.0058. Variation between the CTD down and up trace, as well as at the time of the bottle trip. Other water samples look okay.
- 104 O2 appears 0.04 high at 3803db. Titration okay, no notes. CTDO up & down traces smooth this area. Footnote O2 questionable.
- Station 387**
- Cast 1 Sample Log: "24 bottles used for this cast."
- 109 Titration error. Sample lost. Footnote O2 lost.
- 105 Delta-S at 1465db is -0.0861. Appears to be duplicate draw of 106. Footnote salinity bad.

**Station 388**

117 Sample Log: "Dripping from bottom after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 389**

Cast 1 Autosal Standard dial low, drift +0.002 PSU, indicating problem with initial standard. Initial standard not confirmed with 2nd vial. Corrected data by adding 0.00011 for the data values and assuming no drift. Salinity is a little high (0.001) after correction, but acceptable.

136 Sample log indicates drawn okay, but not run. Salt bottle broken. Footnote Salinity lost.

126 Sample Log: "Air leak." Reseated top end cap, okay. Salinity agrees with CTD and station profile. Other water samples also okay.

125 Sample Log: "Dripping from bottom end cap. Reseated okay." Delta-S at 657db is 0.005. Salinity is acceptable. Other water samples also okay.

115 Sample Log: "Dripping from bottom end cap." Delta-S at 1972db is 0.0014. Other water samples also okay.

113 NO<sub>3</sub> appears 0.3 low at 2276db. Peak good but definitely low. PO<sub>4</sub> & other water samples okay. Footnote Nitrate questionable.

101 NO<sub>3</sub> appears 0.3 low at 4227db. Peak good but definitely low. PO<sub>4</sub> 0.01 low, other water samples same as level above. Footnote Nitrate questionable.

**Station 390**

Cast 1 No comments on the Sample Log.

134 Delta-S at 56db is 0.0403. Autosal diagnostics do not indicate a problem. Variation in CTD trace at stop for bottle trip. Salinity is acceptable.

125 Delta-S at 509db is 0.0105. Autosal diagnostics do not indicate a problem. Variation in CTD trace at stop for bottle trip. Salinity is acceptable.

**Station 391**

Cast 1 No comments on the Sample Log.

**Station 392**

117 O<sub>2</sub> appears 0.1 ml/L high at 808db. Titration okay. No notes. Other water samples okay. Smooth down & up CTDO trace. Corrected oxygen flask number from 1117 to 1177. Data now agrees with CTDO, lower than adjoining stations, but probably okay.

115 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 393**

Cast 1 No comments on the Sample Log.

**Station 394**

Cast 1 No comments on the Sample Log.

**Station 395**

117 Delta-S at 49db is 0.0345. Autosal diagnostics do not indicate a problem. Variation in CTD trace, indicating changing water mass. Salinity is acceptable.

115 Sample Log: "Leaking from bottom end cap."(after air vent open. Reseated, okay) Salinity agrees with CTD and station profile. Other water samples also okay.

110 Sample Log: "Leaking from bottom end cap."(after air vent open. Reseated, okay) Salinity agrees with CTD and station profile. Other water samples also okay.

104 Delta-S at 919db is 0.0135. Autosal run okay. Smooth CTD down trace but spike at this level in S & T on up trace. Assume CTD salinity is the problem. Footnote CTD Salinity questionable. No CTDO is calculated because the CTD Salinity is coded questionable.

103 Sample Log: "Leaking badly from bottom end cap." (after air vent open/dm) "Reseated, okay." Delta-S at 1009db is 0.0015. Other water samples also look okay.

**Station 396**

119 Sample Log: "Open air vent." Salinity agrees with CTD and station profile. Oxygen and nutrients all have mixed layer values while Temp and CTD S show start of thermocline. Since bottles are higher than CTD they could be okay. CTD up trace has spikes this level, water samples do appear to be in mixed layer.

**Station 397**

124-126 CTDO Processor: "CTDOXY fit low near surface: low raw oxy signal. Code CTDO despiked."

115 Sample Log: "Bottom end cap leaking." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 398**

109 Sample Log: "Air vent open." Salinity agrees with CTD and station profile. Other water samples also okay.

107 Sample Log: "Air vent open." Salinity is a little high, 0.001, but acceptable. Other water samples also okay.

**Station 399**

135-136 CTDO Processor: "CTDOXY fit high near surface: high raw oxy signal. Code CTDO despiked."

134 Delta-S at 50db is -0.0504. Gradient and "spike" in CTD trace. Footnote CTD salinity questionable. No CTDO is calculated because the CTD Salinity is coded questionable.

