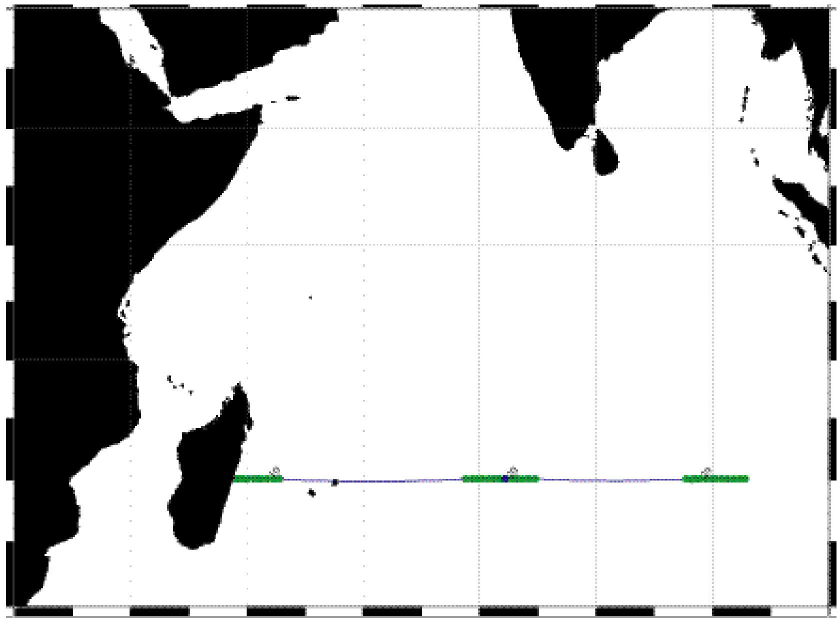
A. Cruise Narrative: IR03



A.1. Highlights

WHP Cruise Summary Information

WOCE section designation	IR03
Expedition designation (EXPOCODE)	318MSOJOURN4
Chief Scientist/affiliation	Dr. Thomas Whitworth III/TA&M*
Dates	1997.JAN.08 - 1997.FEB.14,
Ship	***RV MELVILLE***
Ports of call	Cape Town, South Africa
	Fremantle, W. Australia
Number of stations	37
Geographic boundaries of the stations	19° 59.09'S 48° 54.91'E 92° 48.05'E 20° 00.79'N
Floats and drifters deployed	none
Moorings deployed or recovered	20
Contributing Authors	none listed

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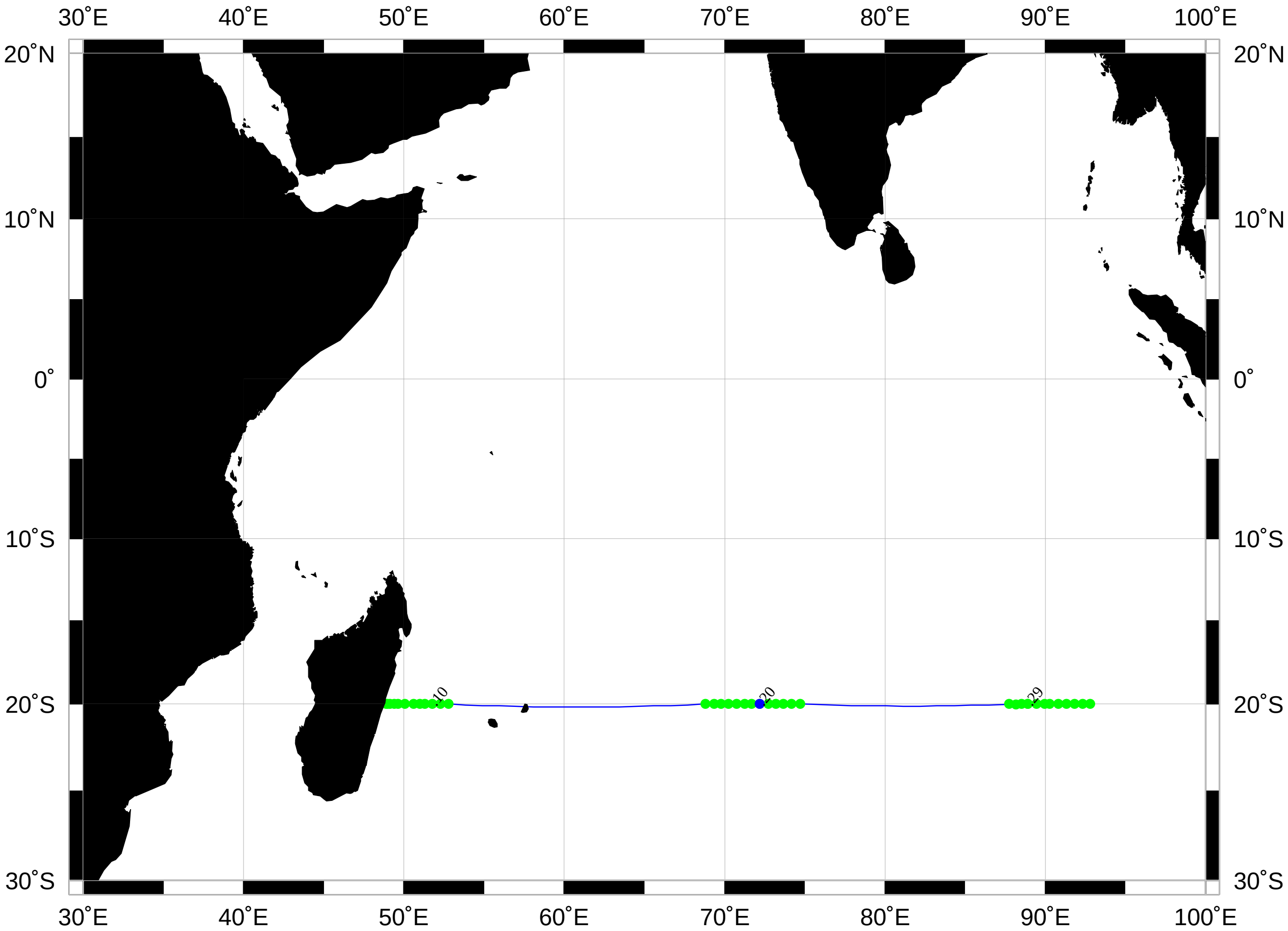
WHP Cruise and Data Information

Instructions: Click on headings below to locate primary reference or use navigation tools above. (Shaded items do not apply to this cruise or documentation was not available when this report was assembled)

Cruise Summary Information	Hydrographic Measurements
Description of scientific program	**CTD Data**
	CTD - general
Geographic boundaries of the survey	CTD - pressure
Cruise tracks: ODF WHPO	CTD - temperature
Description of stations	CTD - conductivity/salinity
Description of parameters sampled	CTD - dissolved oxygen
Bottle depth distributions stns 1-12 stns 13-37	
Floats and drifters deployed	**Bottle Data**
Moorings deployed or recovered	Salinity
	Oxygen
Principal Investigators for all measurements	Nutrients
Cruise Participants	CFCs
	Helium
Problems and goals not achieved	Tritium
Other incidents of note	Radiocarbon
	CO2 system parameters
Underway Data Information	Other parameters
Navigation	**DQE Reports**
Bathymetry	
Acoustic Doppler Current Profiler (ADCP)	CTD
Thermosalinograph and related measurements	S/O2/nutrients
XBT and/or XCTD	CFCs
Meteorological observations	14C
Atmospheric chemistry data	
Acknowledgments / **References**	**Data Processing Notes**

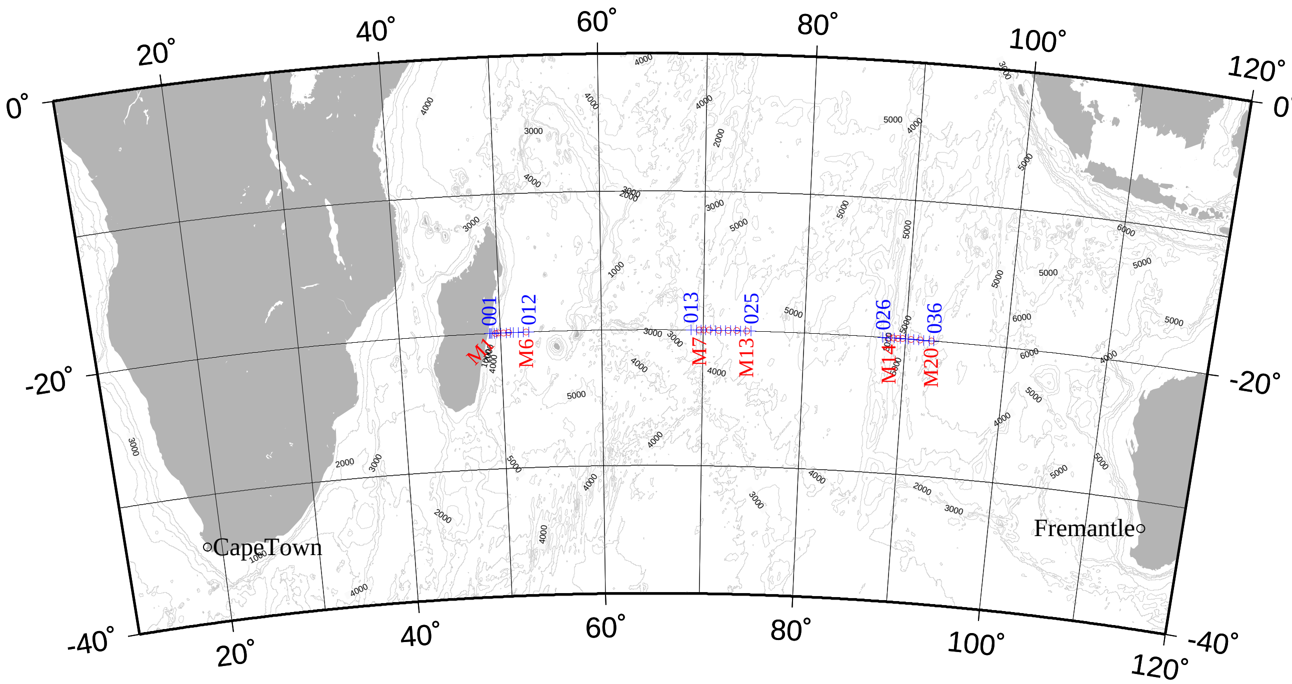
Station Locations for IR03, Whitworth, 1997



Produced from .sum file by WHPO-SIO

World Ocean Circulation Experiment
ICM3W/ICM3C/ICM3E
R/V Melville Sojourn-4
8 January 1997 - 14 February 1997
Cape Town, South Africa - Fremantle, Australia
Expocode: 318MSOJOURN4

Chief Scientist: Dr. Thomas Whitworth
Texas A&M University



ICM3 Cruise Track

Oceanographic Data Facility (ODF)
Final Cruise Report
June 12, 2001

Data Submitted by:

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

DESCRIPTION OF MEASUREMENT TECHNIQUES AND CALIBRATIONS

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. 40 CTD/rosette casts were made, usually to within 5-20 meters of the bottom. One cast at each of 37 WOCE stations was reported. Two test casts prior to the first station, and one cast aborted because of a knotted tag line, were not reported.