115 Sample Log: "Leaking from bottom end cap after air vent open." Delta-S at 1564db is 0.0034. Small T & S features this level. Other water samples look okay. There is a gradient, salinity agrees with adjacent stations.

**Station 400**

133 Sample Log: "Bottle emptied after Rolf(CO2) left hose running. No salt or Barium taken." Footnote Salinity not drawn.

132 PO4 appears 0.1 high at 137db. Peak good but definitely high. NO3 and other water samples okay. Footnote Phosphate questionable.

126 Sample Log: "Leaking from spigot - stopped with top cap reseated." Delta-S at 508db is 0.0049. Other water samples also okay.

122 Sample Log: "Leaking on bottom after air vent open." Delta-S at 911db is -0.0003. Other water samples also okay.

115 Sample Log: "Leaking from bottom end cap (after air vent opened/dm) reseated, leak stopped." Delta-S at 1756db is 0.0008. Other water samples also okay.

113 Sample Log: "Top vent open." Delta-S at 2063db is 0.001. Other water samples also okay.

110 Sample Log: "Leaking from bottom end cap (after air vent opened) reseated, leak stopped." Delta-S at 2520db is 0.001. Other water samples also look okay.

102 Sample Log: "Leaker from spigot. Air leak. Reseated top cap." Delta-S at 4042db is -0.0002. O2 as well as other water samples also okay.

**Station 401**

Cast 1 No comments on the Sample Log.

**Station 402**

126 Sample Log: "Air leak, no freon sample drawn." Salinity agrees with CTD and station profile. Other water samples also okay.

125-131 CTD OXY processor: "CTD oxy low compared to bottles, especially 150 - 550db. CTD oxy matches 4 nearest casts, no obvious problem with bottle oxygens. Footnote CTD oxy and bottle oxy OK.

**Station 403**

126 Sample Log: "Air leak. Reseated top cap, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

125 Sample Log: "Pin hole leak from bottom end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

123 Sample Log: "Big leak bottom end cap, reseated fine." Delta-S at 779db is 0.0489. Autosol run okay. Smooth down & up CTD S trace. Other water samples okay, oxygen agrees well with CTDO and Nutrients have normal gradient. Footnote Salinity bad.

103 Sample Log: "Leaking from bottom end cap after air vent open. Reseated, okay." Delta-S at 4056db is 0.0003. Other water samples also okay.

**Station 404**

125 Sample Log: "Empty, bottom end cap hung up on pinger." Tripped in air during recovery. Footnote samples not drawn.

**Station 405**

136 Sample Log: "No water - tripped above the water surface." Footnote samples not drawn. half-out-of-water. Footnote CTD Salinity bad. No CTDO is calculated because the CTD Salinity is coded bad.

102 Delta-S at 4156db is 0.0009. Autosol run okay. Same value as 2 & 3 at levels above. (2CR 0.00000 diff 1 & 0.00001 diff 3) Adjacent stations and CTD S show slight decrease in salinity at bottom. Salinity is acceptable. O2 appears 0.01 high. No apparent relation to salinity problem. Titration okay. O2 is acceptable.

**Station 406**

133 Sample Log: "No water in tube 33 for nutrient. Took nutrient samples from salt bottle 33. 950406/1700Z." Delta-S is -0.0014 at 98db. Salinity is acceptable. Nutrients are acceptable.

127 No oxygen sample from 27. Footnote O2 not drawn.

121-126 Sample Log: "O2: 121-127 are really 120-126 (off by one bottle)." Corrected during shipboard analysis. O2 is acceptable.

106 Delta-S at 3548db is 0.0121. Autosol run okay. Same value as 8, possible duplicate draw. Other water samples okay. Footnote Salinity bad.

**Station 407**

136 Sample Log: "Air leak. Top cap reseated, okay." Surface sample.

135 Sample Log: "Leaking from bottom end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay, in mixed-layer.

129 Sample Log: "Leaking from bottom end cap. Reseated, okay." (after air vent opened). Salinity agrees with CTD and station profile. Other water samples also okay.



126 Sample Log: "Air leak. Top cap reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

117 Sample Log: "Nuts: off one at 17 so went back to 12 to redraw."

101-111 PO4 rerun values 0.01 to 0.02 low. Footnote PO4 lost. Used NO3 reruns per nutrient analyst on all but 112. Nitrate is acceptable. Nitrite is acceptable. All silicates 2 to 3 UM/L high. Bubble in flow cell during rerun? Footnote Silicate lost.

**Station 408**

Cast 1 Sample log: "What bottle did retrieval hook catch?" No problems apparent.

101 CTD oxy processor: "Small rise in ctdoxy near bottom." Footnote CTD oxy questionable.

**Station 409**

126 Sample Log: "Air-vent leak." Salinity agrees with CTD and station profile. Other water samples okay.

123 Delta-S at 814db is 0.1185. Smooth CTD S gradient. Autosol run okay. Same value as 24. Probable duplicate draw or run. Other water samples okay. Footnote Salinity bad.

109 Delta-S at 2885db is -0.0065. Smooth CTD S gradient. Autosol run okay. Same value as 8. Probable duplicate draw or run. Other water samples okay. Footnote Salinity bad.

**Station 410**

Cast 1 No comments on the Sample Log. Standard dial was set low due to bad first standard. All conductivities ratios were offset by 0.00013. Salinities are acceptable after correction.

**Station 411**

Cast 1 No comments on the Sample Log.

132 Delta-S at 148db is 0.1559. All water samples same as 33 values indicating 32 closed at 88db. CTD trip data looks good. Probably lanyard hangup. Footnote bottle leaking and samples bad.

**Station 412**

129 Sample Log: "Lower end cap leaking." Salinity agrees with CTD and station profile. Other water samples also look okay.

124 Sample Log: "Lower end cap hung up on pinger, no samples." Footnote samples not drawn.

118 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also look okay.

101 Delta-S at 4737 db is 0.0018. Autosol run okay. Oxygen low but nutrients look okay. No notes. Smooth CTD S trace down & up. Salinity is acceptable. O2 appears 0.04 low at 4738db. Titration okay. Salinity high but nutrients look okay. No notes. Some indication of oxygen drop at bottom of CTDO trace but also looks like slowing to stop. Footnote O2 questionable.

**Station 413**

Cast 1 No comments on the Sample Log.

136 Oxygen value appears 0.10 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

108 O2 appears 0.08 high. Titration okay. No notes. Other water samples okay. Normal CTDO gradient. Footnote O2 questionable.

105 NO3 appears 0.2 low. Peak good but definitely low. Slight glitch in PO4 peak but PO4 value looks okay. SiO3 okay. Air bubble in NO2 between 106 & 105. Footnote Nitrate questionable.

**Station 414**

- 131 Draw temp recorded on Sample log as 4.0 at 156db. Data look okay. Assume draw temp was 14.0 not 4.0. O2 is acceptable.
- 129 Sample Log: "Leak from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay."
- 115 PO4 appears 0.04 high at 1707db. Other nutrients okay. Peak good but definitely high. No notes. Footnote Phosphate questionable.
- 112 Sample Log: "Air leak. Reseated top cap, okay." Salinity agrees with CTD and station profile. Other water samples also okay.
- 111-114 Footnote CTD oxy questionable. See 110 comment.
- 110 Sample Log: "Leak from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay. CTD oxy processor: "CTD oxy low relative to bottle data, but OK compared to nearby CTD oxy data. Code questionable where > 0.02 ml/l off from bottles. Data may be OK.

**Station 415**

- 126 Sample Log: "Air leak. Top end cap. Reseated, okay." Delta-S at 69db is -0.0261. High gradient area (start of thermocline). Other water samples also okay.
- 125 Sample Log: "Drip from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.
- 122 Sample Log: "Drip from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.
- 105 Sample Log: "Leak from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 416**

- Cast 1 No comments on the Sample Log.
- 122 Delta-S at 79db is -0.0309. Variation in CTD trace at stop for bottle trip. Salinity is acceptable.
- 118 Salinity: "First average very noisy. Difficult box to run, no station card. Ran end wormley as 26." Salinity value OK.
- 116 Salinity: "First average very noisy. Difficult box to run, no station card. Ran end wormley as 26." Salinity value OK.
- 113 Salinity: "First average very noisy. Difficult box to run, no station card. Ran end wormley as 26." Salinity value OK.

**Station 417**

- 118 Sample Log: "Air leak." Delta-S at 205db is 0.0116. High gradient area. Other water samples also okay.

**Station 418**

- Cast 1 No comments on the Sample Log.
- 119 Oxygen and nutrients indicate bottle closed deeper than intended. Delta-S at 558db is -0.0855. Footnote bottle leaking and samples bad.

**Station 419**

- 135 Delta-S at 42db is -0.0799. Variation in CTD at stop for bottle trip. Salinity is acceptable.
- 133 NO3 appears 3.0 high. PO4 appears 0.2 high. SiO3 appears 0.1 high. NO2 appears 0.1 high. All nutrients same value as 32. Probable duplicate draw. Footnote nutrients bad. Corrected oxygen flask number from 1193 to 1196. O2 is acceptable.