The R/V Melville departed from Cape Town, South Africa on January 8, 1997. The CTD stations were chosen because of their locations along 3 separate lines of moorings deployed during WOCE95-I3 along 20°S in the Indian Ocean. Moorings were recovered during daylight hours; CTD stations were done at night and numbered chronologically. The position order was determined by the best use of ship time to cover all of the target locations, while avoiding several typhoons near the cruise track.

Stations 1-12 (ICM3W) were a re-occupation of I3 stations 562-551 and 562-573, surrounding moorings M1 through M6. Stations 13-25 (ICM3C) re-occupied I3 stations 518-506, near moorings M7 through M13; stations 22-24 were out of longitude sequence and ran east to west between stations 25 and 21. Stations 26-37 (ICM3E), near moorings M14 through M20, were occupied from west to east, except station 36 was east of station 37. The ship returned to Fremantle, W. Australia on February 14, 1997.

844 bottles were tripped resulting in 839 usable bottles. No major 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 1.0, 1.1, and 1.2.

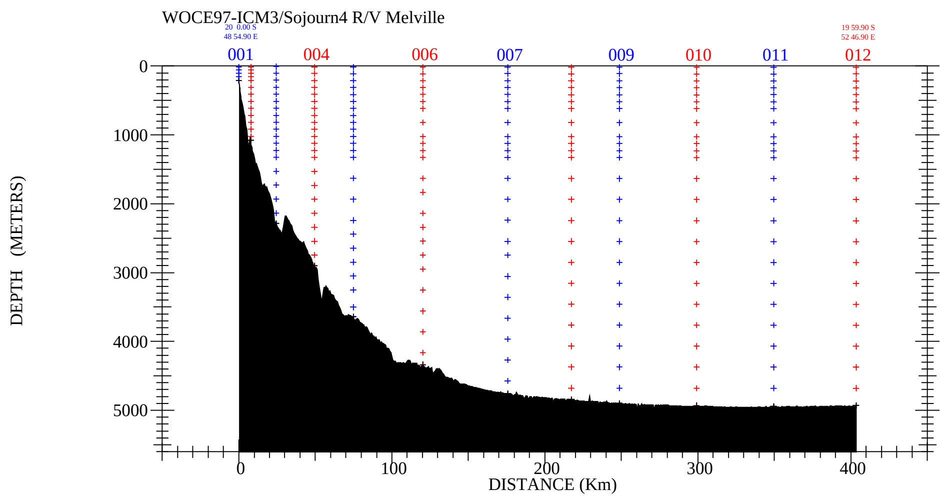


Figure 1.0 ICM3W sample distribution, stas 1-12

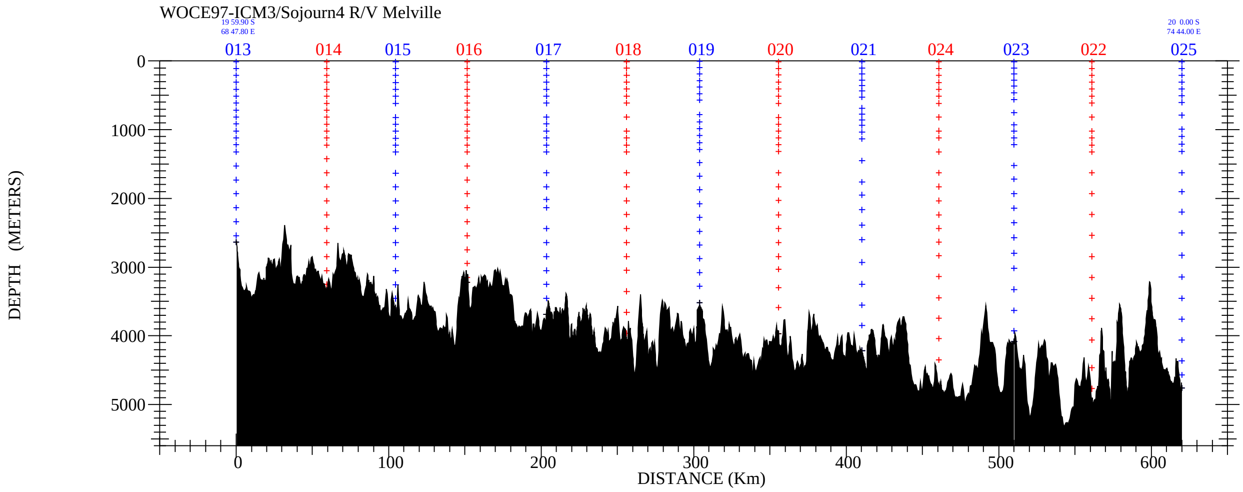


Figure 1.1 ICM3C sample distribution, stas 13-25

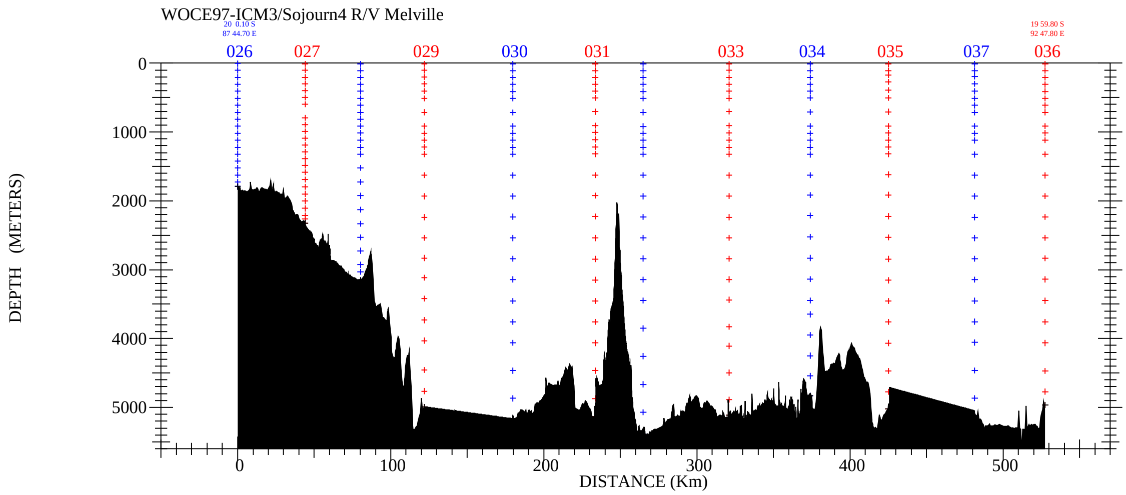


Figure 1.2 ICM3E sample distribution, stas 26-37

There were two gaps in the bathymetry data, between stations 29-30 and 35-36, where depth data were not recorded in the Melville's SeaBeam log files. Part of the track between stations 35-36 was traversed again in transit to station 37; the remainder of the missing data appears as flat sections in the bottom trace.

2. Water Sampling Package

Hydrographic (rosette) casts were performed with a rosette system consisting of a 24-bottle rosette frame (ODF), a 24-place pylon (General Oceanics 1015) and 24 2.7-liter PVC bottles (ODF). Underwater electronic components consisted of an ODF-modified NBIS Mark III CTD (ODF #5) and associated sensors, Simrad or Benthos altimeter, and Benthos pinger. The CTD was mounted horizontally along the bottom of the rosette frame, with a SensorMedics dissolved oxygen sensor deployed next to the CTD. The altimeter provided distance-above-bottom in the CTD data stream. The pinger was monitored during a cast with a precision depth recorder (PDR) in the ship's laboratory. The rosette system was suspended from a three-conductor electro-mechanical cable. Power to the CTD and pylon was provided through the cable from the ship. Separate conductors were used for the CTD and pylon signals. The dissolved oxygen sensor and altimeter were interfaced with the CTD, and their data were incorporated into the CTD data stream.

CTD #3 was used for an aborted test cast; its conductivity and secondary temperature sensors failed, and it was replaced by CTD #5. CTD #5 was used for every cast thereafter, one test cast and stations 1-37.

The deck watch prepared the rosette approximately 30 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. Time, position and bottom depth were logged by the console operator at arrival on station. The rosette was deployed from the starboard A-frame on the main deck. Each rosette cast was lowered to within 5-20 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, 1-24, where the first (deepest) bottle tripped was bottle #1. During station 27, the bottles were inadvertently tripped out of the usual sequence because the pylon ramp shaft was not reset after the previous cast. The trip sequence, deepest to shallowest, was bottles 20-24, then 1-19, at station 27. No bottle replacements were necessary during the cruise. Parts of bottles were replaced as necessary.

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 aft hangar for sampling. The bottles and rosette were examined before samples were taken, and any unusual 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 aft hangar 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. Although the aft hangar was not enclosed on two sides, the CTD was usually shielded from the sun by a van and partially closed doors.

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. Because bottle 23 was tripped deep instead of in the thermocline on station 27, it was determined that one endcap on bottle 23 had probably been leaking for a number of recent stations. The endcap was changed out before station 30. The affected samples were quality coded and comments appear in Appendix D.

3. Underwater Electronics Packages

CTD data were collected with a modified NBIS Mark III CTD (ODF #5). This instrument provided pressure, temperature, conductivity and dissolved O_2 channels, and additionally measured a second temperature and conductivity as a calibration check and backup. Other data channels included elapsed-time, altimeter, accelerometer, water-leak detector and several power supply voltages. CTD #5 supplied a non-standard 17-byte (NBIS-format + 2 bytes) data stream at a data rate of 20 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 3.0 summarizes the winches and serial numbers of instruments and sensors used during ICM3.