- 132 Delta-S at 158db is 0.1421. Same value as 33 salinity. Other water samples look okay. Footnote Salinity bad.
- 124-128 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also okay.
- 112 Sample Log: "Air leak (minor)." Salinity agrees with CTD and station profile. Other water samples also okay.
- 106 Delta-S at 4161db is 0.0024. Five Autosol runs to get agreement. Same value as 7 salinity. Either contaminated run or duplicate draw. Other water samples okay. Footnote Salinity bad.
- 103 Delta-S at 4776db is -0.0024. Autosol diagnostics do not indicate a problem. Salinity lower than adjacent stations. Out of WOCE specs. Footnote salinity questionable.

**Station 420**

- 108-136 No trips after NB7 at 4000m. Problem traced to short in sea cable. CTD data and NB1-NB7 okay. Switched to other winch and repeated complete cast as Cast 2. Footnote samples not drawn. CTD oxy processor: "Used cast 2 bottles to fit CTD oxy above 4050db.
- 234 Sample Log: "Air leak." Delta-S at 67db is -0.0854. High gradient area. Autosol run okay. Other water samples okay (oxygen max.)
- 209 O2 appears 0.06 high at 3649db. Titration has low end voltage (0.971) but otherwise okay. Unable to improve with o2chk. Other water samples look okay. Possible duplicate draw from 8. Footnote O2 questionable.

**Station 421**

- Cast 1 No comments on the Sample Log.
- 134 Delta-S at 58db is 0.0376. Variation in CTD at stop for bottle trip. Salinity is acceptable.

**Station 422**

- Cast 1 No comments on the Sample Log.

**Station 423**

- 135-136 CTDO Processor: "CTDOXY fit high near surface, then jagged to top of thermocline. Footnote CTD oxy questionable.
- 129 Sample Log: "Leaking from bottom end cap(after air vent open)." Salinity agrees with CTD and station profile. Other water samples also okay.
- 108 Oxygen value appears 0.05 ml/l low compared to adjacent stations and CTD oxy values. Oxygen value within 0.004 ml/l of NB09, could be double draw. Footnote oxygen questionable.
- 101 Unlikely 0.001 PSU CTD diff. Three Autosol runs for agreement. Accepted readings exactly the same. Other water samples look okay. Salinity is acceptable.

**Station 424**

- 127 Sample Log: "Dripping from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also look okay.

**Station 425**

- Cast 1 No comments on the Sample Log.
- 133 Delta-S at 88db is -0.0617. Autosol diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is acceptable.
- 109 Delta-S at 3342db is 0.0031. Four Autosol runs to get agreement. Other water samples okay. Possible salt crystal contamination from cap. Footnote Salinity questionable.

**Station 426**

- 122 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also okay.
- 104 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 427**

- 135 Delta-S at 33db is -0.041. Autosal diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is acceptable.
- 134 Delta-S at 63db is 0.0498. Autosal diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is acceptable.
- 127 Sample Log: "Leak from bottom end cap. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 428**

- 132 Delta-S at 159db is 0.028. Autosal diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is acceptable.
- 118 Sample Log: "Leak from bottom end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile Other water samples also okay.
- 104 Delta-S at 4569 is 0.0013. Autosal run okay. Other water samples look okay. Salinity is acceptable.

**Station 429**

- Cast 1 No comments on the Sample Log.
- 136 CTDO Processor: "CTDOXY fit low near surface: low raw oxy signal. CTD oxy off from bottle values in top 180db but matches nearby casts below 16db." Footnote CTD oxy questionable 0 - 16 db.
- 134 Delta-S at 83db is -0.029. Autosal diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is higher than adjacent stations, both bottle and CTD. Salinity profile looks reasonable. Salinity is acceptable.
- 110 Delta-S at 3144db is -0.0025. Autosal diagnostics do not indicate a problem. Salinity low compared with adjacent stations. Out of WOCE specs. Footnote salinity questionable.
- 109 Delta-S at 3347db is -0.0022. Autosal diagnostics do not indicate a problem. Salinity slightly low compared with adjacent stations. Out of WOCE specs. Footnote salinity questionable.

**Station 430**

- 136 Oxygen analyst note: "bubble 3/8". Oxygen value appears 0.05 ml/l off compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.
- 134 Delta-S at 69db is 0.0507. Autosal diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is acceptable.
- 122 Sample Log: "Air leak upper end cap." Salinity agrees with CTD and station profile. Other water samples also okay.
- 121 Sample Log: "No water after Alk." Double draws on helium and tritium with CO2s and freon. Footnote nutrient and salinity samples not drawn.
- 107 Sample Log: "Air leak upper end cap - lanyard from 6." Oxygen looks okay, but nutrients low. Delta-S at 3753db is 0.1238. CO2s drawn between oxygen and nutrient so water leaked on top not mixed down to bottom when oxygen drawn. Footnote bottle leaking, samples bad.
- 101 Oxygen value appears 0.04 ml/l high compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

**Station 431**

117 Sample Log: "Leak bottom end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also look okay.

115 Sample Log: "Leak bottom end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also look okay.

**Station 432**

128 Nutrients and oxygen indicate bottle closed early. Delta-S at 358db is -0.1006. Footnote bottle leaking, and samples bad.

115 Sample Log: "Leak bottom end cap after air vent open." Salinity agrees with CTD and station profile. Other water samples also okay.

108 O2 appears 0.03 high. Slight bump in Down & Up CTDO here but not this much. Silicate also has slight bump. PO4 & NO3 same as adjacent levels. Salinity agrees with CTD and station profile. Footnote O2 questionable.

**Station 433**

136 Sample Log: "Was tripped half in air." Salt & nutrients only. Footnote O2 not drawn.

127 O2 appears 0.27 low. Salinity agrees with CTD and station profile and nutrients also look okay. Titration okay, no notes. Smooth CTDO gradient down & up. Footnote O2 bad.

126 Sample Log: "Air leak." Salinity agrees with CTD and station profile. Other water samples also okay.

123 Sample Log: "Bottom leak." Salinity agrees with CTD and station profile. Other water samples also okay.

103 Sample Log: "Leaking from bottom." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 434**

Cast 1 No comments on the Sample Log.

110 Delta-S at 3093db is -0.0026. Autosal diagnostics do not indicate a problem. Salinity agrees with Station 436. Station 436 is lower than adjacent stations. Not sure what this means. Autosal diagnostics do not indicate a problem with Station 436. Footnote salinity questionable.

102 Delta-S at 4727db is -0.0023. Autosal diagnostics do not indicate a problem. Salinity agrees with previous station. Footnote salinity questionable.

**Station 435**

135 Oxygen value appears 0.03 ml/l off compared to adjacent stations and CTD oxy values. Footnote oxygen questionable.

134 Sample Log: "Air leak, Reseated top cap, okay." Salinity slightly high compared with CTD and station profile. However, within specs of the measurement. Autosal run okay. Fairly high gradient, most salts this area 0.001 to 0.0015 high. Other water samples okay.

132 Salinity must not have been drawn. No comments made by salinity analyst. Sample Log was not properly filled in with salinity bottle numbers, so that was no help with the problem.

**Station 436**

123 Sample Log: "Leak bottom end cap after air vent open. Reseated, okay." Salinity agrees with CTD and station profile. Other water samples also okay.

115 Sample Log: "Leak bottom end cap after air vent open." Salinity agrees with CTD and station profile. Other water samples also okay.

**Station 437**

119 Delta-S at 256db is 0.0281. Autosal diagnostics do not indicate a problem. Variation in CTD at stop for bottle trip. Salinity is acceptable. Autosal diagnostics do not indicate a problem.

118 Delta-S at 306db is 0.0284. Variation in CTD at stop for bottle trip. Salinity is acceptable.

**Station 438**

117 Delta-S at 136db is -0.0383. Salinity lower than adjacent stations. Footnote salinity questionable.

104 Delta-S at 1146db is -0.0319. Autosal run okay. Other water samples okay. No notes. 0.002 higher than 5 at level above. Possible duplicate draw from 5. See 103. Footnote Salinity bad.

103 Delta-S at 1294db is -0.0643. Five runs to get Autosal agreement. Other water samples okay. No notes. 0.002 higher than 4 at level above 0.004 higher than 5 two levels above. Possible duplicate draw from 5 with salt crystal contamination. Footnote Salinity bad.

102 Delta-S at 1545db is -0.0204. Autosal run okay. Other water samples okay. No notes. Possibly associated with problems on 103 & 104, rinsing?? Footnote Salinity bad.

## **B.6. Preliminary report on lowered and vessel-mounted ADCP measurements**

(May 4, 1995)

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Ocean velocity observations were taken on the WHP Indian Ocean Expedition (line I08N) using two acoustic Doppler current profiler (ADCP) systems and accurate navigation data. The two systems are the hull-mounted ADCP and a lowered ADCP mounted on the rosette with the CTD. The data were taken aboard the R/V KNORR from March 10, 1995 to April 15, 1995 between Colombo, Sri Lanka and Fremantle, Australia. The purpose of the observations was to document the upper ocean horizontal velocity structure along the cruise track, and to measure vertical profiles of the horizontal velocity components at the individual hydrographic stations. The observations provide absolute velocity estimates including the ageostrophic component of the flow.