Station(s)	CTD† ID#	Sensormedics Model 147737 Oxygen Sensor	Winch
1-37	5	5-02-22	After
† See table below for ODF CTD #5 serial numbers			

ODF CTD #5 sensor serial numbers:

ODF CTD ID#	Paine Model 211-35-440-05 Pressure	Rosemount Model 171BJ Temperature		GO Model 09035-00151 Conductivity	
		PRT1	PRT2	COND1	COND2
5	77017	15407	15046	E197	E184

Table 3.0 ICM3 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 secondary CTD temperature and conductivity sensors, mounted in a single turret, could have been used to calculate coherent salinities if the primary sensors failed. However, they were primarily used as a secondary temperature calibration reference, eliminating the need for mercury or electronic DSRTs as calibration checks.

The General Oceanics (GO) 1015 24-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 each trip attempt during this leg. The tripbox had its own circuitry to generate and confirm bottle trips. In addition, the pylon emitted trip/confirmation messages into the CTD data stream as an additional check on bottle tripping. The acquisition software averaged CTD data corresponding to the rosette trip as soon as the trip was initiated until the trip confirmed, typically 5-6.4 seconds on ICM3.

4. Navigation and Bathymetry Data Acquisition

P-code navigation data were acquired from the ship's Trimble Tasman GPS receiver via RS-232. Data were logged automatically at one-minute intervals by one of the Sun Sparcstations. Underway bathymetry was logged every 2 minutes by the ship's computer system, recording the Sea Beam 2000 center-beam depth. Unedited depth data were later corrected according to Carter [Cart80], then 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 for bathymetry on vertical sections.

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. One other Sun system, a SPARCstation 5, was networked to the data acquisition system, as well as to the rest of the networked computers aboard the Melville. These systems were available for real-time CTD data display and provided for hydrographic data management and backup. One HP 1200C color inkjet printer provided hardcopy from either 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 were 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.

There were occasional problems with the winch used during this leg. When problems occurred, the winch operator stopped the descent or recovery in order to check the winch. These stops may have caused a slight shift in CTD oxygen data because the raw oxygen signal shifted as oxygen became depleted in water near the stationary sensor. Winch operators attempted to defer check-stops to up-casts whenever possible.

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 100-200 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 5-20 meters of the bottom.

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. 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*.

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
- 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 20 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 20 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 between down- and up-casts as well as adjacent stations. The CTD O_2 sensor was calibrated to check-sample data.

No casts exhibited conductivity offsets or noise 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 interconnect cables 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, some casts exhibited up to a 0.025 sigma theta 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/extrapolation. The only pressure intervals missing/filled during this leg were at 0 db, caused by chopping off going-in-water transition data during pressure-sequencing.

When the down-cast CTD data have excessive noise, gaps or offsets, the up-cast data are used instead. CTD data from down- and up-casts are not mixed together in the pressure-series data because they do not represent identical water columns (due to ship movement, wire angles, etc.). It was not necessary to use any up-casts for ICM3 CTD data.

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 ~1.5°C. The conductivity channel also can shift by 0.001-0.002 mS/cm as raw data values change between 32768/32767, 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 32768/32767 at ~1430±200 db (~3.72±0.18°C theta) during most ICM3 casts. There is no apparent salinity shift seen during this leg because the +0.001 PSU effect typical of the digitizing problem is lost in the higher gradients at these depths vs deeper water.

Appendix C contains a table of CTD casts requiring special attention. ICM3 CTD-related comments, problems and solutions are documented in detail.

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 #3 and CTD #5 at the ODF Calibration Facility in La Jolla. The pre-cruise calibrations were done in November and December 1996, prior to the ICM3 expedition. CTD #5 was calibrated post-cruise in March 1997. Details of only the CTD #5 calibrations are included in this document, since it was the only CTD used for ICM3 reported data.

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 -0.97/-0.05°C to a maximum loading pressure of 6080 db, and 28.84/30.31°C to 1190 db. Figures 7.0 and 7.1 summarize the CTD #5 laboratory pressure calibrations performed in December 1996 and March 1997.

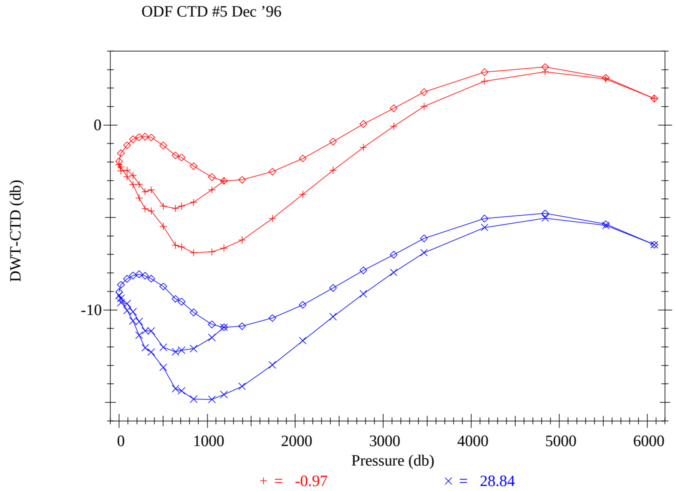


Figure 7.0 Pressure calibration for ODF CTD #5, December 1996.

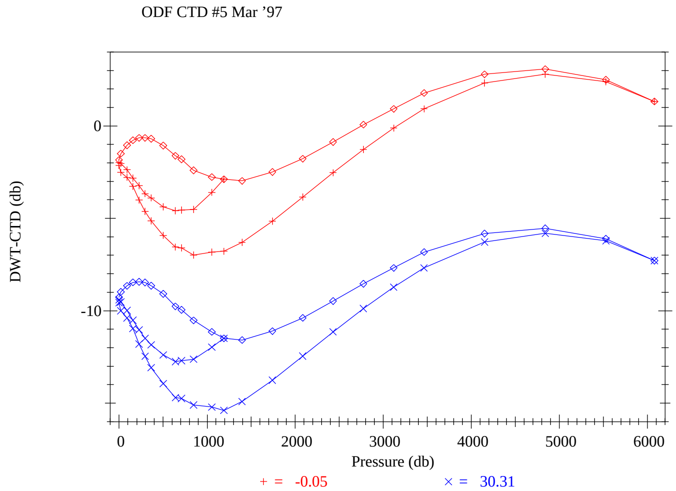


Figure 7.1 Pressure calibration for ODF CTD #5, March 1997.

Additionally, pre-cruise 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 each offset by ~1.5°C to avoid the 0-point discontinuity inherent in the internal digitizing circuitry.

Standard and PRT temperatures were measured at 7 or more different bath temperatures between -1 and 32 °C during November 1996 and March 1997. A minimal temperature re-check was done in December 1996 after installing a new pressure sensor on CTD #5. Since the data points were not identical to the November run, a combination of the November and December calibrations was used for shipboard temperature correction. The December results were more heavily weighted at the two extrema, and the November results gave shape at middle temperatures.

Figures 7.2 and 7.3 summarize the laboratory calibrations performed on the CTD #5 primary PRT during November and December 1996. Figure 7.4 summarizes the combined correction used during the cruise. Figure 7.5 summarizes the post-cruise CTD #5 primary PRT calibration performed in March 1997.

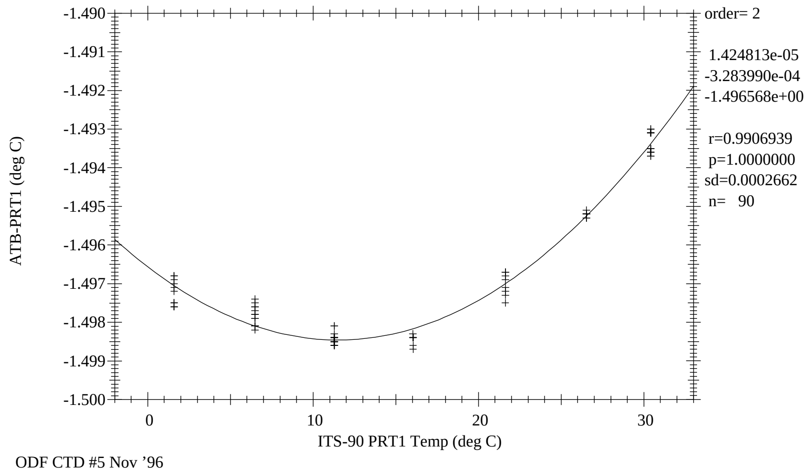


Figure 7.2 Primary PRT Temperature Calibration for ODF CTD #5, November 1996.

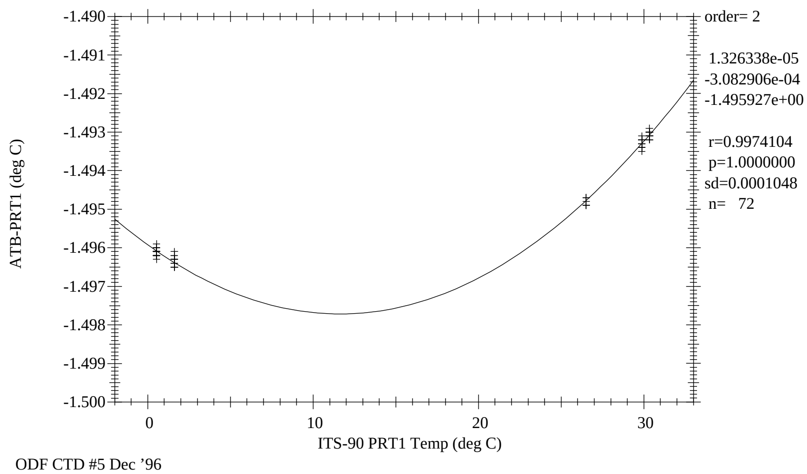


Figure 7.3 Primary PRT Temperature Calibration for ODF CTD #5, December 1996.

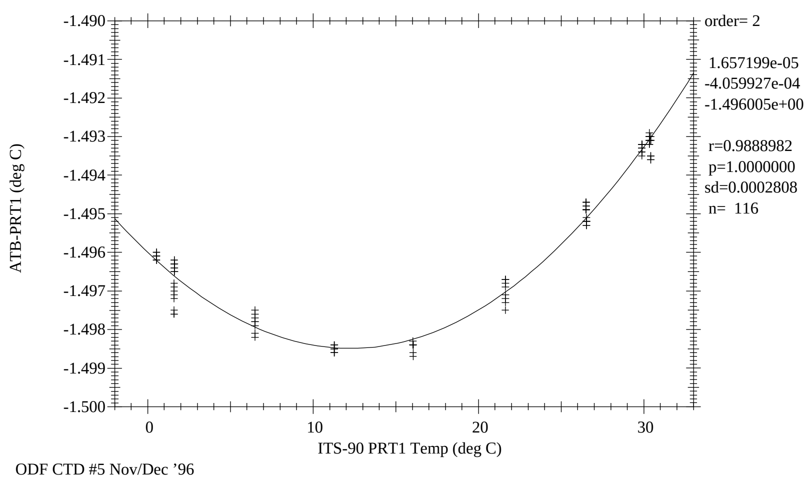


Figure 7.4 Primary PRT Temperature Calibration for ODF CTD #5, Combined Nov.+Dec. 1996.

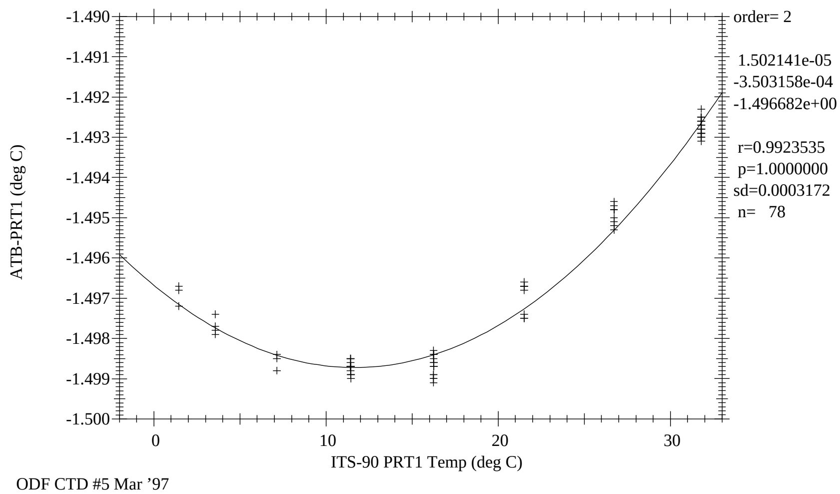


Figure 7.5 Primary PRT Temperature Calibration for ODF CTD #5, March 1997.

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 are reported using the ITS-90 standard.

8. CTD Calibration Procedures

A redundant PRT sensor was used on CTD #5 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.

Other than the first test cast, which is not reported, ODF CTD #5 was used during the entire leg, stations 1-37. Final pressure, temperature, conductivity and oxygen corrections were determined during post-cruise processing.

8.1. CTD #5 Pressure

Pre-cruise pressure calibration data were applied to CTD #5 raw pressures during each cast. 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.

Post-cruise laboratory pressure calibration data showed a shift of less than +0.5 db in the pressure correction at cold or warm bath temperatures. Differences in pre-/post-cruise bath temperatures were normalized before comparing the results. The 0.5-db shift is less than one-fifth the magnitude of the WOCE accuracy specification of 3 db, so no further pressure correction was warranted. The shipboard CTD pressures, corrected to the pre-cruise calibration, were used for final pressure data.

Corrected PDR bottom depths were compared to CTD depths plus distance-above-bottom values during shipboard processing. These differences were too variable to be useful in verifying final pressures. Residual pressure offsets at the end of each up-cast (the difference between the last pressure in-water and 0 db) were monitored during the cruise to check for shifts in the pressure calibration. The residual differences averaged +0.55 db, about the same amount as the pre-/post-cruise pressure calibration differences. Final adjusted ICM3 CTD pressures should be well within the desired WOCE standards.

8.2. CTD #5 Temperature

A second Rosemount PRT sensor (PRT2 = S/N 15046) was deployed as a second temperature channel and compared with the primary PRT channel (PRT1 = S/N 15407) 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.

Comparison of the two CTD #5 PRTs showed consistent differences of about 0.001°C at pressures deeper than 2000 decibars throughout the leg. There is no indication of any significant drift in the CTD #5 PRTs during ICM3. A stable conductivity correction also indicated no shift in the primary PRT.

Figure 8.2.0 summarizes the shipboard comparison between the primary and secondary PRT temperatures.

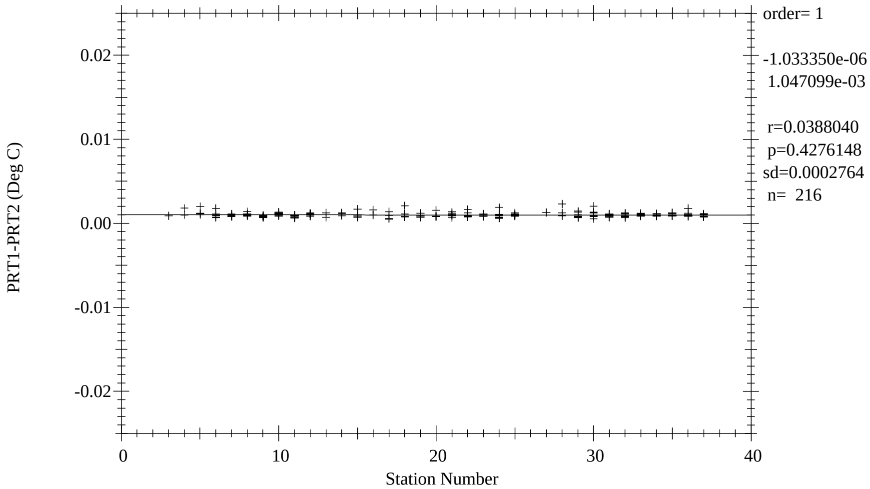


Figure 8.2.0 Shipboard comparison of CTD #5 primary/secondary PRT channels, pressure>2000db.

A weighted combination of the two pre-cruise laboratory calibrations for the CTD #5 primary temperature sensor (PRT1) was applied to all shipboard CTD data. A description of how these two calibrations were combined, and a plot of the result, can be found in Section 7 (CTD Laboratory Calibration Procedures).

Post-cruise laboratory calibrations indicated that CTD-5 PRT1 temperatures shifted up to +0.0005°C, indicating a slightly more negative correction. This was not a significant change, so the shipboard data with the pre-cruise combined calibration applied were used for final CTD temperatures. The pre- to post-cruise laboratory calibration shift for the primary temperature sensor on CTD #5 was one-fourth the magnitude of the WOCE accuracy standard of 0.002°C. ICM3 CTD temperatures should be well within the WOCE accuracy specifications.

ODF discovered a small error in the algorithm used to convert ITS90 temperature calibration data to IPTS68; this error affected ICM3 data. ODF temperature calibrations are reported on the ITS90 temperature scale, but ODF internally maintains these calibrations for CTD data processing on the IPTS68 scale. The error involved converting ITS90 calibrations to IPTS68. The amount of error is close to linear with temperature: approximately -0.00024 degC/degC, with a -0.00036 degC offset at 0 degC. Previously reported data were low by 0.00756 degC at 30 degC, decreasing to 0.00036 degC low at 0 degC. Data reported as ITS90 were also affected by a similar amount. The ICM3 temperatures were corrected for this error, then an additional correction to CTD conductivity was calculated to return CTD salinities to their previous values.

8.3. CTD #5 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.

Conductivity differences above and below the thermocline were fit to CTD conductivity for each station to determine conductivity slopes. Figure 8.3.0 shows the individual preliminary conductivity slopes.

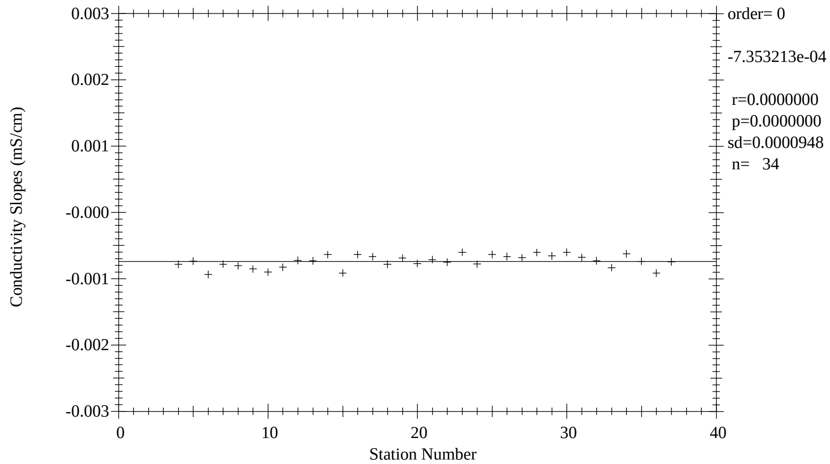


Figure 8.3.0 ICM3 CTD #5 preliminary conductivity slopes by station number.

These preliminary conductivity slopes were then fit to station number, with outlying values (4,2 standard deviations) rejected. The mean of these conductivity slopes was calculated and applied to each cast.

Once the conductivity slope was applied, residual CTD conductivity offset values were calculated for each cast using bottle conductivities deeper than 1400 db. Figure 8.3.1 illustrates the ICM3 preliminary conductivity offset residual values.

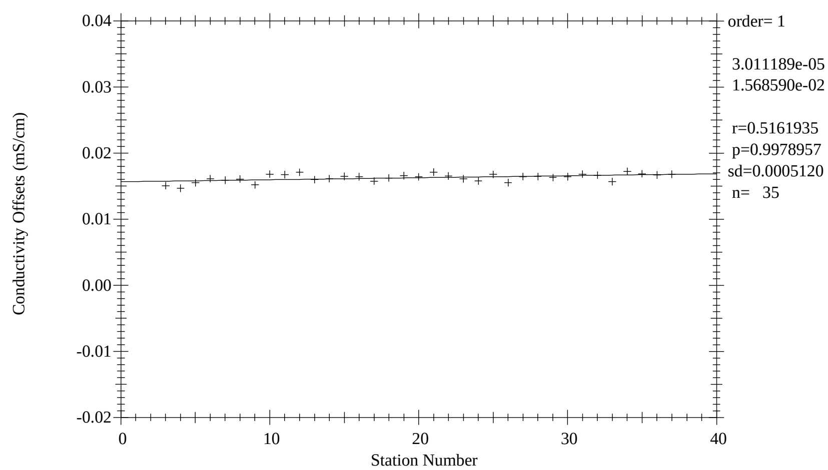


Figure 8.3.1 ICM3 CTD #5 preliminary conductivity offsets by station number.

Smoothed offsets were applied to each cast; no adjustments to these offsets were required, based on deep theta-salinity comparisons of adjacent casts. Cast-by-cast comparisons showed less than a 0.002 mS/cm total drift in the conductivity sensor offset and no slope changes over the entire leg.

The final ICM3 conductivity slopes are summarized in Figure 8.3.2. Figure 8.3.3 summarizes the final conductivity offsets.