Figure B.4.1 shows the cruise track and the near surface currents measured by the hull-mounted ADCP for the N/S segment of the cruise. Figures B.4.2 and B.4.3 show the hull-mounted ADCP velocities near the sill at the southern end of the 90E ridge, and the (approximately) E/W section to Fremantle.

### **B.6.1. Hull-mounted ADCP**

The hull-mounted ADCP is part of the ship's equipment aboard the KNORR. The ADCP is a 150 kHz unit manufactured by RD Instruments. The instrument pings about once per second, and for most of the cruise the data were stored as 5-minute averages or ensembles. The user-exit program, ue4, receives and stores the ADCP data along with both the P-code navigation data from the ship's Trimble receiver and the Ashtech gps receiver positions. The P-code data are used as navigation for the ADCP processing. The ship's gyro-compass provides heading information for vector averaging the ADCP data over the ensembles. The user-exit program calculates and stores the heading offset based on the difference between the heading determination from the Ashtech receiver and from the ship gyro. The ADCP transducer is mounted at a depth of about 5 meters below the sea surface.

As setup parameters, we used a blanking interval of 4 meters, a vertical pulse length of 16 meters and a vertical bin size of 8 meters. Data collection during the first 6 days of the cruise used 200s ensembles, and for the remainder of the cruise ensembles were 300s. During testing, 20s ensembles were used.

On the previous leg (I09N) the ADCP signal degraded near the end of the cruise, giving reliable data to only 125m. In order to try to return the signal to a reasonable level prior to the I08N leg, the ADCP was removed from the ship's hull and cleaned on deck and the preamp boards were tested. The ADCP was remounted in the ship's hull in port with the nominal "forward" beam facing nearly due aft (it was previously mounted with the "forward" beam facing 45 degrees starboard of forward). Although the ADCP appeared to be working in port, a bad connection prevented data collection until 3/12 (19:37 Z). After the bad connection was discovered, the cable connecting the RDI acquisition box and the ADCP in the hull was tied in place in an effort to ensure a good connection. Data acquisition proceeded without incident until the end of the cruise, although beam 2 was weaker than 1,3, or 4 for the entire cruise. A significant decrease in signal strength at 13S corresponded to an oxygen and nutrient front and to a simultaneous decrease in return signal from the lowered ADCP.

Final editing and calibration of the ADCP data is not finished. This involves the usual editing of CTD wire interference and the determination of the actual transducer orientation. In addition, the CTD and underway temperature and salinity must be used to correct the speed of sound because the ADCP thermistor was incorrect for much of the cruise. The temperature difference of (ADCP thermistor-CTD) increased approximately linearly from 0 to 8C during the first 28 days, remained at 8C for the next 6 days, and increased again during the last 1.5 days from 8C to 20C. An unusual event in ADCP data acquisition is that during the first week the amplitude of the reference velocity was halved, and then went back to normal. The factor of two is one of two options available in the software, but why the software changed the amplitude has not been determined.

### **B.6.2. Lowered ADCP**

The second ADCP system is the lowered ADCP (LADCP), which was mounted to the rosette system with the CTD. The LADCP yields vertical profiles of horizontal velocity components from near the ocean surface to near the bottom. The first unit used is a broadband, self-contained 150 kHz system manufactured by RD Instruments. We used single ping ensembles. This unit failed after 9 casts, and we switched to the older narrow-band 300kHz system, which averages pings into ensembles prior to data storage. The data from each instrument is transferred to a PC between casts.

With either instrument, vertical shear of horizontal velocity was obtained from each ping (or ensemble). In the BB case, these shear estimates were vertically binned and averaged for each cast. By combining the measured velocity of the ocean with respect to the instrument, the measured vertical shear, and accurate shipboard navigation at the start and end of the station, absolute velocity profiles are obtained (Fisher and Visbeck, 1993). Depth is obtained by integrating the vertical velocity component; a better estimate



of the depth coordinate will be available after final processing of the data together with the CTD profile data. The shipboard processing results in vertical profiles of u and v velocity components, from a depth of 60 meters to near the ocean bottom in 20 meter intervals. The zonal velocity in the section which crossed the equator is shown in Figure B.4.4.

CTD casts were made at stations 279-442 on the I08N cruise. Broad Band LADCP casts were made at stations 279-291. Narrow Band LADCP casts were taken at all CTD stations thereafter except 292-293 (NBLADCP installation), 353-354 (erase EPROMs in NBLADCP, replace internal battery pack with DC-DC power converter to allow use of external battery pack), 405-406 (erase EPROMs), and 421-428 (terminate a break in cable was caused by shorting the battery across the rosette upon deployment at station 405). Deep BBLADCP casts often have noise problems below 3000 meters or so due to poor instrument range and interference from the return of the previous ping. NBLADCP stations occasionally showed data dropout in the bottom 1000m.