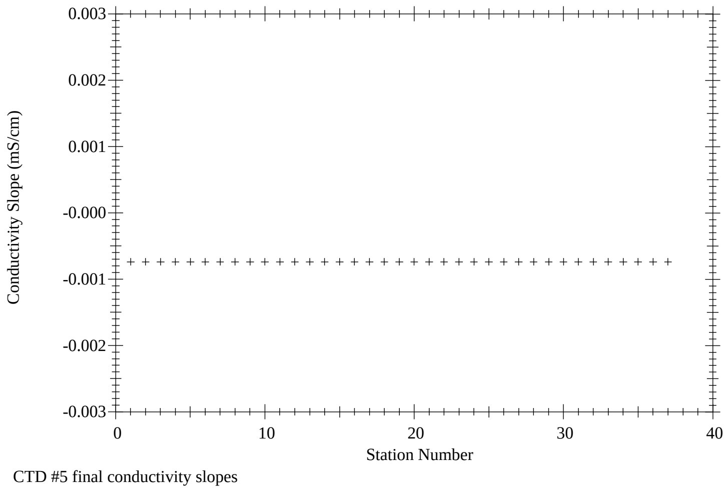


Figure 8.3.2 ICM3 CTD #5 conductivity slope corrections by station number.

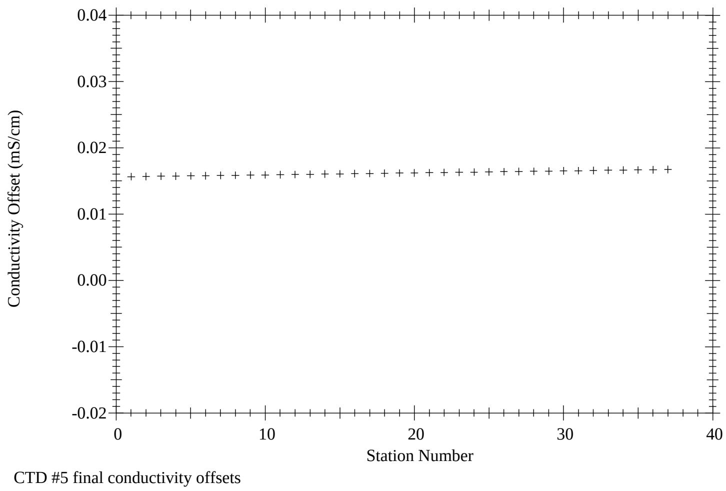


Figure 8.3.3 ICM3 CTD #5 conductivity offsets by station number.

Since the pre-cruise CTD temperature and pressure calibrations were used for final data, the shipboard CTD conductivity corrections were considered final. However, the conductivities were adjusted with a quadratic temperature-dependent correction to compensate for the change in temperatures caused by fixing the ITS90 to IPTS68 conversion error, noted at the end of Section 8.2. The change in salinity values after the combined temperature and conductivity changes was insignificant, within ±0.0002 PSU. The adjusted ICM3 temperature and conductivity correction coefficients are tabulated in Appendix A.

Summary of Residual Salinity Differences

Figures 8.3.4, 8.3.5 and 8.3.6 summarize the ICM3 residual differences between bottle and CTD salinities after applying the conductivity corrections. Only CTD and bottle salinities with final quality code 2 (acceptable) were used to generate these figures and statistics. Residual differences exceeding ±0.025 PSU are included in the calculations for averages and standard deviations, even though they are not plotted.

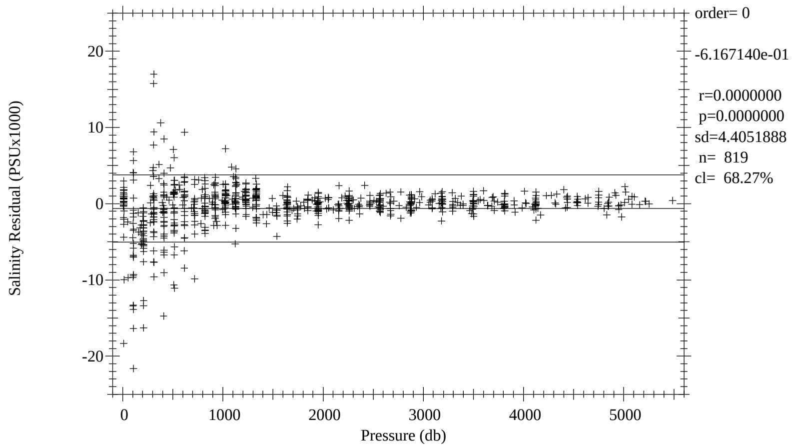


Figure 8.3.4 Salinity residual differences vs pressure (after correction).

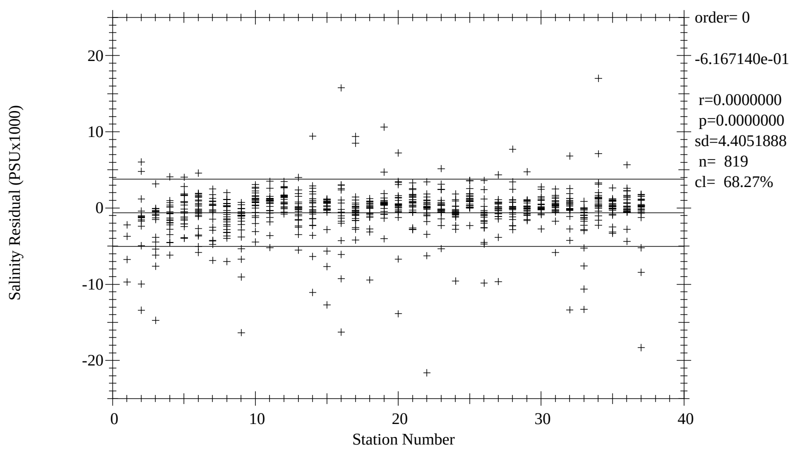


Figure 8.3.5 Salinity residual differences vs station # (after correction).

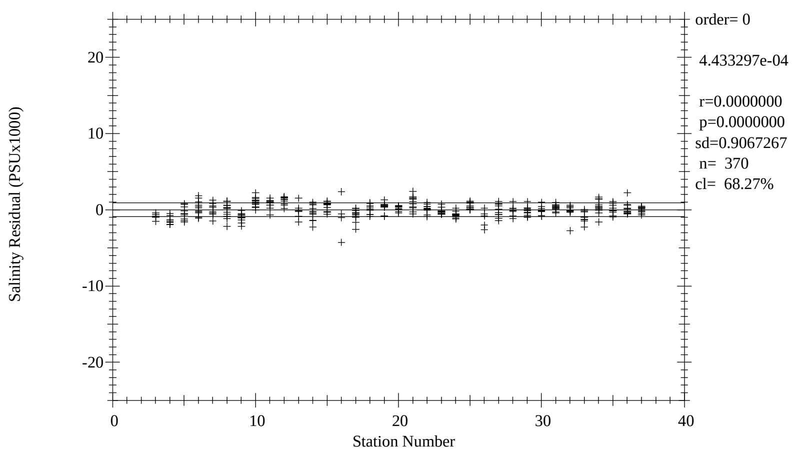


Figure 8.3.6 Deep salinity residual differences vs station # (after correction).

The CTD conductivity calibration represents a best estimate of the conductivity field throughout the water column. 3σ from the mean residual in Figures 8.3.5 and 8.3.6, or ±0.0067 PSU for all salinities and ±0.0014 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 precision of the CTD salinities appears to be better than 0.0005 PSU.

Deep ICM3 theta-salinity properties were compared with casts at the same locations from the WOCE95-I3 cruise. Although different standard batches were used for salinity analyses, the two data sets compared well, less than 0.0005 PSU difference overall in salinity.

8.4. CTD Dissolved Oxygen

A single brand new O_2 sensor was used during all of ICM3.

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 as oxygen becomes depleted in water near the sensor. All winch stops or slow-downs that may have affected CTD oxygen data are documented in Appendix C.

Because of these same stop/slow-down problems, up-cast CTD O_2 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.

After analyzing post-cruise laboratory calibrations, it was decided to use shipboard CTD corrections as final for all parameters, including oxygen. CTD oxygen data changed insignificantly (maximum 0.0017 ml/l in warm water) as a result of adjustments to temperature and conductivity corrections from the ITS90 to IPTS68 conversion error mentioned at the end of Section 8.2.

Figures 8.4.0 and 8.4.1 show the residual differences between the corrected CTD O_2 and the bottle O_2 (ml/l) for each station. Only CTD and bottle oxygens with final quality code 2 (acceptable) were used to generate these figures and statistics. Residual differences exceeding ±0.5 ml/l are included in the calculations for averages and standard deviations, even though they are not plotted.

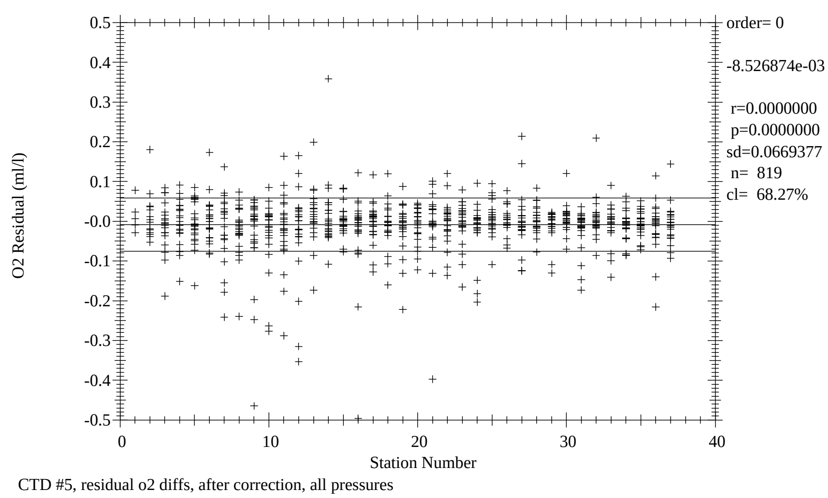


Figure 8.4.0 ICM3 O_2 residual differences vs station # (after correction).