### **B.6.3. Navigation**

The ship used a Trimble P-code receiver for navigation, with data coming in at once per second. We have stored this once per second data for the entire cruise, except for two periods (1/2 day and 2 hours) where 1 minute data were substituted. We also decimated this once per second data by a factor of 10 to 10-second intervals and stored these processed files as daily matlab files of latitude, longitude and time.

The Ashtech receiver uses a four antennae array to measure position and attitude. The heading estimate was used with the gyro to provide a heading correction for the ADCP ensembles. The Ashtech data was stored by the ADCP user-exit program along with the ADCP data.

### **B.6.4. ADCP References**

Fisher, J. and M. Visbeck, 1993; Deep velocity profiling with self-contained ADCPs; J. Atmos. Oceanic Technol., 10, 764-773.

### **B.7. No preliminary report on chlorofluorocarbon measurements**

(April 15, 1995)

### **B.8. No preliminary report on helium and tritium measurements**

(April 15, 1995)

### **B.9. Preliminary report on bathymetry measurements**

(Lynne Talley and Frank Delahoyde, April 15, 1995)

The Knorr's Raytheon Line Scan Recorder was used throughout I08N/I05E both for recording depths and for use with the pinger on the CTD/rosette. Depths were recorded every 5 minutes, entered on the ODF CTD computer, and merged with navigation acquired from the ship's Magnavox MX GPS system via RS-232, logged at one minute

intervals. The merged navigation and bathymetry file provides 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].

The PDR paper rolls and computer records will be taken to Stu Smith at Scripps Institution of Oceanography where the data will be added to the general dataset for the Indian Ocean. The recorded bathymetry differs significantly from that on the Gebco charts at the juncture of Broken Ridge and the Ninetyeast Ridge.

**B.9.1. Bathymetry Reference Carter, D. J. T., Wormley, Godalming, Surrey. GU8 5UB. U.K., 1980. Computerised Version of Echo-sounding Correction Tables (Third Edition). Marine Information and Advisory Service, Institute of Oceanographic Sciences.**

**B.10. Preliminary report on underway IMET measurements**  
(Michael Thatcher, April 15, 1995)

The following IMET sensors were installed and in use during I08N.

Type	Serial number	Label
Air temperature	119	TMP
Barometric Pressure	118	BPR
Precipitation	113	PRC
Relative Humidity	xx	HRH
Sea Surface Temperature	108	SST
Short Wave Radiation	003	SWR
Wind Speed and Direction	002	WND (3/10 - 3/31)
Wind Speed and Direction	107	WND (3/31 - 4/15)

**Data:**

The data were logged to ASCII text files, one containing ship navigational information, and the other containing meteorological information. David Newton (SIO) has complete copies of this data which he has reformatted into single combined files, by day with an added error code of "-99" for bad or missing data.

**Known problems:**

Wind sensor - There was a failing board in the wind sensor which was replaced during the port stop prior to sailing (unit 107). Unfortunately the changed board made matters worse and as a result the wind speed would frequently jump to an unreasonably high value, such as 90 meters per second for a period of one minute and data would also occasionally contain "?" characters. The data logger appears to have recorded the "?" characters in the place of wind direction when they appeared. The "?" were verified to be originating in

the wind instrument and not in the data logger. As a result of the two failed boards, the spare wind sensor (unit 002) was re-calibrated and put into use.

Unfortunately, though the data were good, they were not always there and the sensor would cease to provide information. This "timing out" grew worse over time and finally after additional trouble-shooting and swapping yet another board between the two sensors, we were able to re-utilize unit 107 with the WNDSPVN board from unit 002 and the new SCR board received from WHOI. Data logging was constant from this point on (3/31/95). None the less about 12% of this data reflects the errors seen in the previous leg and should be discarded. An entirely new and working wind sensor will be installed during the port stop for the next leg.

The gyre and speed log experienced a problem at the beginning of the cruise due to a power switch on a junction box being inadvertently turned off in the main lab (3/15/95). Once the source of the problem was found and corrected, there were no further large gaps in this area of the data logging.

**B.11. No preliminary report on underway pCO<sub>2</sub>, pN<sub>2</sub>O measurements**  
(April 15, 1995)

**B.12. No preliminary report on carbon dioxide measurements**  
(April 15, 1995)

**Figures**

Figure A.1. WOCE I08N/I05E Cruise Track

Figure A.2. (a) Stations 278-354 (WOCE I08N).  
(b) Stations 355-394.  
(c) Stations 395-442 (WOCE I05E).

Figure A.3. ALACE floats and surface drifters deployed (WOCE I08N/I05E).

Figure A.4. (a) CTD station times from ship stopping to underway.  
(b) CTD station times from CTD deployment to recovery.  
(c) Average wirespeed as a function of station number.

Figure A.5. (a) Bottle salinity,  
(b) bottle oxygen,  
(c) CTD salinity,  
(d) silica,  
(e) nitrate and  
(f) phosphate vs. potential temperature, for I08N/I05E stations 315-317 (3/95) and Geosecs station 449 (4/78), at 5 S, 80 E. Solid lines connect the I08N/I05E values.

Figure A.6. (a) Bottle salinity,  
(b) bottle oxygen,  
(c) CTD salinity,  
(d) silica,  
(e) nitrate and  
(f) phosphate vs. potential temperature, for I08N/I05E stations 328-331 (3/95) and R/V Wilkes stations 18-20 (4/79), at 12 30'S, 80 E. Solid lines connect the I08N/I05E values.

Figure A.7. (a) Bottle salinity,  
(b) bottle oxygen,  
(c) CTD salinity,  
(d) silica,  
(e) nitrate and  
(f) phosphate vs. potential temperature, for I08N/I05E stations 377-381 (3/95) and R/V Charles Darwin stations 67-69 (5/87), at about 29 30'S, 86 E. Solid lines connect the I08N/I05E values.

Figure A.8. (a) Bottle salinity,  
(b) bottle oxygen,  
(c) CTD salinity,  
(d) silica,  
(e) nitrate and  
(f) phosphate vs. potential temperature, for I08N/I05E stations 405-407  
(4/95) and I08S stations 10-12 (12/94), at 34 S, 95 E. Solid lines connect  
the I08N/I05E values.

Figure B.1.1. Pressure calibration for ODF CTD #1, December 1994.

Figure B.1.2. Temperature calibration for ODF CTD #1, December 1994.

Figure B.1.3. Comparison between the primary and secondary PRT channels.

Figure B.1.4. 5-cast grouping conductivity slopes by station number.

Figure B.1.5. CTD conductivity offsets by station number.

Figure B.1.6. Salinity residual differences after correction by pressure.

Figure B.1.7. Salinity residual differences after correction by station.

Figure B.1.8. Deep salinity residual differences after correction by station.

Figure B.1.9. O<sub>2</sub> residual differences after correction by station.

Figure B.1.10. O<sub>2</sub> residual differences (>3000db).

Figure B.4.1. (a) Vessel-mounted acoustic doppler current profiler current vectors for I08N.

(b) The same for I05E.

Figure B.4.2. Lowered acoustic doppler current profiler velocities for the portion of I08N  
crossing the equator.

Figure V1. I08N Potential temperature. (0-5500 dbar)

Figure V2. I08N Potential temperature. (0-1000 dbar)

Figure V3. I08N Salinity (CTD). (0-5500 dbar)

Figure V4. I08N Salinity (CTD). (0-1000 dbar)

Figure V5. I08N Sigma 4. (0-5500 dbar)

Figure V6. I08N Sigma theta. (0-1000 dbar)

Figure V7. I08N Oxygen (discrete). (0-5500 dbar)

Figure V8. I08N Oxygen (discrete). (0-1000 dbar)

Figure V9. I08N Silicate. (0-5500 dbar)

Figure V10. I08N Silicate. (0-1000 dbar)

Figure V11. I08N Nitrate. (0-5500 dbar)

Figure V12. I08N Nitrate. (0-1000 dbar)

Figure V13. I08N Phosphate. (0-5500 dbar)

Figure V14. I08N Phosphate. (0-1000 dbar)

Figure V15. I05E Potential temperature. (0-5500 dbar)

Figure V16. I05E Potential temperature. (0-1000 dbar)

Figure V17. I05E Salinity (CTD). (0-5500 dbar)

Figure V18. I05E Salinity (CTD). (0-1000 dbar)

Figure V19. I05E Sigma 4. (0-5500 dbar)

Figure V20. I05E Sigma theta. (0-1000 dbar)

Figure V21. I05E Oxygen (discrete). (0-5500 dbar)

Figure V22. I05E Oxygen (discrete). (0-1000 dbar)

Figure V23. I05E Silicate. (0-5500 dbar)

Figure V24. I05E Silicate. (0-1000 dbar)

Figure V25. I05E Nitrate. (0-5500 dbar)

Figure V26. I05E Nitrate. (0-1000 dbar)

Figure V27. I05E Phosphate. (0-5500 dbar)

Figure V28. I05E Phosphate. (0-1000 dbar)