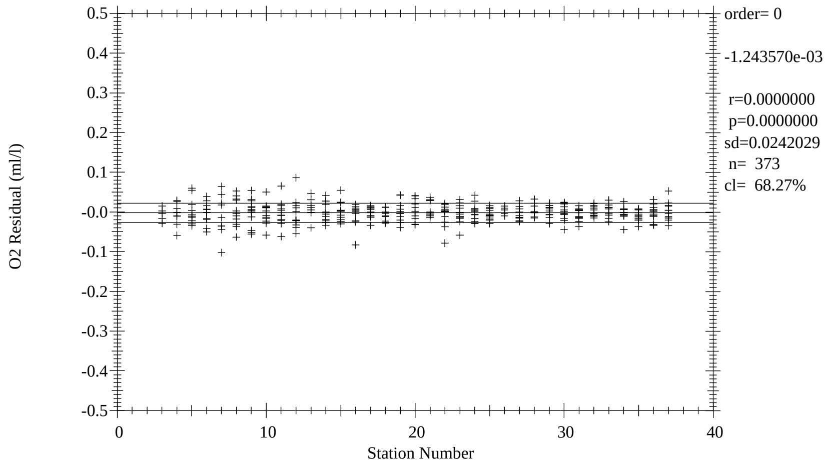


Figure 8.4.1 ICM3 Deep O_2 residual differences vs station # (after correction).

The standard deviations of 0.067 ml/l for all oxygens and 0.025 ml/l for deep oxygens are only intended as indicators of how well the up-cast bottle and down-cast CTD O_2 values match up. 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 τ_p, and two temperature responses τ_{Ts} and τ_{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, τ_{og}, is a fitting parameter. Oxygen partial-pressure is then calculated:

$$O_{pp} = [c_1 O_c + c_2] \cdot f_{sat}(S,T,P) \cdot e^{(c_3 P_l + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt})} \tag{8.4.0}$$

where:

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

ICM3 CTD O_2 correction coefficients (c_1 through c_6) are tabulated in Appendix B.

9. Bottle Sampling

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

- O_2;
- Nutrients;
- Salinity.

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

Normal sampling practice included opening the drain valve and then 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.

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. It 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 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 is footnoted as bad or questionable, the CTD O_2 is not reported.

Table 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 001-037								
	Reported	WHP Quality Codes						
	Levels	1	2	3	4	5	7	9
Bottle	844	0	830	8	1	0	0	5
CTD Salt	844	0	843	1	0	0	0	0
CTD Oxy	843	0	843	0	0	1	0	0
Salinity	839	0	820	10	9	0	0	5
Oxygen	838	0	820	8	10	1	0	5
Silicate	839	0	830	0	9	0	0	5
Nitrate	839	0	830	0	9	0	0	5
Nitrite	839	0	830	0	9	0	0	5
Phosphate	839	0	579	251	9	0	0	5

Table 10.0 Frequency of WHP quality flag assignments for ICM3.

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

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.

12. Salinity Analysis

Equipment and Techniques

A single Guildline Autosal Model 8400A salinometer (#48-263) was used for measuring salinity on all stations. The salinometer was modified by ODF and contained interfaces for computer-aided measurement. The water bath temperature was set and maintained at 24°C. The salinometer was located in a temperature-controlled laboratory.

The salinity analyses were performed when samples had equilibrated to laboratory temperature, within 9-30 hours after collection. The salinometer was standardized for each group of analyses (typically one cast, usually 24 samples) using at least one fresh vial of standard seawater per group. 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 sample conductivity was redetermined until readings met software criteria for consistency. 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. 839 salinity measurements were made and 60 vials of standard water were used. On test station 998, all 24 bottles were tripped at ~1745db; salinity samples were drawn but not analyzed. The estimated accuracy of bottle salinities run at sea is usually better than 0.002 PSU relative to the particular standard seawater batch used.

The original analyses for station 5 samples were lost because of a full floppy disk; there was no hard disk on the salinity PC. The disk was checked before each successive run, plus data were hardcopied sample-by-sample, to insure this did not happen again. No other problems with salinity analyses were noted.

Laboratory Temperature

The temperature stability in the salinometer laboratory was fair. The lab temperature rose over 1°C during the first 7 samples of the second test-cast analysis, causing the run to be aborted. That problem was resolved before the first WOCE cast, and the lab temperature generally stayed within 1°C of the Autosal bath temperature for the rest of the leg.

Standards

At least one fresh vial of IAPSO Standard Seawater (SSW) Batch P-125 was used to standardize the salinometer for each run of samples.

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. 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 draw 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 analyzed within 1-15 hours of collection, and then the data were merged into 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.

Sample temperatures were measured at the time the samples were drawn from the rosette bottle, and these temperatures were useful in indicating whether or not a bottle tripped properly.

838 oxygen measurements were made, with no major problems with the analyses.

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 ±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 were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

Duplicate measurements

On test station 998, all 24 bottles were tripped at ~1745db. Oxygen samples were analyzed for each of the bottles. Bottle 9 failed to trip and no oxygen value could be obtained. Bottle 22 oxygen was drawn but not analyzed; no reason was documented. Bottle 6 was documented as having a "funny end point" and its value was 1.7 μM/kg higher than the average. Table 13.0 shows the standard deviation of the remaining 21 samples.

Oxygen (μM/kg) Mean	164.5
Standard Deviation (μM/kg)	0.28
Number of Samples Used	21

Table 13.0 test station 998 Oxygen

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 one hour after sample collection. Occasionally samples were refrigerated up to 12 hours at 2-6°C. All samples were brought to room temperature prior to analysis.

The methods used are described by Gordon *et al.* [Gord92]. The analog outputs from each of the four colorimeter 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 660nm.

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 bypassed, 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 45 ml polypropylene, screw-capped "oak-ridge type" 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 24 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 primary standard solutions. Dry standards were pre-weighed at the laboratory at ODF, and transported to the vessel for dilution to the primary standard. Sets of 5-6 different standard concentrations were analyzed periodically to determine any deviation from linearity as a function of concentration for each nutrient analysis. A correction for non-linearity was applied to the final nutrient concentrations when necessary. In addition, a "deep seawater" high nutrient concentration check sample was run with each station as an additional check on data quality.

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.

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.

On test station 998, all 24 bottles were tripped at ~1745db. Nutrient samples were drawn but not analyzed. 839 nutrient samples were analyzed.

Standards

Na_2SiF_6, the silicate primary standard, was obtained from Aesar Chemical Company 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.

Comparisons with I3 Nutrient Data

No major problems were encountered with the measurements other than poor laboratory temperature consistency. Nitrate, silicate and nitrite values compare with I3 overall. However, phosphate values from ICM3 are consistently offset higher than those from I3. The offset between the two cruises was worse in the first 12 stations on the ICM3 leg (>4%), then lessens to about 2% in subsequent stations. Deep N:P ratios for the first 12 stations give a value of ˜13.7, while subsequent stations give a value of ˜14.2. This latter value (˜14.2) is more consistent with measurements from other regions of the Indian Ocean, including I3. Since nitrates compare well, this points to suspect phosphate data.

Unfortunately, no conclusive reason can be found for the higher ICM3 data. Since this is an offset rather than a gradual change from low to high concentrations, this is most likely a baseline (i.e. distilled water) problem. The standards checked out well. Unfortunately, the water used for the "deep" check sample was changed between Stations 12 and 13, so is of no help. Standards were changed here as well, but the analyst reported good agreement between the old and new standards. There were no analytical changes made between the first group and second group of stations (station 12 to station 13). The same group of standards (same maker, lot number, weighing analyst) were used on both cruises, and all standards within each cruise compared well. The analytical chemistries, standards, and data processing methods were the same for both cruises.

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Appendix A

WOCE97-ICM3: CTD Temperature and Conductivity Corrections Summary

Sta/ Cast	PRT Response Time(secs)	ITS-90 Temperature Coefficients $corT = t2*T^2 + t1*T + t0$ t2	t1	t0	Conductivity Coefficients $corC = ct2*corT^2 + ct1*corT + c1*C + c0$ ct2	ct1	c1	c0
001/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01567
002/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01570
003/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01573
004/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01576
005/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01579
006/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01582
007/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01585
008/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01588
009/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01591
010/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01594
011/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01597
012/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01600
013/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01603
014/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01606
015/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01609
016/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01612
017/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01615
018/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01618
019/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01621
020/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01624
021/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01627
022/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01630
023/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01633
024/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01636
025/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01639
026/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01642
027/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01645
028/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01648
029/02	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01651
030/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01654
031/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01657
032/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01660
033/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01663
034/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01666
035/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01669
036/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01672
037/01	.22	1.6572e-05	-4.0599e-04	-1.4960	1.33146e-06	2.19221e-04	-7.35321e-04	0.01675

Appendix B

Summary of WOCE97-ICM3 CTD Oxygen Time Constants

(time constants in seconds)

Temperature		Pressure	O_2 Gradient
Fast(τ_{Tf})	Slow(τ_{Ts})	(τ_p)	(τ_{og})
16.0	512.3	13.0	16.0

WOCE97-ICM3: Conversion Equation Coefficients for CTD Oxygen

(refer to Equation 8.4.0)

Sta/ Cast	O_c Slope (c_1)	Offset (c_2)	P_l coeff (c_3)	T_f coeff (c_4)	T_s coeff (c_5)	$\frac{dO_c}{dt}$ coeff (c_6)
001/01	6.85265e-05	2.09466e-01	3.48700e-04	1.14038e-02	-1.60779e-02	7.58541e-07
002/01	1.07427e-04	-1.89521e-02	5.04177e-04	-5.40731e-04	-1.34328e-02	1.97202e-07
003/01	1.98686e-04	1.70785e-02	5.87752e-05	-6.60179e-04	-3.45476e-02	2.39883e-07
004/01	1.62989e-04	5.36197e-02	9.75913e-05	-1.06538e-03	-2.80033e-02	-3.82415e-07
005/01	1.61051e-04	3.30164e-02	1.23651e-04	-5.71853e-03	-2.41724e-02	3.50914e-07
006/01	1.80514e-04	-1.24865e-02	1.34347e-04	-1.06248e-03	-3.01220e-02	8.75088e-07
007/01	1.53970e-04	4.28565e-02	1.29166e-04	-4.93122e-04	-2.54351e-02	9.74213e-07
008/01	1.56373e-04	3.47457e-02	1.32857e-04	-5.66029e-03	-2.25341e-02	1.08212e-06
009/01	1.37569e-04	6.26948e-02	1.36340e-04	-1.03018e-02	-1.28265e-02	6.54936e-07
010/01	1.66656e-04	4.97826e-03	1.41286e-04	-1.70343e-02	-1.60852e-02	2.50733e-06
011/01	1.49874e-04	4.46876e-02	1.34769e-04	-1.04479e-02	-1.63094e-02	3.29535e-07
012/01	1.49118e-04	4.52499e-02	1.34017e-04	-6.54158e-03	-1.83342e-02	3.48449e-07
013/01	1.95091e-04	-4.74004e-03	9.06865e-05	-7.06031e-03	-2.92754e-02	-8.75338e-07
014/01	1.74594e-04	2.35631e-02	1.08473e-04	3.72299e-03	-3.35158e-02	4.14521e-07
015/01	1.68748e-04	1.69809e-02	1.23843e-04	-8.17985e-03	-2.20109e-02	6.49542e-07
016/01	1.69140e-04	2.82550e-02	1.13673e-04	-6.37085e-03	-2.37957e-02	9.35490e-07
017/01	1.70618e-04	4.23813e-03	1.32944e-04	-8.61803e-03	-2.28884e-02	-9.52904e-08
018/01	1.60196e-04	7.85741e-03	1.44966e-04	-1.24095e-02	-1.75805e-02	-3.12027e-07
019/01	1.64978e-04	2.91461e-02	1.21651e-04	-5.10728e-03	-2.51254e-02	2.88410e-07
020/01	1.66257e-04	2.60097e-02	1.22729e-04	-8.73202e-03	-2.20151e-02	2.43296e-07
021/01	1.66015e-04	1.83741e-02	1.28132e-04	-5.97364e-03	-2.35063e-02	-6.67608e-07
022/01	1.63039e-04	1.98278e-02	1.31465e-04	-1.06976e-02	-1.98101e-02	1.73888e-06
023/01	1.55938e-04	2.64910e-02	1.37141e-04	-1.14040e-02	-1.72166e-02	2.48695e-06
024/01	1.65796e-04	1.68249e-02	1.30632e-04	-8.59104e-03	-2.23233e-02	9.75165e-07
025/01	1.63990e-04	1.50798e-02	1.34079e-04	-9.52077e-03	-2.10605e-02	1.70855e-06
026/01	2.02251e-04	8.71563e-03	4.94564e-05	-8.68184e-03	-2.97404e-02	1.12165e-07
027/01	1.39587e-04	3.64036e-02	1.64445e-04	-9.05775e-03	-1.51019e-02	1.11197e-06
028/01	1.61767e-04	2.02686e-02	1.30770e-04	-8.01802e-03	-2.17032e-02	4.87416e-07
029/02	1.58663e-04	2.47385e-02	1.34311e-04	-7.38854e-03	-2.11448e-02	3.83759e-07
030/01	1.60164e-04	1.93714e-02	1.36413e-04	-1.01659e-02	-1.94391e-02	1.24249e-06
031/01	1.57034e-04	2.74181e-02	1.35065e-04	-7.90612e-03	-2.01414e-02	6.76008e-07

Sta/ Cast	O_c Slope (c_1)	Offset (c_2)	P_l coeff (c_3)	T_f coeff (c_4)	T_s coeff (c_5)	$\frac{dO_c}{dt}$ coeff (c_6)
032/01	1.56029e-04	3.29188e-02	1.32305e-04	-7.02339e-03	-2.13411e-02	1.16119e-06
033/01	1.55254e-04	3.01498e-02	1.36068e-04	-5.04383e-03	-2.26469e-02	-5.24700e-07
034/01	1.57627e-04	2.38620e-02	1.37957e-04	-9.30608e-03	-2.06421e-02	1.03771e-06
035/01	1.59867e-04	2.71807e-02	1.32824e-04	-6.13846e-03	-2.38606e-02	-8.00108e-08
036/01	1.56038e-04	2.75938e-02	1.36674e-04	-5.28057e-03	-2.31612e-02	8.37644e-07
037/01	1.64041e-04	1.30133e-02	1.37295e-04	-6.52043e-03	-2.38022e-02	9.28094e-07

Appendix C

WOCE97-ICM3: CTD Shipboard and Processing Comments

Key to Problem/Comment Abbreviations	
DG/DI	density gradient/inversion in top 10db, data consistent/smooth in time-series ctd; possibly real
BQ	bottle oxygen value(s) questionable/missing, need to estimate for ctdoxy fit
OF	ctdoxy fit off more than 0.02 ml/l (deeper) or 0.10 ml/l (shallower) compared to bottle data and/or nearby ctd casts
SR	extensive ship-roll during cast; potential for density inversions and noisy Oxygen
WS	winch stopped to check possible winch problem; potential shift in ctdoxy signal

Key to Solution/Action Abbreviations	
DO	despiked Oxygen
DS	despiked Salinity (changed Temperature and/or Conductivity)
DU	down/up ctdoxy differ or similar features at different pressures in this area; but downcast ctd Salinity and Oxygen structures often correspond well with each other
EB	used nearby bottles and/or casts to estimate bottle oxygen value(s) for ctdoxy fit
GD	downcast high-gradient areas Deeper than upcast, ok if (upcast) bottles do not match (downcast) ctdoxy in these areas
NA	no action taken, use default quality code 2
NR	cast not processed, not reported with final data
O3	quality code 3 Oxygen in .ctd file for pressures specified
S3	quality code 3 Salinity in .ctd file for pressures specified

Cast	Problem/Comment	Solution/Action
998/01	TEST cast 1; CTD #3 Conductivity failed 1505db down, PRT2 data bad	NR/Aborted ~1700m after tripping all 24 btls
997/01	TEST cast 2: CTD #5, data ok	NR
005/01	DI/-0.015 OF/-0.04 to -0.08 ml/l compared to nearby btls/casts	NA/may be real O3/3456-3682db
006/01	DI/-0.01 BQ/surface+bottom	NA/may be real EB/surface+bottom
007/01	DI/-0.01	NA/may be real
010/01	DG/+0.15, 0-4db, ctdT drops -0.2°C top 6db; ctdS/ctdoxy low at surface SR/unstable Temperature, numerous density inversions	NA/may be real DS/S3/6-16db
011/01	DI/-0.025, 0-6db, Temperature rises 0.08°C	NA/may be real
012/01	DI/-0.01	NA/may be real

Cast	Problem/Comment	Solution/Action
014/01	DI/-0.02, 0-6db OF/WS/5.5 mins. at 436db, max. +0.25 ml/l compared to nearby area	NA/may be real O3/436-440db; otherwise, ctdoxy similar to upcast
016/01	kink in wire end of cast	reterminate wire after cast
017/01	WS/1.5 mins. at 28db, 3 mins. at 1014db, slow to 40m/min rest of down	NA/no apparent effect on ctdoxy
018/01	WS/2 mins. at 1194db, 1 min. at 1374db, 3.5 mins. at 1400db, 2.5 mins. at 2280db: brake trouble/testing OF/max.+0.04 ml/l at btm compared to btls, nearby casts; shifts after small slowdown	NA/ctdoxy drops around 1400db down + up O3/4066-4114db/btm
019/01	large wire angle last part of upcast; ship traveled 1.7 miles during cast	NA
021/01	OF/max. +0.40 ml/l, down-up ctdoxy very different BQ/bottom 2 bottles	DU/GD 15-30m top 450db EB/bottom
023/01	DI/-0.01	NA/may be real
025/01	SR/OF/max. -0.12 ml/l at surface, max. ±0.10 ml/l to 320db; very noisy raw ctdoxy data due to shiproll	O3/0-16db, O3/106-110db, DU/GD 10-15m 20-350db
027/01	WS/1 min. at 1222db to adjust level wind	NA/no apparent effect on ctdoxy
028/01	DG/+0.04 at surface	NA/may be real
029/01	ABORT near surface for knotted tag line	NR
030/01	BQ/surface	EB/surface
031/01	DI/-0.01	NA/may be real
033/01	DI/-0.01 WS/2.5 mins. at 5152db, winch op. radio died	NA/may be real NA/short, temporary drop just below stop
036/01	odd offset section in rawoxy, possible sea-slime	DO/2400-2468db
037/01	DI/-0.02	NA/may be real

Appendix D

WOCE97-ICM3: Bottle Quality Comments

Remarks for deleted samples, missing samples, PI data comments, and WOCE codes other than 2 from WOCE97-ICM3/Sojourn4. 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 001

Cast 1 Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

Station 002

Cast 1 Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

Station 003

Cast 1 Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

Station 004

Cast 1 Sample Log: "Squids galore." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

Station 005

Cast 1 PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

118 Sample log: "Bottle 18 empty. Bottom end cap hanging loose. No Samples." Pressure is 618db.

112 Oxygen value appears 0.10 ml/l high compared to CTDOXY. Compared to adjacent stations, value could be interpreted to be a little high. Footnote oxygen questionable. Pressure is 1232db.

Station 006

Cast 1 Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

124 Oxygen analyst: "Computer hang up while titrating o2 sample. Sample lost." Pressure is 11db.

101 Oxygen analyst: "Sample overtitrated, bad endpoint." Oxygen value looks 0.1 ml/l high compared to adjacent stations and CTDOXY. Footnote oxygen bad. Pressure is 4401db.

Station 007

Cast 1 PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.

115 CTD Conductivity offset during stop for bottle trip. Offset lasts for approximately 25 meters, maybe due to biological contamination. High gradient area also. No CTDOXY is calculated because the CTD salinity is coded questionable. Footnote CTD salinity questionable and CTD oxygen not reported. Pressure is 1129db.

108 Sample log: "Lanyard caught, bottom end cap failed to close. No Sample." Pressure is 2776db.

104 All sample values wildly off. Values almost match samples from about 2000 db. Bottle hung up then closed higher in water column. Footnote bottle did not trip as scheduled, all values bad. Pressure is 4020db.

102	Oxygen analyst note: "Funny end-point." Oxygen value +0.05 ml/l high compared to CTDOXY trace. Footnote oxygen questionable. Pressure is 4645db.
Station 008	
Cast 1	Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.
104	Oxy analyst note: "Bad end point." Oxygen value may be 0.05 ml/l high compared to CTDOXY and adjacent stations. Footnote oxygen questionable. Pressure is 4125db.
Station 009	
Cast 1	Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable. All salinity values appear to be 0.001 low compared to CTD value. End wormley, standard seawater, value appears to be 0.00004 high. Values within specifications.
Station 010	
Cast 1	Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.
114	Oxygen value appears 0.15 ml/l high compared to CTDOXY and adjacent stations. Footnote oxygen questionable. Pressure is 1232db.
Station 011	
Cast 1	Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.
Station 012	
Cast 1	Sample Log: "No comments." PO4 appears high compared with I3 data. Suspect PO4 baseline problem. Footnote PO4 questionable.
123	Delta-S = 0.02 psu. Salinity analyst took 4 runs to get 2 values to agree. May be salt crystal contamination. Footnote salinity questionable. Pressure is 107db.
Station 013	
111	Sample Log: "Spigot sticky." Data are acceptable. Pressure is 1024db.
104	Nutrient analyst: "PO4 seems 0.01 uM high" Footnote po4 questionable. Pressure is 2157db.
Station 014	
Cast 1	Sample Log: "No comments."
Station 015	
Cast 1	Sample Log: "No comments."
Station 016	
Cast 1	Sample Log: "Kink in CTD wire removed; retermination."
101-106	Salinity appears to be 0.002 low on deep bottles compared to CTD and adjacent stations. Autosal log okay, no other notes. Footnote deep salinities on station 016 questionable. PI agrees.
Station 017	
Cast 1	Sample Log: "No comments."
Station 018	
109	Sample Log: "Bottle closed, but had only a few inches of water in it. No samples." Pressure is 2260db.

Station 019

114 Oxygen value looks 0.02 ml/l high compared to CTDOXY. Could be interpreted high compared to adjacent stations. Footnote oxygen questionable. Pressure is 1094db.

114-113 Sample Log: "Top end caps on bottles 13 and 14 jostled by retrieving line during bumpy recovery." Bottle parameters appear okay compared to adjacent stations, except oxygen for 14. See 114 oxygen comments.

Station 020

Cast 1 Sample Log: "No comments."

Station 021

Cast 1 Sample Log: "No comments."

101-102 Oxygen values about 0.1 ml/l high compared to CTDOXY and adjacent stations. PI agrees. Footnote oxygen questionable.

Station 022

Cast 1 Sample Log: "No comments."

Station 023

Cast 1 Sample Log: "No comments."

123 Probable end-cap leak, shows up as noticeable Delta-S, but at a depth with a sharp salinity and oxygen gradient. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 101db.

105 Nutrient analyst: "PO4 seems 0.03 uM high" PI agrees. Footnote po4 questionable. Pressure is 3054db.

Station 024

Cast 1 Sample Log: "No comments."

123 Probable end-cap leak, shows up as noticeable Delta-S, but at a depth with a sharp salinity and oxygen gradient. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 108db.

Station 025

Cast 1 Sample Log: "No comments."

123 Probable end-cap leak, shows up as large Delta-S. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 108db.

Station 026

Cast 1 Sample Log: "No comments."

Station 027

Cast 1 Sample Log: "O2 draw temperatures indicate bottom bottle is 20 - pylon shaft pointer is at 19 (surface bottle). Therefore, suspect surface bottle is 19, bottom bottle is 20." Bottle trip order is 20-24, then 1-19.

124 Oxygen analyst note: "Funny end point." PI: "Oxygen value looks perfect on theta- o2 plots." Oxygen value acceptable. Pressure is 2023db.

123 Probable end-cap leak, shows up as large Delta-S. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 2131db.

Station 028

Cast 1 Sample Log: "No comments."

123	Probable end-cap leak, shows up as large Delta-S. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 108db.
101	Salinity value about 0.0026 higher than CTD and adjacent stations. Footnote salinity questionable. PI agrees. Pressure is 3194db.
Station 029	
223	Probable end-cap leak, shows up as large Delta-S. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 105db.
208	Sample log: "Petcock on bottle 8 gone - no samples." Pressure is 2865db.
Station 030	
124	Sample log: "Lanyard stuck in bottom of bottle 24, water coming out as rosette brought aboard. No water for samples." Pressure is 13db.
123	Probable end-cap leak, shows up as large Delta-S. PI: "All bottle properties should be coded as bad for bottle 23 on stations 023-025 and 027-030." Pressure is 108db.
Station 031	
Cast 1	Sample Log: "No comments."
123	Marine tech log: "Changed end-cap on bottle 23." Bottle 23 on all previous stations has large Delta-S. Starting with station 31, bottle 23 has better agreement with CTDSAL. Pressure is 107db.
Station 032	
Cast 1	Sample Log: "Forgot O2 draw temperature."
Station 033	
105	Sample log: "Lanyard caught in top end cap bottle 5, didn’t seat properly." Salinity value off by 0.06 psu from CTD value and adjacent stations. Nutrient values equally bad. Footnote bottle leaking and all bottle parameters bad. Pressure is 3884db.
103	Delta-S greater than 0.002, oxygen +0.08 ml/l high. No apparent reason, footnote oxygen and salinity questionable. PI agrees. Pressure is 4568db.
101	Delta-S greater than 0.003 psu. No apparent reason, footnote salinity questionable. PI agrees. Pressure is 5202db.
Station 034	
Cast 1	Sample Log: "No comments."
Station 035	
Cast 1	Sample Log: "No comments."
Station 036	
Cast 1	Sample Log: "No comments."
Station 037	
Cast 1	Sample Log: "No comments."

WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
01/23/98	Whitworth	SUM/CTD	Submitted; Steve Rutz did the ftp
03/15/00	Whitworth	CTD/BTL	Data are Public I have conferred with Bruce Warren, and we agree that the ICM3 data from 1997 can be made public.
12/13/00	Buck	CTD/BTL/SUM	Website Updated; Data added to website Added to Non-WHP website. Note, the cruise dates are: Jan 08 - Feb 14, 1997 also known as ICM03W
06/19/01	Swift	CTDTMP	Update Needed An oceanographically-insignificant error in CTDTMP data for this cruise has been found (ca. -0.00024*T - 0.00036 degC). A data update is forthcoming. In the interim the corrected data files can be obtained from: ftp://odf.ucsd.edu/pub/HydroData/woce/crs
06/20/01	Johnson	CTD	Data Update; Processing error corrected

revised data available by ftp ODF has discovered a small error in the algorithm used to convert ITS90 temperature calibration data to IPTS68. This error affects reported Mark III CTD temperature data for most cruises that occurred in 1992-1999. A complete list of affected data sets appears below.

ODF temperature calibrations are reported on the ITS90 temperature scale. ODF internally maintains these calibrations for CTD data processing on the IPTS68 scale. The error involved converting ITS90 calibrations to IPTS68. The amount of error is close to linear with temperature: approximately -0.00024 degC/degC, with a -0.00036 degC offset at 0 degC. Previously reported data were low by 0.00756 degC at 30 degC, decreasing to 0.00036 degC low at 0 degC. Data reported as ITS90 were also affected by a similar amount. CTD conductivity calibrations have been recalculated to account for the temperature change. Reported CTD salinity and oxygen data were not significantly affected.

Revised final data sets have been prepared and will be available soon from ODF (ftp://odf.ucsd.edu/pub/HydroData). The data will eventually be updated on the whpo.ucsd.edu website as well. IPTS68 temperatures are reported for PCM11 and Antarktis X/5, as originally submitted to their chief scientists. ITS90 temperatures are reported for all other cruises.

Changes in the final data vs. previous release (other than temperature and negligible differences in salinity/oxygen):

S04P: 694/03 CTD data were not reported, but CTD values were reported with the bottle data. No conductivity correction was applied to these values in the original .sea file. This release uses the same conductivity correction as the two nearest casts to correct salinity.

AO94: Eight CTD casts were fit for ctdoxy (previously uncalibrated) and resubmitted to the P.I. since the original release. The WHP- format bottle file was not regenerated. The CTDOXY for the following stations should be significantly different than the original .sea file values:

009/01
013/02
017/01
018/01
026/04
033/01
036/01
036/02

I09N: The 243/01 original CTD data file was not rewritten after updating the ctdoxy fit. This release uses the correct ctdoxy data for the .ctd file. The original .sea file was written after the update occurred, so the ctdoxy values reported with bottle data should be minimally different.

DATA SETS AFFECTED:

WOCE Final Data - NEW RELEASE AVAILABLE:

WOCE Section ID	P.I.	Cruise Dates
S04P	(Koshlyakov/Richman)	Feb.-Apr. 1992
P14C	(Roemmich)	Sept. 1992
PCM11	(Rudnick)	Sept. 1992
P16A/P17A (JUNO1)	(Reid)	Oct.-Nov. 1992
P17E/P19S (JUNO2)	(Swift)	Dec. 1992 - Jan. 1993
P19C	(Talley)	Feb.-Apr. 1993
P17N	(Musgrave)	May-June 1993
P14N	(Roden)	July-Aug. 1993
P31	(Roemmich)	Jan.-Feb. 1994
A15/AR15	(Smethie)	Apr.-May 1994
I09N	(Gordon)	Jan.-Mar. 1995
I08N/I05E	(Talley)	Mar.-Apr. 1995
I03	(Nowlin)	Apr.-June 1995
I04/I05W/I07C	(Toole)	June-July 1995
I07N	(Olson)	July-Aug. 1995
I10	(Bray/Sprintall)	Nov. 1995
ICM03	(Whitworth)	Jan.-Feb. 1997

non-WOCE Final Data - NEW RELEASE AVAILABLE:

Cruise Name	P.I.	Cruise Dates
Antarktis X/5	(Peterson)	Aug.-Sept. 1992
Arctic Ocean 94	(Swift)	July-Sept. 1994

Preliminary Data - WILL BE CORRECTED FOR FINAL RELEASE ONLY

NOT YET AVAILABLE:

Cruise Name	P.I.	Cruise Dates
WOCE-S04I	(Whitworth)	May-July 1996
Arctic Ocean 97	(Swift)	Sept.-Oct. 1997
HNRO7	(Talley)	June-July 1999
KH36	(Talley)	July-Sept. 1999

"Final" Data from cruise dates prior to 1992, or cruises which did not use NBIS CTDs, are NOT AFFECTED.

Post-1991 Preliminary Data NOT AFFECTED:

Cruise Name	P.I.	Cruise Dates
Arctic Ocean 96	(Swift)	July-Sept. 1996
WOCE-A24 (ACCE)	(Talley)	May-July 1997

	XP99	(Talley)	Aug.-Sept. 1999
	KH38	(Talley)	Feb.-Mar. 2000
	XP00	(Talley)	June-July 2000

12/27/02	Bartolacci	Cruise ID	Website Updated
	changed line # from icm03 to ir03 I have added ICM03 current meter cruise to the IR03 repeat cruises: IR03_b • expocode: 318MSOJOURN4 • Jan 08 - Feb 14, 1997 • Melville/USA • Chief Scientist Whitworth I have woce format checked the files, completed minor edits where needed, created exchange and net cdf files, an index.html page and station tracks. This cruise is filed as ir03_b and awaits linking to the website tables.		
02/10/03	Kappa	Cruise ID	Website Updated
	changed line # from icm03 to ir03 in metadatabase		
02/26/03	Kappa	DOC	Cruise Reports Assembled
	PDF and TEXT cruise reports contain Final ODF CTD and BTL data reports, and these WHPO Data Processing Notes		